

Potential Effects of Structural Sunlight Obstruction  
on  
AAFC Research Plots  
Theberge Homes Proposed Buildings

Prepared for:

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## Potential Effects of Structural Sunlight Obstruction on AAFC Research Plots Theberge Homes Proposed Buildings

### **I. Introduction**

#### **Overview**

Miller Engineering was asked on behalf of Theberge Homes to review the circumstances surrounding an application for a high-rise at 780 Baseline Road in Ottawa, Ontario, which is adjacent to the Central Experimental Farm (CEF).

The height of the proposed building is such that during certain periods of time, the adjacent research plots will be shadowed under various conditions of full and partial sunlight.

Questions from Agriculture and Agri-Food Canada (AAFC) have arisen with regards to the potential impact of shadowing and reduced sunlight affecting the conditions under which certain plants would be grown, and the attributes of adult plants and soil in that area.

#### **Scope**

Theberge Homes has requested that Miller Engineering, as an outside party, review the potential impact of the proposed development adjacent to the agronomy research station located within the city of Ottawa, Ontario. The Agriculture and Agri-Food Canada (AAFC) claims that the proposed structures will result in reduction in sunlight and the increased variability of sunlight could make its farmland “unusable for most field experiments.”

### **II. Background**

#### **Proposed Structures**

The proposed development includes three structures to be located at 780 Baseline Road in Ottawa, Ontario. The proposed design consists of one tower that is 32 stories tall and two towers that are 24 stories tall. The buildings will be used for apartments as part of the City of Ottawa’s effort to provide more housing for its growing population.

#### **Testing Facility**

Ottawa Research and Development Center is located at 960 Carling Avenue in Ottawa, Ontario. It includes the Central Experimental Farm (CEF), spanning 1,055 acres a few kilometers from downtown Ottawa (AAFC, 2021). The CEF studies barley, oats, corn, soybean, spring wheat, and winter wheat (AAFC, 2022).

### **III. Potential for Sunlight Obstruction Shade Study**

Miller Engineering was provided a letter from Agriculture and Agri-Food Canada (AAFC), addressed to the city planner of Ottawa, which outlined its concerns regarding the impact of

the proposed structures on the CEF at Ottawa Research and Development Center. The letter included the results of a Shade Study (“AAFC study”) done to quantify the potential reduction of sunlight that the proposed structures would impose on the CEF.

## Conditions of Shade Study

The AAFC commissioned a graphical shade study relative to the proposed buildings and their location next to the AAFC plots. The conditions and assumptions associated with this shade study included:

- The growing season of April 1<sup>st</sup> to November 30<sup>th</sup>
- Cloudless conditions (full sunlight every day)
- Used the sun’s position in the sky at one-minute intervals
- Created models using height and other exterior dimensions of the proposed structures
- The area of study was a four-kilometer squared block (400 hectares) centered on the location of the proposed structures
- The four square-kilometer block was divided into smaller 4 m<sup>2</sup> polygons

## Conclusions from Shade Study

- 189,387 theoretical minutes of potential cloudless sunlight could be received at that latitude during the growing season.
- The shadowing would affect an area of the test plots that equaled about 0.19 km<sup>2</sup> of land (19 hectares) out of the 4 km<sup>2</sup> block (400 hectares) that was modeled.
- The amount of sunlight reduction varied from about 1% to about 20% depending on location in the plot and sun angles.
- Based on totally cloudless conditions, the theoretical lost minutes of sunlight would be in the range of 1,893 to 37,877 minutes during the growing season.

## Miller Analysis of Cloud Considerations

Considering the expected cloud coverage from local Ottawa data, the following table was developed.

Table 1. Shade study adjusting for typical cloud coverage in Ottawa, Ontario

Variable	Calculation	Value
Unobstructed sunlight per season (AAFC study)	A	189,387 minutes
Cloud coverage per season (Canada Weather Stats, n.d.)	B	66,620 minutes
Estimated actual Sunlight per season adjusted for cloud coverage	A - B	122,767 minutes
“Shade Study” stated Sunlight reduction (AAFC study)	0.20 x 189,387	37,877 minutes
Actual Sunlight reduction (Miller Engineering)	0.20 x 122,767	24,553 minutes

Based on Miller analysis, the amount of sunlight reduction would be about 1/3 less than the value noted in the Shade Study itself. The significance of that loss will be explored in the following sections; however, the studies cited utilize a percent reduction as opposed to a particular quantitative value of loss in minutes. These studies will be utilized after a short overview of the Ottawa Research Development Center.

**IV. Ottawa Research and Development Center**

The Ottawa Research Development Center is one of four research and development centers in Ontario and one of 21 research and development centers in Canada.

We appreciate the role that the Central Experimental Farm (CEF) must serve to the province and country and are interested if there are unique roles it is serving which might not be duplicatable through other research centers. We do recognize that a small portion (~ 47 acres out of about 1000 acres) is involved in the present matter, and a portion of those acres would see minimal effect on their sunlight.

The national picture for research facilities and crop production in Canada is presented in the following tables. The commodities researched at the various centers are summarized in Table 2. The commodities researched in funded projects at Ottawa Research and Development Center are summarized in Table 3, to the best that we were able to discover online.

Table 2. Overview of Focus Areas of AAFC Research and Development Centers (AAFC, 2022)

	<b>Research Commodity</b>	<b>Number of Research Centers That Mention This Area on Their Website</b>
Areas of Research at Ottawa Research and Development Center	Wheat (Durum)	7
	Corn	5
	Oats	4
	Barley	3
	Soybeans	2
	Cereal (wheat, oats, barley)	2
	Oilseeds (canola, soybean, etc)	6
	Dairy/Manure	3
Areas of Research Not Emphasized at Ottawa Research and Development Center	Beef	8
	Fruits	6
	Vegetables	5
	Pulse (legumes -chickpeas, lentils, and peas)	4
	Swine	4
	Potatoes	3
	Peas	2
	High value crops	2
	Dry beans	1
	Rye	1
	Triticale (hybrid wheat and rye)	1
	Nuts	1
	Tomatoes	1
Poultry	1	

Table 3. Focus Areas of Funded Projects at Ottawa Research and Development Center with End Dates Ranging from 2022-2027 (AAFC, 2022)

<b>Research Commodity / Focus Area</b>	<b>Number of On-going Funded Projects at Ottawa Research and Development Center</b>
Barley	4
Wheat	3
Cereal (wheat, oats, barley)	3
Fungi	3
Pest Management	3
Sustainability	3
Crop response	3
Soil	2
Insects	2
Oats	1
Soybeans	1
Vegetables	1
Legumes	1
Weeds	1
Manure	1
Invasive Species	1
Fertilizer	1
Drought	1

Output from research centers is sometimes measured by publications. The list of publications from the Ottawa Center is shown in Table 4.

Table 4. Number of publications and presentations from Ottawa Research and Development Center by Focus Area (AAFC, 2023)

<b>Research Commodity / Focus Area</b>	<b>Number of Publications/Presentations from Ottawa Research and Development Center in 2023</b>
Soybeans	11
Manure	6
Wheat	5
Dairy	5
Methane	5
Fungi	4
Flax	3
Barley	2
Oilseeds (canola)	1
Livestock	1
Sustainability	1

We have not tried to correlate research center activity by quantity of production per province, but that could be done. However, interesting data from 2017-2021 was available for the primary province production areas. We see Ontario is a very substantial producer nationally in corn, soybeans, and winter wheat (USDA, n.d.). Southern Ontario, between Lake Huron and Lake Erie, dominate the production in that province. Production maps are available through United States Department of Agriculture Foreign Agriculture (Appendix A & B).

A study of the above data would reveal that multiple research and development centers throughout Canada are studying the same commodities as that of the CEF. Unique to the Ottawa facility funding is the emphasis on barley, but their publications emphasize soybeans, in one major project, as we read it. There are two other research and development centers in Ontario (e.g., London and Harrow) that undoubtedly contribute to the research of Ontario's primary crops as well.

### **Findings Based on Above Analysis of Canadian Agriculture Data**

- Multiple research and development centers throughout Canada are studying the same crops that Ottawa Research and Development Center studies.
- Ontario contributes less than 1% of the national production of barley and oats.
- Ontario contributes over 50% of the national production of corn, soybeans, and winter wheat.
- Ontario's production of corn, soybeans, and winter wheat is concentrated in the southwest region of Ontario.

### **Application of Analysis to Ottawa Research and Development Center**

- The Ottawa Research and Development Center does not appear to be unique in its areas of study.
- It is unclear why Ottawa Research and Development Center emphasizes barley and oats when Ontario does not contribute significantly to Canada's production of these crops.
- There are two research and development centers located in southwest Ontario (London and Harrow) that are more geographically appropriate for the study of corn, soybeans, and winter wheat.

## **V. Scientific / Agronomy Implications**

### **Non-Crop Specific Studies**

#### ***Touil et al., 2019***

In a review of several studies evaluating the effect of partial shade caused by agrivoltaics, up to 25% sunlight reduction was found to have no significant effects on crop yield. Inhibitory effects on the production of crops occurred when sunlight reduction ranged from 50% to 100%.

#### ***Gommers et al., 2013***

When plants are exposed to shade, they exhibit tactics known as "shade avoidance" and "shade tolerance" to mitigate the effects of the shade. All plants that experience a reduction in sunlight will adapt to the change by optimizing photosynthesis. Shade avoidance is displayed through stem elongation and reduced branching while shade tolerance is displayed through increased leaf area, lowered chlorophyll ratios, and higher photosystem ratios.

### **Crop Specific Studies**

#### ***Corn – Riska et al., 2022***

When studying four hybrid varieties of corn, shade had no statistically significant differences in dry weight, height, and leaf area for those grown with 25% sunlight reduction than those grown with 0% sunlight reduction. For the corn grown with 50% sunlight reduction, there was a significant difference in stem diameter than corn grown with 0% sunlight reduction. Two varieties of corn were able to produce high yields under a 50% reduction in sunlight.

## **Corn – Ramos-Fuentes et al., 2023**

The partial shade of solar panels from the application of agrivoltaics can reduce the irrigation inputs of corn production by 19-47%, compared to unshaded plots of land.

## **Grass Species - Semchenko, et al., 2011**

In a study of the effect of partial shading on grass species, grass species grown with 25% reduction in sunlight had no significant differences in dry mass than the grass species grown with no reduction in sunlight. When the reduction in sunlight was greater than 50%, there was a net facilitative effect on plant mass. At a reduction in sunlight of 90%, there was significantly lower dry mass than of that grown under full sunlight.

## **Soybean – Fan et al., 2018**

When exposed to 8.7% and 31.1% reduction in sunlight due to intercropping with corn, the yield of soybeans decreased significantly. The soybeans showed many changes in features such as stem height, stem biomass, and leaf biomass to acclimate to the shaded environment.

## **Winter Wheat – Weselek et al., 2021**

In southwest Germany, the impact of 30% sunlight reduction from being grown under a solar array was evaluated. The yield of winter wheat ranged from -19% to +3%. However, during a hot, dry summer, the yield of winter wheat increased by 2.7%.

## **Winter Wheat – Tromsdorff et al., 2011**

During a hot, dry summer in Germany, a study of 40% sunlight reduction resulted in a 3% increase in yield for winter wheat.

## **Wheat – Lakshmanakumar, 2018**

During winter in India, a study of four varieties of wheat were evaluated based on sunlight reduction. Conditions of 33% and 66% sunlight reduction here did result in a decreased grain yield.

## **Wheat and Barley – Arenas-Corraliza et al., 2019**

The impact of 0%, 10%, and 100% sunlight reduction on wheat and barley was studied under Mediterranean conditions. A factor of 10% and 50% light reduction resulted in a 19% increase in yield for barley. Wheat had no significant change in yield at 10% reduction but a 19% increase in yield at 50% light reduction.

## **Specialized New Uses of Shaded Areas - Agrivoltaics**

In the event of partial shading on the Ottawa research plots, the opportunity for novel research in the agrivoltaics sector and urban farming areas exists in the future. Agrivoltaics is the use of land for both agriculture purposes and energy generation through photovoltaics (i.e., solar panels). Ontario has about 94% of Canada's total cumulative installed capacity for photovoltaics (Baldus-Jeursen, 2019). Additionally, research has been ongoing to evaluate the potential for agrivoltaics in Ontario (Pearce, 2022).

## **Conclusions Based on Literature**

- Corn and grasses (e.g., wheat and barley) were not significantly affected by 25% or less sunlight reduction.
- Soybean were significantly affected by as little as 8.7% sunlight reduction.



- For wheat grown in hot, dry climates, 30% sunlight reduction can have a positive effect on the yield of wheat. For wheat grown in cold climates, over 30% sunlight reduction can have an inhibitory effect on yield.

### **Application of Literature to Ottawa Research and Development Center**

- Corn and grasses (e.g., wheat and barley) exposed to up to 20% reduction in sunlight, will not be significantly affected in terms of yield and other attributes.
- Soybean will be affected even by small amounts of sunlight reduction. Therefore, management practices should prevent soybeans from being grown in the potentially affected plots.
- With good management practices recognizing potential diminishing effects on certain crops, lightly shaded areas can be used to the benefit of various crop programs (e.g., agrivoltaics).

### **VI. Other Factors Affecting Experimental Plots**

The factor of intermittent shade already exists at these research fields. Portions of its fields are exposed to shade from the tree belt along Fisher Road, as well as from developments that have already been built.

The factor of intermittent shade will actually become more prevalent given the recent approval of a similar high-rise building development at 1081 Carling Avenue.

Many of the fields adjacent to the CEF are even currently subjected to exhaust from cars that use the four-lane road that runs through and along the CEF, and chemicals that are used on the roadway and adjacent properties.

Finally, the city of Ottawa is planning to build a transit line along Baseline Road. This line will run along the CEF, impacting the farm through construction dust, increased traffic, and drainage.

Despite being exposed to these many variabilities for many years, the CEF has apparently continued to operate effectively, as evidenced by over forty publications and presentations in 2023. One can question why the additional effects from the proposed structures would be anything but “de minimis” (of little significant further influence).

### **VII. Opinions**

1. Ottawa Research and Development Center is not unique in terms of the crops that they study. Many other research facilities throughout Ontario and Canada would seem capable of conducting similar research, and such research may be located closer to where a majority of production is occurring, i.e., research regarding oats and barley.
2. The AAFC shade study estimated a range of 1% to about 20% reduction in sunlight caused by the proposed structures. The potential area of concern appears to be about 47 acres out of an approximate 1000 acres for the CEF site. Within the potentially affected area, the ~20% reduction would likely be limited to less than two acres. The average expected impact across the 47 acres would likely be about 5% reduction in sunlight.
3. We acknowledge within the AAFC October 24, 2023, Development Application response, that the points made under #5-#11 of the Results section indicate reasonable concerns. Research reported again below indicates sunlight obstructions on certain crops can be a positive or

negative influence. Our overview findings suggest the effects across this acreage can be minimal. Additional tall structures on the perimeter or even planned in-field structures, which limit lighting, can be positive under the right management strategies, i.e., agrivoltaics.

4. In review, there has been substantial research relative to the effects of reduced sunlight on certain crops. Example findings are:
  - Corn and wheat are not significantly affected by 25% sunlight reduction.
  - Soybean is significantly affected by as little as 8.7% sunlight reduction.
  - For wheat grown in hot, dry climates, a 30% sunlight reduction can increase yield.
  - For wheat grown in cold climates, a 30% sunlight reduction can have a negative effect on yield.
5. One can conclude from the example studies that:
  - Corn and grasses (e.g., wheat and barley) exposed to up to 20% reduction in sunlight, will not be significantly affected in terms of yield and other attributes.
  - Soybean will be affected even by small amounts of sunlight reduction. Therefore, management practices should prevent soybeans from being grown in the potentially affected shaded plots.
  - Under certain management strategies, lightly shaded areas can be used to the benefit of various crop programs (e.g., study of agrivoltaics).
6. A number of plantings and buildings have already been allowed adjacent to the Central Experimental Farm. Given other tall structures in the area, there has been no evidence presented by AAFC that suggests shading from these other obstruction structures and plantings nearby have impacted the AAFC's programs at the CEF.
7. Test plots in urban areas will have the potential for sunlight obstruction and contaminants such as vehicle exhaust, road salt seepage, and manufacturing and process plant fumes. While less advantageous for crops intended for rural farming, there is a trend to promote "urban farming". In which case, these variations in conditions might be representative of what such urban farmers will experience, and which should be further researched. Should the CEF then focus some efforts on urban farming research, where partial sunlight obstruction will be a desired variable?
8. In the short term, the proposed structures would have little effect on future crop tests, given optimal management strategies on the part of AAFC. In the long term, the various other potential urban influences on the AAFC may cause concern regarding use of this location and choice of crops to test here, versus a more remote facility.
9. We would conclude that the impact of the proposed high structures relative to AAFC can be of a de minimis nature, and even of a benefit. Such benefit will depend on management's recognition that reduced sunlight can be a potential positive factor for some crop projects.

Respectfully submitted,

James Miller, PE, PhD  
Helen Miller, EIT, M.S. Ag & Bio Engineering

ATTACHMENTS

## VIII. References

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IX. Appendix

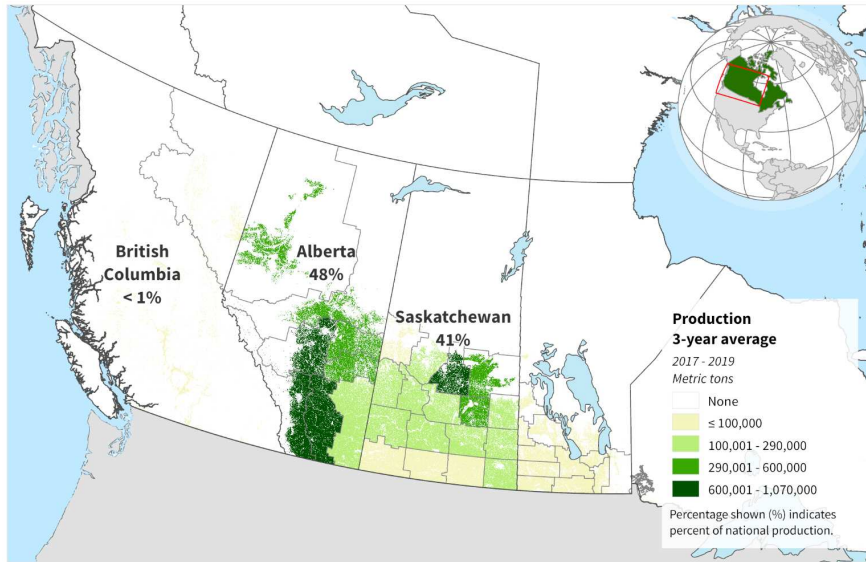
A. Three-year average of crop production by province in Canada ranging from 2017-2021 (USDA, n.d.)

<b>Commodity</b>	<b>Province</b>	<b>Percent of Production</b>
Barley	Alberta	48%
	Saskatchewan	41%
	British Columbia	<1%
Corn	Ontario	63%
	Quebec	26%
Oats	Saskatchewan	52%
	Manitoba	20%
	Alberta	19%
	British Columbia	<1%
Rapeseed	Saskatchewan	55%
	Alberta	28%
	Manitoba	16%
	British Columbia	<1%
Soybean	Ontario	55%
	Manitoba	24%
	Quebec	16%
	Saskatchewan	4%
Spring Wheat	Saskatchewan	41%
	Alberta	37%
	Manitoba	18%
Sunflower Seed	Manitoba	97%
	Alberta	2%
	Saskatchewan	1%
Wheat	Saskatchewan	45%
	Alberta	42%
	Manitoba	15%
	Ontario	6%
	Quebec	<1%
	Ontario	83%
	Saskatchewan	6%

Winter Wheat	Alberta	5%
	Manitoba	3%
	Quebec	2%

B. Production Maps of Canada (USDA, n.d.)

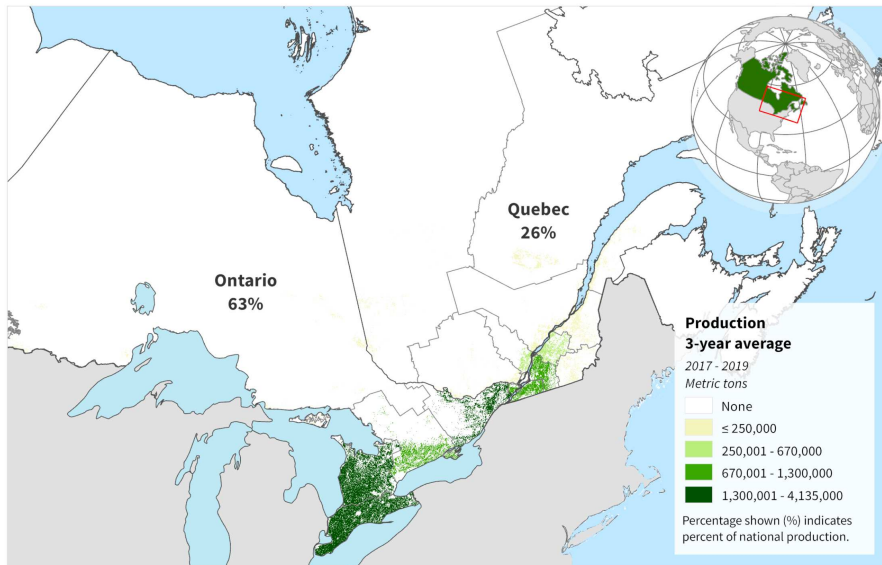
**Canada: Barley Production**



**USDA** Foreign Agricultural Service  
U.S. DEPARTMENT OF AGRICULTURE

Sources: Statistics Canada, Estimated production by Small Area Data (SAD) Region; Agriculture and Agri-Food Canada (AAFC), Annual Crop Inventory 2018

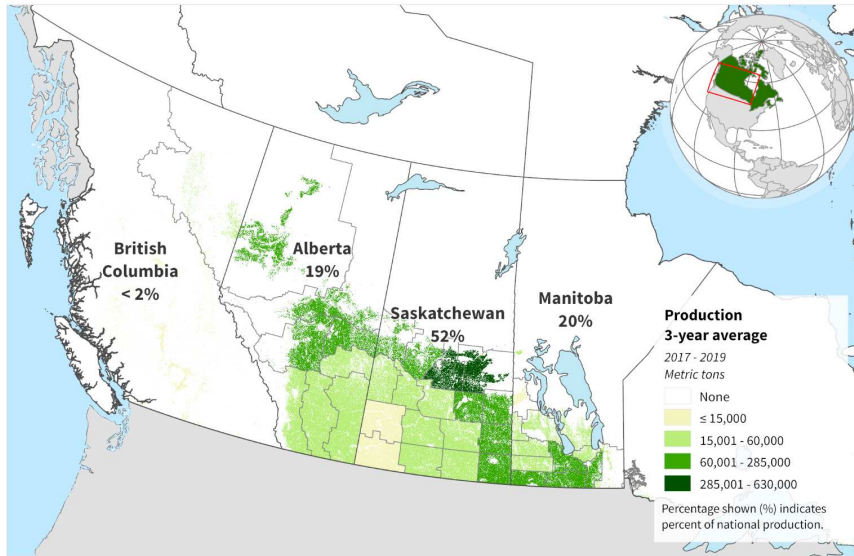
**Canada: Corn Production**



**USDA** Foreign Agricultural Service  
U.S. DEPARTMENT OF AGRICULTURE

Sources: Statistics Canada, Estimated production by Small Area Data (SAD) Region; Agriculture and Agri-Food Canada (AAFC), Annual Crop Inventory 2018

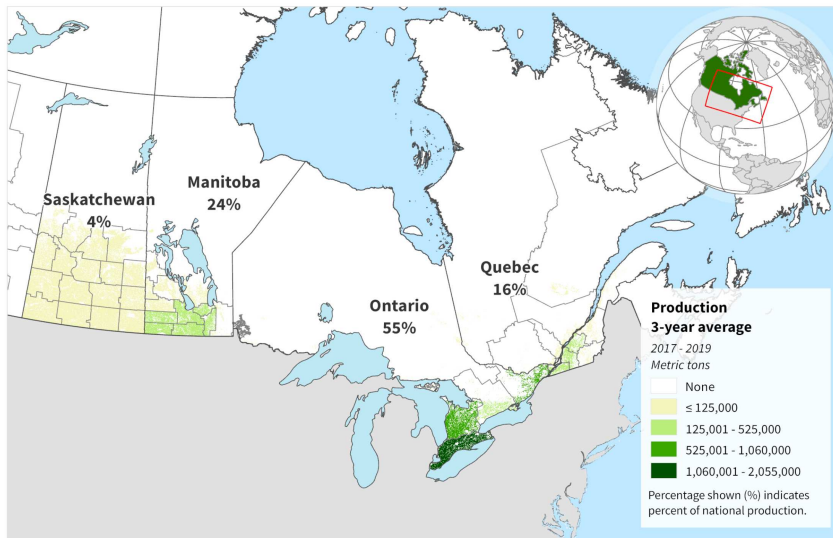
Canada: Oat Production



USDA Foreign Agricultural Service  
U.S. DEPARTMENT OF AGRICULTURE

Sources: Statistics Canada, Estimated production by Small Area Data (SAD) Region; Agriculture and Agri-Food Canada (AAFC), Annual Crop Inventory 2018

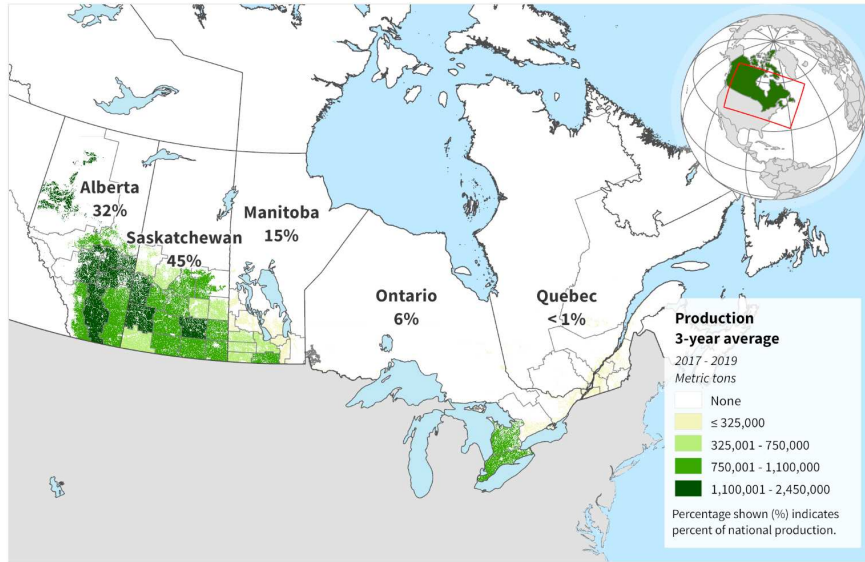
Canada: Soybean Production



USDA Foreign Agricultural Service  
U.S. DEPARTMENT OF AGRICULTURE

Sources: Statistics Canada, Estimated production by Small Area Data (SAD) Region; Agriculture and Agri-Food Canada (AAFC), Annual Crop Inventory 2018

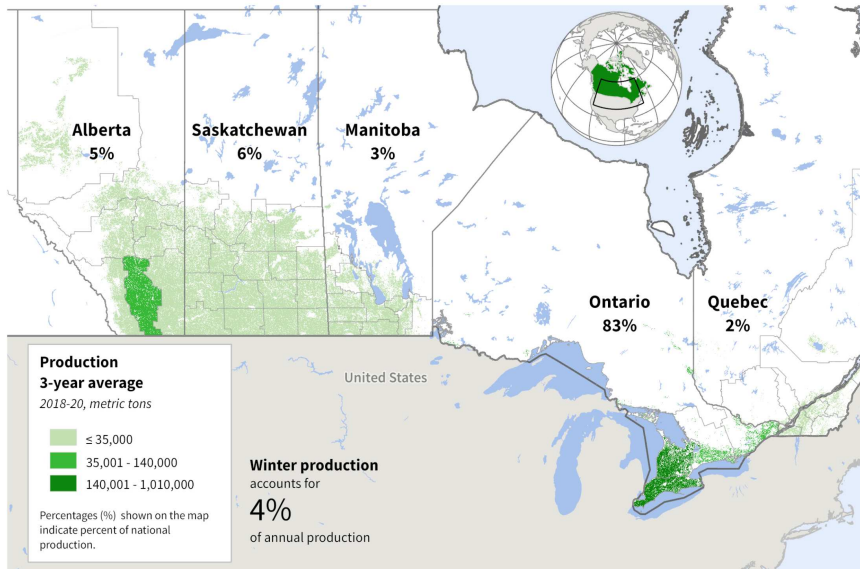
**Canada: Wheat Production**



**USDA** Foreign Agricultural Service  
U.S. DEPARTMENT OF AGRICULTURE

Sources: Statistics Canada, Estimated production by Small Area Data (SAD) Region; Agriculture and Agri-Food Canada (AAFC), Annual Crop Inventory 2018

**Canada: Winter Wheat Production**



**USDA** Foreign Agricultural Service  
U.S. DEPARTMENT OF AGRICULTURE

Sources: Statistics Canada, Estimated production by Small Area Data (SAD) Region; Agriculture and Agri-Food Canada (AAFC), Annual Crop Inventory 2018



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 533 - Human Factors Engineering II  
 539 - Safety Design Engineering

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***Professional Society Affiliations***

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 Human Factors and Ergonomics Society  
 American Society of Agricultural and Biological Engineers  
 American National Standards Institute  
 American Society for Testing and Materials  
 Society of Automotive Engineers  
 National Fire Protection Association  
 National Safety Council

**PROFESSIONAL WORK EXPERIENCE SUMMARY**

1997 Emeritus Professor, Industrial and Operations Engineering (IOE), The University of Michigan  
 1976 - 1997 Associate Professor of Industrial and Operations Engineering (IOE), The University of Michigan  
 1981 - present President, J.M. Miller Engineering, Inc.  
 1978 - 1980 Special Assistant for Safety to Dr. Eula Bingham, U. S. Assistant Secretary of Labor, OSHA

*OSHA responsibilities included:*

- Directing promulgation and revision of construction, general industry, and maritime OSHA safety standards.
- Liaison activities between OSHA and NIOSH, U.S. Department of Transportation, Mine Safety and Health Administration, labor unions, trade associations, and industry organizations.
- Negotiation of agreements involving OSHA and U.S. Coast Guard.
- Research needs and project area definition and prioritization.
- Recruiting, staffing, and budgeting.

1977 - 1978 Acting Director of Safety Standards, Federal OSHA, Washington D.C.  
 1971 - 1976 Assistant Professor of IOE, University of Michigan  
 1964 - 1966 Corporate Methods Engineer, Owens-Corning Fiberglas, Toledo, Ohio

**PUBLICATIONS**

**Books and Chapters**

Miller, J.M. & Cook, B.T. (2019). This game had a bad ending. In M.S. Wogalter (Ed.), *Forensic Human Factors and Ergonomics: Case studies and analyses* (pp. 149-161). Boca Raton, FL: CRC Press, Taylor & Francis.

Miller, J.M. (2012). Hazard communication and right-to-know regulatory issues. In J.M. Haight (Ed.), *The safety professionals handbook: Management applications* (pp. 237-292). Park Ridge, IL: ASSE.

Miller, J.M. (2008). Hazard communication and right-to-know regulatory issues. In J.M. Haight (Ed.), *The safety professionals handbook: Management applications* (pp. 199-252). Park Ridge, IL: ASSE.

Miller, J.M. (2006). Standards reference bibliography chapter. In M.S. Wogalter (Ed.), *Handbook of warnings* (pp. 795-804). Mahwah, NJ: Erlbaum.

Miller, J.M., & Lehto, M.R. (2001). *Warnings and safety instructions: Annotated and indexed fourth edition*. Ann Arbor, MI: Fuller Technical Publishing.

Miller, J.M., & Lehto, M.R. (1997). Principles of prevention: Safety information. In J.M. Stellman (Ed.), *ILO encyclopaedia of occupational health and safety*. Geneva, Switzerland: International Labour Office.

Miller, J.M., Lehto, M.R., & Frantz, J.P. (1991). *Warnings and safety instructions: Annotated and indexed*. Ann Arbor, MI: Fuller Technical Publishing.

Miller, J.M., Lehto, M.R., & Frantz, J.P. (1994). *Instructions and warnings: The annotated bibliography*. Ann Arbor, MI: Fuller Technical Publishing.

Miller, J.M., Lehto, M.R., & Frantz, J.P. (1990). *Instructions and warnings: The annotated bibliography*. Ann Arbor, MI: Fuller Technical Publishing.

Miller, J.M., & Hulsker, J. (Eds.). (1990). *Vincent and Theo Van Gogh: A dual biography*. Ann Arbor, MI: Fuller Technical Publishing.

Miller, J.M., & Lehto, M.R. (1987). *Warnings: Vol. 2: An annotated bibliography*. Ann Arbor, MI: Fuller Technical Publishing.

Miller, J.M., & Lehto, M.R. (1986). *Warnings: Vol. 1: Fundamentals, design and evaluation methodologies*. Ann Arbor, MI: Fuller Technical Publishing.

Miller, J.M. (1982). The management of occupational engineering. In G. Salvendy (Ed.), *Handbook of industrial engineering* (pp. 6.14.1-18). New York: Wiley. [American Publishers Association Award for the Best Engineering Book in 1982]

**Refereed Publications**

- Miller, J.M., & Frantz, J.P. (1993). Communicating a safety-critical limitation of an infant carrying product: The effect of product design and warning salience. *International Journal of Industrial Ergonomics*, 11, 1-12.
- Miller, J.M., & Rhoades, T.P. (1992). Methods used on atypical climbing systems. In S. Kumar (Ed.), *Advances in industrial ergonomics and safety IV*. London: Taylor & Francis.
- Miller, J.M., & Frantz, J.P. (1992). The effect of product design and warning salience on the perception of safety-critical product attributes: A case study in infant carriers. In S. Kumar (Ed.), *Advances in industrial ergonomics and safety IV*. London: Taylor & Francis.
- Miller, J.M., Frantz, J.P., & Lehto, M.R. (1991). Must the context be considered when applying generic safety symbols: A case study in flammable contact adhesives. *Journal of Safety Research*, 22, 147-161.
- Miller, J.M., Lehto, M.R., & Frantz, J.P. (1991). Prediction of slip resistance in climbing systems. *International Journal of Industrial Ergonomics*, 7, 287-301.
- Miller, J.M., & Rhoades, T.P. (1990). Revisions of TMC Recommended Practice RP-404 "Truck and truck tractor access systems." *SAE Journal of Commercial Vehicles*.
- Miller, J.M., & Rhoades, T.P. (1989). Revisions of TMC Recommended Practice RP-404 "Truck and truck tractor access systems" (SAE Technical Paper Series #892523; also presented at the SAE Truck and Bus Meeting, Charlotte, November 1989). Warrendale, PA: Society of Automotive Engineers. [Voted outstanding paper in 1989 commercial vehicle field]
- Miller, J.M., & Lehto, M.R. (1988). The effectiveness of warning labels. *Journal of Products Liability*, 11, 225-270.
- Miller, J.M., & Lehto, M.R. (1987). Scientific knowledge acquisition during the extension of GSA: An expert system for Generic Safety Analysis. *International Journal of Industrial Ergonomics*, 11, 61-75.
- Miller, J.M., Rhoades, T.P., & Lehto, M.R. (1987). *Slip resistance predictions for various metal step materials, shoe soles and contaminant conditions* (SAE Technical Paper Series #872288; also presented at the SAE Truck and Bus Meeting, Dearborn, November 1987). Warrendale, PA: Society of Automotive Engineers.
- Miller, J.M. (1985). An experimental application of knowledge engineering: A Generic Safety Analysis system. *Proceedings of the IEEE Conference on Systems, Man and Cybernetics, Tucson, AZ*.
- Miller, J.M. (1983). Slippery work surfaces: Towards a performance definition and quantitative Coefficient of Friction (COF) criteria. *Journal of Safety Research*, 14(4), 145-148.
- Miller, J.M., & Wiker, S. (1983). Acceleration exposures in forward seating areas of bowrider recreational boats. *Human Factors*. Response to Advance Notice of Proposed Rulemaking on Unregulated Hazards on the Outer Continental Shelf, 45 Fed. Reg. (November 1980).
- Notice of Proposed Rulemaking for Modification to 29 CFR Part 1907, Laboratory Accreditation, 45 Fed. Reg. (November 1980).
- Memorandum of Agreement on Occupational Health Standards for Workplaces Aboard Inspected Vessels, 45 Fed. Reg. (Feb. 11, 1980). [between U.S. Coast Guard and OSHA]
- Memorandum of Understanding [U.S. Coast Guard and OSHA]: Occupational Safety and Health on Artificial Island, Installations and Other Devices on the Outer Continental Shelf of the United States, 45 Fed. Reg. pp (Feb. 11, 1980).
- Response to Advanced Notice of Proposed Rule Making on Unregulated Hazards on the Outer Continental Shelf, 44 Fed. Reg. (Sept. 20, 1979).
- Educational/Scientific Diving (ANPR), 44 Fed. Reg. (Aug. 17, 1979).
- Verticalization Package of OSHA 1910/1926 Safety and Health Standards, 44 Fed. Reg. (February 1979).
- Miller, J.M. (1977). A critique of the Poulton book: Tracking skill and manual control. *Journal of Industrial Engineering*.
- Miller, J.M., & Pfauth, M. (1976). Work surface friction coefficients: A survey of relevant factors and measurement methodology. *Journal of Safety Research*.
- Miller, J.M. (1976). Commercial motor carrier driver hazards and workspace design. *Human Factors Journal*.
- Miller, J.M., Chaffin, D., Dinman, B., Smith, R., & Zontine, D. (1975). Psychomotor and neuromuscular changes in workers exposed to inorganic mercury. *Journal of the American Industrial Hygiene Association*.
- Miller, J.M., Hancock, W., & Foulke, J. (1973). *Comparison of MTM-1, GPD, MTM-2, and the AMAS systems*. Des Plaines, IL: MTM Association.
- Miller, J.M. (1972). Use of human subjects in human factors research. *Journal of the Human Factors Society*, 14(1).
- Miller, J.M. (1971). Student visual and control behavior in the real aircraft instrument landing task, The Ohio State University, 1971. [Doctoral dissertation]
- Miller, J.M. (1965). Capacity concept for improved production management decision making, The Ohio State University, 1965. [Master's thesis]

**Other Publications (Technical Reports, Technical Bulletins, Proceedings, Contracts, etc.)**

- Miller, J.M. (2012). *OSHA mandates changes to all MSDS & labels* (Miller Engineering Technical Bulletin 7-12:GHS). Ann Arbor, MI: Miller Engineering, Inc.
- Miller, J.M. (2011). *Implementing a hazard communication program* (Miller Engineering Technical Bulletin). Ann Arbor, MI: Miller Engineering, Inc.
- Miller, J.M. (2010). *Auto/truck accident reconstruction & analysis* (Miller Engineering Technical Bulletin). Ann Arbor, MI: Miller Engineering, Inc.
- Miller, J.M. (2010). *Common household hazards for children* (Miller Engineering Technical Bulletin). Ann Arbor, MI: Miller Engineering, Inc.
- Miller, J.M. (2010). *Evaluating compliance of chemical labels & MSDS (OSHA, ANSI, and the new GHS)* (Miller Engineering Technical Bulletin). Ann Arbor, MI: Miller Engineering, Inc.
- Miller, J.M. (2010). *How to design a warning label* (Miller Engineering Technical Bulletin). Ann Arbor, MI: Miller Engineering, Inc.
- Miller, J.M. (2010). *Occupational exposure to benzene* (Miller Engineering Technical Bulletin). Ann Arbor, MI: Miller Engineering, Inc.
- Miller, J.M., Grieser, B.C. (1998). *Boat handhold placement*. Edgewater, MD: American Boat and Yacht Council.
- Miller, J.M., Grieser, B.C. (1998). *Boat boarding ladder placement*. Edgewater, MD: American Boat and Yacht Council.
- Miller, J.M., Grieser, B.C., & Clark, D.R. (1996). *Analysis of designs and principles of movement transition intended for boat handholds and boarding ladders*. Edgewater, MD: American Boat and Yacht Council.
- Miller, J.M., Grieser, B.C., Clark, D.R. (1996). *Experimental determination of lateral boat accelerations during turns at bow seat versus stern seat locations*. Edgewater, MD: American Boat and Yacht Council.
- Miller, J.M., Grieser, B.C., & Clark, D.R. (1996). *Bowrider backrest height variables*. Edgewater, MD: American Boat and Yacht Council.
- Miller, J.M., Main, B., & Igball, C. (1994). *Occupant protection in recreational boating*. Annapolis, MD: American Boat and Yacht Council.
- Miller, J.M., Main, B., & Frantz, J.P. (1993). The ability of two lay groups to judge product warning effectiveness. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, Santa Monica, CA, 1989-1993*.
- Miller, J.M., Frantz, J.P., & Rhoades, T.P. (1991). A model for developing and evaluating product information. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, San Francisco, CA*.
- Miller, J.M., Main, B., & Rhoades, T.P. (1991). *Driver expectancy as a potential traffic control criteria at rural state highway intersections* (Miller Engineering Technical Report). Ann Arbor, MI: Miller Engineering.
- Miller, J.M., Rhoades, T.P., & Frantz, J.P. (1990). Emerging methodologies for the assessment of safety related product communications. *Proceedings of the Annual Meeting of the Human Factors Society, Orlando, FL, 34*.
- J.M. Miller Engineering. (1990). *Static testing – Boat seating systems*. Westland, MI: Defiance – STS. (Test #7269)
- Miller, J.M., & Rhoades, T.P. (1988). Measurement and comparison of “required” versus “available” slip resistance. *Proceedings of the Annual Meeting of the Human Factors Society, Edmonton, AB, 34*.
- Miller, J.M., & Rhoades, T.P. (1987). Towards the development of a consensual design standard for casual furniture chairs. *Interface 87, Symposium on Human Factors and Industrial Design in Consumer Products, Rochester, NY, 5*.
- Miller, J.M., & Lehto, M.R. (1987, October). *Predicting warnings-induced behavior changes*. Paper presented at the 31<sup>st</sup> Annual Meeting of the Human Factors Society, New York, NY.
- Miller, J.M., & Lehto, M.R. (1986, September/October). *Warnings: Methodology, presentation, and interpretation*. Paper presented at the 30<sup>th</sup> Annual Meeting of the Human Factors Society, Dayton, OH.
- Miller, J.M., & Lehto, M.R. (1985). An experimental application of knowledge engineering: A Generic Safety Analysis system. *IEEE International Conference on Systems, Man and Cybernetics, Tucson, AZ*.
- Miller, J.M. (1985, March). *The application of safety ergonomic methodologies to the analysis of accidents resulting in litigation*. Paper presented to the staff of the Office of General Counsel of Ford Motor Company, Dearborn, MI.
- Miller, J.M., Lehto, M.R., & Clark, D. (1984). An isomorphism between fault tree analysis and LISP data structures. *Proceedings of the USA-Japan Conference on Human-Computer Interaction, Honolulu, HI, 1*.
- Miller, J.M., & Clark, D. (1983). *A generic safety standard system for robotic and other types of automated manufacturing machinery* (Final Rep.). Ann Arbor, MI: The University of Michigan, College of Engineering, Center for Research in Integrated Manufacturing (CRIM).
- Miller, J.M. (1983). *“Slippery” vs. “slip resistant” work surfaces: The background for a regulatory definition*. Washington, DC: Occupational Safety and Health Administration. (NTIS No. PB8 3 243634)
- Miller, J.M. (1983). *A bibliography of Coefficient of Friction literature relating to slip type accidents*. Washington, DC: Occupational Safety and Health Administration. (NTIS No. PB8 3 243626)
- Miller, J.M., Chaffin, D., & Andres, R. (1983). *Work surface friction: Definitions, laboratory and field measurements, and a comprehensive bibliography*. Ann Arbor, MI: The University of Michigan, Center for Ergonomics.
- Miller, J.M. (1982). *Safety aspects of automated devices*. Ann Arbor, MI: The University of Michigan, Center for Robotics and Integrated Manufacturing, Management Systems Division.
- Miller, J.M., Boydston, L., & Kochhar, D. (1981). *Simulator based evaluation of perceptually disabled drivers* (IEEE

- Miller, J.M., Boydstun, L., & Kochhar, D. (1981). An approach to training the disabled driver. *International Conference – IEEE Systems, Man and Cybernetics*.
- Miller, J.M., Boydstun, L., & Kessel, D. (1980). Assessment of perceptually disabled individual's driving skills with a driving simulator. *Proceedings, Annual Meeting of the Human Factors Society, 24*.
- Miller, J.M., Boydstun, L., Kessel, D., & Hensen, D. (1980). Driver's training program: A methodology for determining the training needs of individuals with perceptual disabilities. *Proceedings, International Conference on Rehabilitation Engineering, Toronto, ON*.
- Miller, J.M., Boydstun, L., Kessel, D., & Langolf, G. (1979). Spherical harmonics: A new method for estimating maximum reach distance. *Proceedings, Annual Meeting, Human Factors Society, 23*.
- Miller, J.M., et al. (1979). Digital simulation techniques for drivers training and skill evaluation. *Proceedings, Interagency Conference on Rehabilitation Engineering, Atlanta, GA*.
- Miller, J.M. (1979). Human factors implications for power boat designer. *Proceedings, Symposium on Power Boat Design, Boating Industry Association, Ann Arbor, MI*.
- Miller, J.M. (1979). *Occupational accidents of drivers of auto haul commercial trucks* [A statistical report describing accidents occurring to the U.S. and Canadian universe of 20,000 auto haul truck drivers in 28 companies]  
Editor for the program and *Proceedings of the Human Factors Society 22<sup>nd</sup> Annual Meeting* (1978).
- Appropriateness of Standards for Commercial Vehicle Cab Interior Design (Aug. 1978). [Response to a Federal Register Docket, submitted to U.S. Department of Transportation on behalf of the International Brotherhood of Teamsters]
- Miller, J.M., & Bingham, E. (1978, February). *What's ahead for OSHA standards*. Invited paper for the Greater New York Safety Council and the New Jersey Chamber of Commerce, New York, NY.
- Miller, J.M., & Herrin, G. (1978, January). *Relation of workers compensation data to national OSHA priorities*. Invited paper for the Bureau of Labor Statistics, Memphis, TN.
- Miller, J.M., & Bingham, E. (1977, October). *Priorities for future OSHA standards activities*. Invited paper for the National Safety Council for the National Safety Congress, Chicago, IL.
- Miller, J.M., & Pollock, S. (1977). Analysis of automobile emissions laboratory operations: Final report to the U.S. Environmental Protection Agency. Washington, DC: The Agency.
- Miller, J.M., & Gatchell, S. (1977). The visual behavior of recreational boat operators: Final report. Washington, DC: U.S. Coast Guard.
- Miller, J.M., & Pfauth, M. (1975). Safety research requirements relevant to industrial floor friction. Atlanta, GA: NIOSH.
- Miller, J.M. (1972-1974). Human factors implications of recent government legislation. *University of Michigan Human Factors Engineering Summer Conference, Ann Arbor, MI*.
- Miller, J.M. (1974). An experiment to test the visual detection capabilities of boating operators under representative stressors. Calabasas, CA: Wyle Laboratories.
- Miller, J.M., & Gatchell, S. (1974). Boating operators maneuvering responses using hand vs. foot throttles. Calabasas, CA: Wyle Laboratories.
- Miller, J.M., & Gatchell, S. (1974, November). *Final subcommittee report, visibility pilot research (phase I)* (SAE VRI 13.1, Vol. II). Warrendale, PA: Society of Automotive Engineers.
- Miller, J.M., & Stiehl, C. (1974). Perception, decision making and skill in relation to a boating operators performance. *Proceedings, Human Factors Society, Huntsville, AL, 18*.
- Miller, J.M. (1974). Identifying human factors causes from boating accident data. *Proceedings, Human Factors Society, Huntsville, AL, 18*.
- Miller, J.M., & Gatchell, S. (1974). Boating operator performance stressors. *Proceedings, Human Factors Society, Huntsville, AL, 18*.
- Miller, J.M., & Gatchell, S. (1974). Prediction of driver's eye location. *Proceedings, Human Factors Society, Huntsville, AL, 18*.
- Miller, J.M., & Gatchell, S. (1974, June). *Final report, visibility pilot research (phase I)* (SAE VRI 13.1). Warrendale, PA: Society of Automotive Engineers.
- Miller, J.M. (1974). Work measurement as a tool in teaching dental students and scheduling simultaneous patients. *Proceedings, The American Institute of Industrial Engineers, New Orleans, LA, 25*.
- Miller, J.M., & Foulke, J. (1973). *Instruction manual for visual activity monitor* (Contract No. F33615-73-C-0232). Dayton, OH: Wright-Patterson Air Force Base.
- Miller, J.M. (1973). Visual behavior changes of student pilots flying instrument approaches. *Proceedings, Human Factors Society, Washington, DC, 17*.
- Miller, J.M. (1973). *Human factor applications in boating safety* (U.S. Coast Guard Contract). Washington, DC: U.S. Coast Guard. (NTIS Nos. AD 780-988, Vol. I, 781-205, Vol. II)
- Miller, J.M., & Chaffin, D. (1973). *Behavioral and neurological evaluation of workers exposed to inorganic mercury* (Contract No. 5T01-0N00161-02). Atlanta, GA: NIOSH.
- Miller, J.M., Chaffin, D., Dinman, B., Smith, R., & Zontine, D. (1973). *An evaluation of the effects of chronic mercury exposures on EMG and psychomotor functions: Final report* (Contract No. 5T01-0N00161-02). Atlanta, GA: NIOSH.

- Miller, J.M. (1972). *Commercial vehicle occupational health hazards* (SAE No. 720264). Warrendale, PA: Society of Automotive Engineers. [Selected for publication in 1972 *Transactions of Annual Meeting*]
- Miller, J.M., & Weislogel, S. (1970). *Study to determine the operational profile and mission of the certificated instrument rated private and commercial pilot* (Contract No. FAA-RD-70-51). Washington, DC: Federal Aviation Administration.

### **Technical In-House Articles**

- J.M. Miller Engineering. (2019). *Button batteries & children*. Retrieved from <http://www.millerengineering.com/sample-page/technical-bulletins/button-batteries-children>
- J.M. Miller Engineering. (2019). *Vaping E-cigarettes & vaporizers, and their lithium ion batteries*. Retrieved from <http://www.millerengineering.com/sample-page/technical-bulletins/vaping-e-cigarettes-and-vaporizers>
- Miller Engineering, Inc. (2011). *Technical bulletin: Implementing a hazard communication program*. Retrieved from <http://www.millerengineering.com/sample-page/technical-bulletins/implementing-a-hazard-communication-program>
- Miller Engineering, Inc. (2010). *Technical bulletin: Auto/truck accident reconstruction & analysis*. Retrieved from <http://www.millerengineering.com/sample-page/technical-bulletins/auto-truck-accident-reconstruction-analysis>
- Miller Engineering, Inc. (2010). *Technical bulletin: Common household hazards for children*. Retrieved from <http://www.millerengineering.com/sample-page/technical-bulletins/common-household-hazards-for-children>
- Miller Engineering, Inc. (2010). *Technical bulletin: Evaluating compliance of chemical labels & MSDS (OSHA, ANSI, and the new GHS)*. Retrieved from <http://www.millerengineering.com/sample-page/technical-bulletins/evaluating-compliance-of-chemical-labels-msdss>
- Miller Engineering, Inc. (2010). *Technical bulletin: How to design a warning label*. Retrieved from <http://www.millerengineering.com/sample-page/technical-bulletins/how-to-design-a-warning-label>
- Miller Engineering, Inc. (2010). *Technical bulletin: Occupational exposure to benzene*. Retrieved from <http://www.millerengineering.com/sample-page/technical-bulletins/occupational-exposure-to-benzene>

**Helen Miller, EIT**  
**BS Mechanical Engineering, MS Ag&Bio Engineering**  
helen@millerengineering.com

## Education

M.S. in Biosystems and Agricultural Engineering, Michigan State University, East Lansing, MI

Thesis: *A Decision Support System to Evaluate the Economic Feasibility of Solar Technology on Dairy Farms*

B.S. in Mechanical Engineering, Michigan State University, East Lansing, MI

Additional major in Psychology, minor in Agribusiness Management

Engineering Certification: Passed initial Engineer In Training examination

December 2020

## Relevant Experience

*Project Engineer* - Miller Engineering, Inc., Ann Arbor, MI

(2019 – Present)

- Case experience regarding fermentation, farm vehicle road safety, agricultural equipment, generator testing, recreational vehicles, cranes, product recalls, etc.
- Studied lawsuits regarding product failure, warnings & regulations, and human factors engineering.
- Researching OSHA standards, applying engineering principles, and writing reports.

*Research Assistant* – Michigan State University, East Lansing, MI

(5/21 – 5/23)

- Tractor newly converted to electric motor: Prepared formal plan for obtaining performance metrics.
- Tractor metrics: Included but not limited to tractor slip, hydrostatic pressure, and drawbar force.
- Agricultural Mechanization: Assisted with development of course.

*Teaching Assistant* – Michigan State University, East Lansing, MI

(1/21 – 5/23)

- Over 50 biosystems & agricultural engineering undergraduate students.
- Agricultural and biosystems engineering junior design: Supervised and assisted creation of ag & bio design projects.
- Agricultural and biosystems engineering remote learning model: Developed for professor as well as ag and bio students.
- Agricultural engineering electronics lab: Set up agricultural related electrical and sensor components for monitoring.
- Instrumentation: Oscilloscopes, data acquisition systems, sensors, circuit boards, etc.
- Provided clear and effective feedback on technical writing to develop students into stronger technical writers.

*ASABE International Conference*, Volunteer Student Coordinator

(7/21)

- Alliance for Modernizing African Agriculture: Lead the construction of the formal report, delegated tasks to a group of 12 agricultural engineering graduate students from other land-grant universities across the United States

*Research Assistant* – Mid Michigan Research, LLC, East Lansing, MI

(1/20 – 4/21)

- Internal combustion engine modeling of cylinder fluid flow.
- For the above model: Compiled data for various variables and mended computer aid design (CAD) modeling errors on Converge CFD Software.

*Property Management Intern* - Kalajoki Farms, Clatskanie, OR

(5/16 – 8/16)

- Rural Energy for America Program (REAP) government funded solar plant supervision of the installation.
- Prepared a home for rent through restoration, creative decision-making, and appliance installation.
- On farm equipment operation; tractors; irrigation systems; manual labor; weed control; electronic land surveying.

## Presentations

*ASABE International Conference: Alliance for Modernizing African Agriculture*

(7/21)

Title: The Potential of Solar Energy to Modernize African Agriculture

*ASABE Global Initiative Conference: Sustainable Energy for a Sustainable Future*

(10/22)

Title: A Decision Support System to Evaluate the Economic Feasibility of Solar Technology on Dairy Farms

## Relevant Skills

- Extensive experience with MS Office Suite, Slack, and other professional tools
- Extensive experience using: Camtasia, CONVERGE CFD, and Rstudio
- Moderate experience using: CSS, HTML, JavaScript, Matlab, NX 11 CAD, Altaire Inspire, SPSS, Minitab, Qualtrics
- Proven track record of effective time management with multiple projects, strong communication through several mediums to different groups, and systematic problem-solving of complex tasks.

## Affiliations

*American Society of Agricultural and Biological Engineers*

2021 – Present

*American Society of Mechanical Engineers*

2020 – Present

*Engineers Without Borders*, Michigan State University

2019 – Present

*Tau Beta Pi, Engineering Honors Fraternity*, Michigan State University

2018 – Present

*4H – Rabbitry, Western and English Horsemanship*

2010 – 2016

## **ABOUT MILLER ENGINEERING AGRICULTURAL EXPERTISE**

We are more than engineering consultants as we actually manage the farming of 1000 acres of land in Idaho and Oregon. Also we have designed and operate a hydroelectric plant on the Snake River, and designed and built a solar farm to operate pressured pivot irrigation systems under a US Government Grant (REAP). The agricultural, academic, publications and forensic experience of our engineers in the allow us to act as experts in many of the warning, labeling, toxic material, vehicular accidents, animal safety, and other types of issues and incidents confronted in agricultural operations. We can assist with everything from agricultural accident analysis to systems design from simple individual pieces of equipment to complicated automatic irrigation, solar and hydroelectric systems.

On staff we also have a licensed applicator for herbicides, fertilizer, pesticides, insecticides, and restricted use chemicals. Below are examples of areas we have provided agricultural engineering expertise:

- **Agricultural Safety Engineering**
  - Tractor, Farm Implement, and Harvesting Safety (OSHA 29 CFR 1929)
  - Dairy and Food Processing Safety and Health
  - Cannabis and Hemp Processing Safety
  - Machine Guarding, Entrapment, & Entanglement
- **Farm Tools, Vehicles, Equipment, and Machinery**
  - Tractor Overturns/Rollovers
  - Irrigation & Hydroelectric Power Systems
  - All-Terrain Vehicle (ATV) Usage
- **Farm Accident Analysis/Reconstruction**
  - Hay, Crop and Grain Harvesting Accidents
  - Grain and Crop Conveyor and Elevator Storage and Accidents
  - Horse (Equine) and Cattle (Bovine) Accidents
- **Agricultural Chemical Safety, Applications, and Exposure**
  - Pesticide Use, Compliance, Disposal, and Contamination
  - Licensed Restricted Use and Chemigation Applicators
  - Wastewater
- **Construction Safety, Training, and Accidents (OSHA 29 CFR 1926)**
  - Building Materials
  - Building Codes

# Our Working Farms and Ranches

Our 1,000 acres of ranch, farm and timberlands in Idaho and Oregon, as well as our solar farm and hydroelectric power plant on the Snake River (shown below), have the usual pieces on farm equipment: tractors, swathers, balers, rakes, planters, harvesters, tilling equipment, backhoes, skid steers, and ATV's. Crops produced include potatoes, alfalfa, sugar beets, barley for Coors and Budweiser, winter wheat, beans, carrots, and three types of corn: sweet, field, and silage corn. The ranch is also home to 300 registered black angus cattle.

These properties are available for various test or demonstration purposes of crops and equipment, and they are available for use by clients. We also use our contacts with our many local farmers to gather data about the equipment they buy and use. We are happy to make this connection to our farms available.