A vision for dairy cows and farms in Canada in 2068

(What is Canada’s vision for dairy in the future?)
The Past: **Looking back to Kentucky in 1950’s**

Born February 1954
Pictured at 10 yr. of age
8y 1m: 16,990M 626F
6.3 SD above US Avg.
Why Dairy? *It feeds the most people from our land base.*

![Graph showing carrying capacity of U.S. agricultural land across different diets.]

Versions of Current Diets:
- OMNI 100
- OMNI 80
- OMNI 60
- OMNI 40
- OMNI 20
- OVO
- LAC
- VEG

Proportion of cropland available for cultivated cropping

Carrying Capacity (10^8 persons)
Population forecast: *Growth of population will be in Africa and Asia*


93% of growth will be in Asia and Africa, 82% in Africa alone.
Feeding the world: What does Canadian dairy want to do?

Canadian Exports, 2017, Billions US$

- Oilseeds: $7.9
- Cereals: $6.3
- Meats: $5.0
- Fish and crustaceans: $4.8
- Vegetables: $4.5
- Prepared cereals and flour: $3.3
- Fats and oils: $3.2
- Prepared vegetables and fruits: $1.8
- Misc. edible: $1.6
- Cocoa: $1.5
- Animals: $1.4
- Others: $4.9

Total Dairy: $0.4 Billion

http://www.dairyinfo.gc.ca/index_e.php?s1=dff-fcil&s2=imp-exp&s3=exp
Currently: 10% of countries produce 75% of world’s cow’s milk.
Currently: *Yield varies 40–fold among 10 countries with most milk cows*

### Total = 147 million cows

<table>
<thead>
<tr>
<th>Country (cows, M)</th>
<th>FAO STAT 2014 Data; 12 May 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>India (46)</td>
<td><img src="India" alt="Bar Graph" /></td>
</tr>
<tr>
<td>Brazil (23)</td>
<td><img src="Brazil" alt="Bar Graph" /></td>
</tr>
<tr>
<td>China (12.6)</td>
<td><img src="China" alt="Bar Graph" /></td>
</tr>
<tr>
<td>Pakistan (11.8)</td>
<td><img src="Pakistan" alt="Bar Graph" /></td>
</tr>
<tr>
<td>Ethiopia (11.4)</td>
<td><img src="Ethiopia" alt="Bar Graph" /></td>
</tr>
<tr>
<td>USA (9.2)</td>
<td><img src="USA" alt="Bar Graph" /></td>
</tr>
<tr>
<td>Sudan (7.7)</td>
<td><img src="Sudan" alt="Bar Graph" /></td>
</tr>
<tr>
<td>S. Sudan (7.6)</td>
<td>![Bar Graph](S. Sudan)</td>
</tr>
<tr>
<td>Russia (7.6)</td>
<td><img src="Russia" alt="Bar Graph" /></td>
</tr>
<tr>
<td>Tanzania (7.0)</td>
<td><img src="Tanzania" alt="Bar Graph" /></td>
</tr>
</tbody>
</table>

- Milk Yield, kg
- World median = 1,453 kg
- Above
- Below

Currently, yield varies 40–fold among 10 countries with most milk cows.
Climate change: **Projected changes in Canadian temperatures 2050-2081**

Warmer <> Wetter <> Longer growing seasons <> More extremes

Climate change. USA dairies move to regions with adequate water.

Dairies will shift from seven states that produce 42% of milk today.

Longer Growing Seasons & More Rain

Darker shades have more severe water shortages.

Climate Change, Water, and Risk: Current Water Demands Are Not Sustainable  www.nrdc.org/globalWarming/watersustainability
Milk yield: *Experts’ forecast of milk yield in USA in 2067*

- **Actual Yields**
- **Top USA Cow 2017**
- **12 SD above national average**
- **Top USA Herds 2017**
- **Exponential**
- **Linear**

**Trend after Genomics**

- 3.8 million cows
- 7.5 million cows

JHB ADSA 2017
Top yields: *Potential is far beyond our averages.*

<table>
<thead>
<tr>
<th></th>
<th>Corn(^1,2) bu/acre</th>
<th>Soybeans(^1,2) bu/acre</th>
<th>Milk(^1,2) lbs/cow</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Record(^2)</strong></td>
<td>542</td>
<td>171</td>
<td>78,170</td>
</tr>
<tr>
<td><strong>Average(^1)</strong></td>
<td>171</td>
<td>48</td>
<td>22,498</td>
</tr>
<tr>
<td><strong>Std. Dev.</strong></td>
<td>47.9</td>
<td>13.0</td>
<td>4,500</td>
</tr>
<tr>
<td><strong>R minus A</strong> (SD units)</td>
<td>7.7</td>
<td>9.5</td>
<td>12.2</td>
</tr>
</tbody>
</table>

\(^1\) Yield averages are for **2014** in USA.

\(^2\) Records are for **2016 or 2017** (updated 12.21.2017).

*Biological capacity is clearly far beyond average yield.*
Forecasts: *Milk prices in USA and world will continue to be VOLATILE!*

Inflation Adjusted Mailbox Prices USA

Original data: Hoard’s Dairyman April 25, 2018, page 264 (NZ shows 75% difference).
Forecasts: *Cows per herd in USA will continue to INCREASE*

Profitability: **Larger herds spread fixed costs over more units of milk.**

Source: 2017 Dairy Benchmark Summary, Farm Credit Services of America (~103 farms, 4299 cows per farm).

<table>
<thead>
<tr>
<th>Revenue (ECM adjusted)</th>
<th>$/100 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Milk Price per 100 lbs. (Mailbox)</td>
<td>$16.67</td>
</tr>
<tr>
<td>Total Revenue per 100 lbs.</td>
<td>$17.83</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expenses (ECM adjusted)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed Costs</td>
<td>$7.54</td>
</tr>
<tr>
<td>Herd Replacement Costs</td>
<td>$1.86</td>
</tr>
<tr>
<td>Labor Costs</td>
<td>$1.75</td>
</tr>
<tr>
<td>Other Costs</td>
<td>$5.27</td>
</tr>
<tr>
<td>Total Expenses per 100 lbs.</td>
<td>$16.41</td>
</tr>
</tbody>
</table>

| Net income per 100 lbs                      | $1.44      |
| Net income per cow                          | $359       |
Looking ahead: **Farmers will share specialized facilities (Lateral Integration)**

**Reduce fixed costs/cow**

**Adopt common protocols**

**Volume discounts**

**Common design of facilities**
Precision management: *Sensors, robotics, algorithms*
Technology: *Systems, artificial intelligence*

- Soils
- Crops
- Silo/bales
- Lagoon
- Natural areas
- Barns
- Milking center
- Personnel
- Equipment
- Commodities
- Robots
- Air
- Waterways
- Roads
- Vehicles

Cow friendly
Reliable, Repeatable
Precision, Accuracy
Less labor
Looking ahead: **Understanding the dairy herd as a SUPERORGANISM**

We cannot learn about herds by studying these:
13 production units (herds)

- Study practices, trends, long-term
- Use sensors, surveys, samples
- Assess micro- and macro-environments
- What characterizes “good management”?
- Do herds behave as superorganisms?

Study: **Herds in close proximity**
Looking ahead: Genetics of cows of the future

- Efficient, smaller environmental footprint
- Gene based, not breed based
- Proprietary genes licensed in embryos
- Healthier, fertile, polled
- Gene editing to move genes within & among breeds

4.2% Fat. 3.1% Protein
Caseins, fatty acids
SCC <200,000, A2A2
Protein engineering (gene editing) ....*what is this all about?*

Source: https://www.the-scientist.com/?articles.view/articleNo/47256/title/From-Stem-Cell-to-Oocyte-In-a-Dish/
Genetics of the future: **Focus shifts to managing epigenetics**

Environmental Action ➞ Observed Response

- **Incidence, metritis**
- **Incidence, ketosis**
- **Incidence, RP**
- **Days to 1st AI**
- **First calving interval**
- **Incidence, mastitis**
- **SCC average**
- **Persistency of yield**
- **Productive life**
- **Lifetime protein**
- **Age first calving**
- **Lifetime fat**
- **Lifetime milk**
- **Days to 1st CL**
- **Energy balance**
- **Net income**
- **BCS**
- **Dry matter intake**
- **ME protein**
- **ME**
- **ME milk**
- **Lactose%**
- **Protein%**
- **Fat%**

Genetic vs. Epigenetic (broadly defined)

- **Genetic**
- **Epigenetic (broadly defined)**

- **19%**
- **81%**

Bennet Cassell, Using Heritability for Genetic Improvement [https://pubs.ext.vt.edu/404/404-084/404-084.html]
Example: How does weight loss affect fertility of a cow’s eggs?

“Britt Hypothesis” Here’s what observed.

Maintained = 62% CR

Lost = 25% CR

Here’s a diagram of our hypothesis.

Primordial pool
Activated oocyte from ovarian reserve

Microscopic size

Weight loss Environment

Days Before or After Calving

Ultrasound size

Ovulation of egg

101 Days

The Britt Hypothesis: 26 years later...

Pregnancy Rates Timed AI

789 cows
25%
Lost

675 cows
38%
Maintained

423 cows
84%
Gained

Pregnancy rate per timed AI (%)

Body Condition Change During 3 Weeks Postpartum

We will change weight loss patterns!

Carvalho et al, J Dairy Science 97:3666-3683, 2014

J. Dairy Sci. 100 (4) 3143–3154
Managing the epigenome: Current examples of epigenetic-like effects

Milk fresh cows 4X for first 3 weeks of lactation

Cooling cows in late pregnancy

Laporta et al
JDS 101 (Suppl. 2): 151, 2018

Cooling During Dry Period Carryover Effects
(all were cooled beyond granddams)

- Granddaughter 2nd lactation
- Granddaughter 1st lactation
- Daughter 2nd lactation
- Daughter 1st lactation
- Granddams

kg Milk 35 weeks of lactation

- Grandam Cooled
- Grandam Hot
Looking ahead: **Managing the cow’s and farm’s natural Microbiome**

*Microbiomics* – relationships with genomically beneficial microbes that live within animals, plants, soils and in all environments
Looking ahead: Managing the microbiome to benefit crops and cows
What is Canada’s vision for dairy in the future?