2017 Sustainability Lab Project

Presented by:
Rodrigo Errea
Ben Housman
Kyle Hurst

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Contents

• Overview
• Supplier Landscape
• Framework and Analysis
• Recommendations and Next Steps
• Works Cited
• Appendix
Allagash has committed to purchasing 1 million lbs of grains annually from Maine farmers by 2021

• Currently, Allagash purchases ~100,000 lbs of local grains annually, which represents approximately 2% of their total grains purchased
• Grain prices from local Maine farmers are approximately 2-3x higher than prices from farmers in Wisconsin (where Allagash currently purchases ~98% of its grains)
Given our *preliminary* analysis, if Allagash were to purchase an extra 900,000 lbs of Maine grains then the company could create approximately 20 new local jobs and reduce carbon emissions by 55,000 kg of CO2 eq at an additional purchasing cost of $390,000.

### Summary Table

<table>
<thead>
<tr>
<th>Difference (New Supplier Mix minus Business As Usual)</th>
<th>Minimize Costs - Optimal Supplier Mix</th>
<th>Business As Usual(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Impact</td>
<td>Sustainability Impact</td>
<td></td>
</tr>
<tr>
<td>Supply (lbs)</td>
<td>Price ($/lb)</td>
<td>Cost ($/yr)</td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-700,000</td>
<td>$0.00</td>
<td>-$245,000</td>
</tr>
<tr>
<td>700,000</td>
<td>$0.06</td>
<td>$512,656</td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
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<tr>
<td>Midwest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-200,000</td>
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<td>-$60,000</td>
</tr>
<tr>
<td>200,000</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Oats</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>$0.00</td>
<td>$0</td>
</tr>
<tr>
<td>Local</td>
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<td>n/a</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>$0.05</td>
</tr>
</tbody>
</table>

Notes:

1. Business as usual assumes 100,000 lbs of grains are purchased in Maine.
Contents

• Overview
• **Supplier Landscape**
• Framework and Analysis
• Recommendations and Next Steps
• Works Cited
• Appendix
Supplier Landscape

98% of Grain Supply
- Malted Barley: 3.5M lbs
- Wheat: 2.1M lbs
- Oats: 0.35M lbs

2% of Grain Supply
- Malted Barley: 0.07M lbs
- Wheat: 0.007M lbs
- Oats: 0.019M lbs
Capacity Constraints

- Maine’s primary agricultural export is potatoes
  - Shifted from grains in the 20th century
- 1.65M lbs of Barley are produced in Maine annually (as of 2012)
  - The majority of the Barley is used for feedstocks
  - Not malt quality
  - Farmer techniques, inadequate storage facilities, and low demand constrain growth
- Maine only has two malt houses
  - These malt houses are limited to 400,000 lbs of malted grain per year per malt house
  - Maine Malt House is currently working to increase capacity by 500%
- Recent increase in red wheat production for bakeries
  - White wheat is not produced in significant quantities in Maine currently
Contents

• Overview
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• Framework and Analysis
• Recommendations and Next Steps
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Preliminary Data Analysis
We analyzed suppliers cost, labor and emissions data to obtain reasonable inputs for our model.

Optimization Modeling
We built two optimization models using the data to inform Allagash of the optimal grain mix while considering various constraints (local supply requirement, farmer and malting capacities, grain mix, etc.)

Quantifiable Results
We then summarized and quantified the: (1) economic and (2) sustainability implications of increasing local Maine grain supply by 9x in the next five years versus Allagash’s “business as usual” case.
Framework & Analysis
Key Inputs

- **Cost**
  - Grain prices are a key determinant in assessing the economic impact of purchasing local grains
  - Capacity constraints, both production and malting, were also considered and affect the supply available for purchase

- **Local Economy**
  - Jobs created per $ of revenue local farms generate
  - Indirect job multiplier
  - No job loss in Midwest due to industrial farming scale and ability to absorb loss of Allagash business

- **Emissions**
  - Distance between local farms compared to the Midwest
  - Transportation type (i.e. truck or rail), which informed:
    - Freight capacity
    - Fuel efficiency
    - Emissions rate
Why Optimization?

- Optimization is a common analytical tool used to determine the “optimal”, or best, mix of options given various internal rules/targets and external limitations (constraints).
- An optimization model can provide Allagash with the lowest cost (i.e. best) mix of Maine and Midwest suppliers to meet its goal of 1M lbs of local grains.

Other Examples of Optimization Modeling

Finance, Investment Portfolios

Retail, Supply Chain Analytics
Framework & Analysis

Assumptions – Cost and Local Economy

Cost Assumptions

- Grain and transportation prices are constant
- Prices provided by Allagash are accurate
- All dollars are in “today’s” dollars

<table>
<thead>
<tr>
<th>Supply (lbs)</th>
<th>Price ($/lb)</th>
<th>Cost ($/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,950,000</td>
<td>$0.35</td>
<td>$2,082,500</td>
</tr>
<tr>
<td>800,000</td>
<td>$0.72</td>
<td>$579,178</td>
</tr>
<tr>
<td>700,000</td>
<td>$0.30</td>
<td>$210,000</td>
</tr>
<tr>
<td>200,000</td>
<td>$0.90</td>
<td>$180,157</td>
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<td>900,000</td>
<td>$0.30</td>
<td>$270,000</td>
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<tr>
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<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>8,550,000</td>
<td>$0.39</td>
<td>$3,321,834</td>
</tr>
</tbody>
</table>

Local Economy Assumptions

- 50% of revenue contributes to wage expenses
- Average worker salary $12.29
  [See Works Cited 7]
- 2,087 annual work hours/worker
- 1.5 standard job multiplier for indirect job creation
- Job creation in Maine will not impact jobs at Midwest supplier since Allagash is a small customer for them.

Local Economy Impact

<table>
<thead>
<tr>
<th>Jobs creation</th>
<th>(Units)</th>
<th>Local</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wage Expense</td>
<td>(% of Revenue)</td>
<td>[1]</td>
<td>50%</td>
</tr>
<tr>
<td>Average Worker Salary</td>
<td>($/hr)</td>
<td>[2]</td>
<td>$12.29</td>
</tr>
<tr>
<td>Work Hours per Year</td>
<td>(hrs/yr)</td>
<td>[3]</td>
<td>2,087</td>
</tr>
<tr>
<td>Job Multiplier</td>
<td>(Total Jobs/Direct Jobs)</td>
<td>[6]</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Framework & Analysis

Assumptions - Emissions

- Due to supplier process data constraints, all agricultural emissions are assumed the same for commercial and local suppliers [See Works Cited 2, 3, 4, 5, 6]
- Agriculture production per grain assumed industry standard values associated with analogous climates [2]
- Rail fuel efficiency assumed to be 423 short ton-miles per gallon
- Line haul efficiency assumed to be 6.5 miles per gallon
- Diesel fuel emissions assumed to be 22.38 lbs CO2 per gallon
- Red wheat malting process assumed to produce 30% less emissions than barley malting process due to reduced energy requirements associated with red wheat malting processes [1]
- Blue Ox and Maine Malt House assumed to have max annual capacity of 400,000 lbs of malted grain [7]
- Maine Malt House expansion expected to achieve additional production capacity in 2019
Model 1: Minimize total economic costs of purchasing grains while meeting local sourcing targets

**Total Cost of Sourcing: Objective Function**

**Sustainability Impacts**

**Local Sourcing Target**
**Model 2: Minimize sustainability impacts while meeting local sourcing targets**

<table>
<thead>
<tr>
<th>Annual Demand</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Beer Demand</td>
<td>90,000</td>
<td>(barrels)</td>
</tr>
<tr>
<td>Lbs/Barrel</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Pounds</td>
<td>6,750,000</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Lbs</td>
<td>900,000</td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Lbs</td>
<td>900,000</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8,550,000</td>
<td></td>
</tr>
</tbody>
</table>

**Sustainability Issue Caps**

<table>
<thead>
<tr>
<th>Importance</th>
<th>Sustainability Issues</th>
<th>Target Value</th>
<th>Total Value</th>
<th>Relative Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>GW Global Warming (kg CO2 eq)</td>
<td>8,000,000</td>
<td>8,042,980</td>
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<tr>
<td>90%</td>
<td>LE Local Economy (Jobs Impacted)</td>
<td>1</td>
<td>225</td>
<td>225.00</td>
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</tbody>
</table>

**Objective Function**

- Total Cost of Sourcing: $3,527,500
- Sustainability weight
- Sustainability Impacts
- Local Sourcing Target
Each supplier faces capacity constraints and impacts both the environment and the local economy differently.
Both models recommend the best quantity per grain type and per supplier to achieve the firm’s local targets while satisfying its constraints.

<table>
<thead>
<tr>
<th>Detailed Supplier Inputs/Outputs</th>
</tr>
</thead>
</table>

### Barley

<table>
<thead>
<tr>
<th>Name</th>
<th>Category</th>
<th>XI</th>
<th>Price</th>
<th>Cost</th>
<th>Capacity</th>
<th>GW</th>
<th>LE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bliss</td>
<td>Midwest</td>
<td>5,750,000</td>
<td>0.35</td>
<td>$2,012,500</td>
<td>15,000,000</td>
<td>0.99</td>
<td>0</td>
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<tr>
<td>Maine Malhouse (local)</td>
<td>100,000</td>
<td>0.78</td>
<td>$2,534,819</td>
<td>700,000</td>
<td>0.98</td>
<td>0.00023</td>
<td></td>
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<tr>
<td>Blue Ox</td>
<td>local</td>
<td>700,000</td>
<td>0.67</td>
<td>$4,545,650</td>
<td>700,000</td>
<td>0.94</td>
<td>0.00023</td>
</tr>
<tr>
<td>Supplier 4</td>
<td>-</td>
<td>0</td>
<td>10.00</td>
<td>$0</td>
<td>-</td>
<td>0.94</td>
<td>0.00023</td>
</tr>
<tr>
<td>Supplier 5</td>
<td>-</td>
<td>0</td>
<td>0.70</td>
<td>$0</td>
<td>-</td>
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</tr>
<tr>
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<td>-</td>
<td>0</td>
<td>0.57</td>
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<td>-</td>
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<td>0.00023</td>
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<tr>
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<td>0</td>
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<td>$0</td>
<td>-</td>
<td>0.94</td>
<td>0.00023</td>
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<tr>
<td>Supplier 8</td>
<td>-</td>
<td>0</td>
<td>0.98</td>
<td>$0</td>
<td>-</td>
<td>0.94</td>
<td>0.00023</td>
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<tr>
<td>Supplier 9</td>
<td>-</td>
<td>0</td>
<td>0.94</td>
<td>$0</td>
<td>-</td>
<td>0.94</td>
<td>0.00023</td>
</tr>
<tr>
<td>Supplier 10</td>
<td>-</td>
<td>0</td>
<td>0.70</td>
<td>$0</td>
<td>-</td>
<td>0.94</td>
<td>0.00023</td>
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</tbody>
</table>

**Total**

Barley: 6,750,000

<table>
<thead>
<tr>
<th>Midwest Total</th>
<th>XI</th>
<th>Price</th>
<th>Cost</th>
<th>Capacity</th>
<th>GW</th>
</tr>
</thead>
<tbody>
<tr>
<td>6,750,000</td>
<td>$0.40</td>
<td>$2,712,599</td>
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</table>

<table>
<thead>
<tr>
<th>Local Total</th>
<th>XI</th>
<th>Price</th>
<th>Cost</th>
<th>Capacity</th>
<th>GW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000,000</td>
<td>$0.70</td>
<td>$700,000</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

### Red Wheat

<table>
<thead>
<tr>
<th>Name</th>
<th>Category</th>
<th>XI</th>
<th>Price</th>
<th>Cost</th>
<th>Capacity</th>
<th>GW</th>
<th>LE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bliss</td>
<td>Midwest</td>
<td>900,000</td>
<td>0.3</td>
<td>$2,700,000</td>
<td>1,000,000</td>
<td>0.85</td>
<td>0.00023</td>
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<tr>
<td>Maine Malhouse (local)</td>
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<td>0.90</td>
<td>$50</td>
<td>900,000</td>
<td>0.85</td>
<td>0.00023</td>
<td></td>
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<tr>
<td>Supplier 8</td>
<td>-</td>
<td>0</td>
<td>0.75</td>
<td>$50</td>
<td>-</td>
<td>0.85</td>
<td>0.00023</td>
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<td>Supplier 9</td>
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<td>Supplier 10</td>
<td>-</td>
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<td>0.40</td>
<td>$50</td>
<td>-</td>
<td>0.85</td>
<td>0.00023</td>
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<tr>
<td>Supplier 11</td>
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<td>$50</td>
<td>-</td>
<td>0.85</td>
<td>0.00023</td>
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</tbody>
</table>

**Total**

Red Wheat: 900,000

<table>
<thead>
<tr>
<th>Midwest Total</th>
<th>XI</th>
<th>Price</th>
<th>Cost</th>
<th>Capacity</th>
<th>GW</th>
</tr>
</thead>
<tbody>
<tr>
<td>900,000</td>
<td>$0.30</td>
<td>$2,700,000</td>
<td></td>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th>Local Total</th>
<th>XI</th>
<th>Price</th>
<th>Cost</th>
<th>Capacity</th>
<th>GW</th>
</tr>
</thead>
<tbody>
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<td>#DIV/0!</td>
<td>$0</td>
<td>700,000</td>
<td>0</td>
</tr>
</tbody>
</table>

### Oats

<table>
<thead>
<tr>
<th>Name</th>
<th>Category</th>
<th>XI</th>
<th>Price</th>
<th>Cost</th>
<th>Capacity</th>
<th>GW</th>
<th>LE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bliss</td>
<td>Midwest</td>
<td>900,000</td>
<td>0.3</td>
<td>$2,700,000</td>
<td>1,000,000</td>
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<tr>
<td>Aurora Mills (local)</td>
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<td>0.57</td>
<td>0.00023</td>
<td></td>
</tr>
<tr>
<td>Maine Malhouse (local)</td>
<td>0</td>
<td>0.99</td>
<td>$0</td>
<td>-</td>
<td>0.57</td>
<td>0.00023</td>
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<tr>
<td>Supplier 4</td>
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<td>0.80</td>
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<td>0.00023</td>
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<tr>
<td>Supplier 5</td>
<td>-</td>
<td>0</td>
<td>0.77</td>
<td>$0</td>
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<td>0.00023</td>
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<tr>
<td>Supplier 6</td>
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<td>-</td>
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<td>Supplier 10</td>
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<td>0</td>
<td>0.76</td>
<td>$0</td>
<td>-</td>
<td>0.57</td>
<td>0.00023</td>
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</table>

**Total**

Oats: 900,000

<table>
<thead>
<tr>
<th>Midwest Total</th>
<th>XI</th>
<th>Price</th>
<th>Cost</th>
<th>Capacity</th>
<th>GW</th>
</tr>
</thead>
<tbody>
<tr>
<td>900,000</td>
<td>$0.30</td>
<td>$2,700,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Local Total</th>
<th>XI</th>
<th>Price</th>
<th>Cost</th>
<th>Capacity</th>
<th>GW</th>
</tr>
</thead>
<tbody>
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<td>#DIV/0!</td>
<td>$0</td>
<td>700,000</td>
<td>0</td>
</tr>
</tbody>
</table>
Contents

• Overview
• Supplier Landscape
• Framework and Analysis
• **Recommendations and Next Steps**
• Works Cited
• Appendix
Recommendations

Ultimately, Allagash’s decision about investing in local grains boils down to the company’s values. The 1M lb local grain initiative will cost about $390,000 more than if Allagash were to purchase those grains from the Midwest; however, we estimate that it will create approximately 20 more local jobs and ~55,000 fewer kg of carbon emissions.

One consideration that fell beyond the scope of our research but is worth evaluating is the potential branding effect of purchasing more local grains, which could generate positive marketing and reception from consumers as Allagash positions itself as a more sustainable craft brewery. This branding could potentially increase revenues, thereby offsetting the higher cost
Roadmap – Most Economical

55 tons CO2 emissions mitigated

Assuming no capacity change for each supplier

Increased material cost of $390,000

Maximizes malted barley purchase from Maine malting facilities

$7,100 / ton CO2 mitigated

Roadmap to 1M lbs of Local Grains (Most Economical Strategy)
Roadmap – Most Sustainable

126 tons CO2 emissions mitigated

Assuming no capacity change for each supplier

Increased material cost of $675,000

Maximizes rolled oat purchase from local suppliers

$5,500 / ton CO2 mitigated

Roadmap to 1M lbs of Local Grains (Most Sustainable Strategy)
Future Work

Upstream Supply Chain Optimization

• Coordinate with Suppliers to:
  • Discuss efficient GHG tilling practices
  • Share grain knowledge
  • Discuss operational sustainability practices

• Facilitate Grain Storage Cooperative
  • Discuss investment into grain storage
  • Enter risk sharing contracts to incentivize capacity investment
  • Communicate with suppliers to facilitate planned crop expansion of specific grain strains

Downstream Supply Chain Optimization

• Examine packaging to:
  • Reduce carton footprint
  • Maximize use of recycled bottles

GHG emissions by percentage of total emissions. Courtesy of The Carbon Footprint of Fat Tire Amber Ale, 2008
Future Work – Supply/Demand Dynamics

- As Allagash starts demanding more local grains, the production will increase and the learning curve will help costs and prices go down.
- However, it will also increase the value of land cultivation, which might ultimately increase costs.
- Finally, as production goes up in response to higher demand, the imbalance of Supply and Demand will also increase, thus increasing the prices to find a new equilibrium.
- Allagash should consider all the feedback loops in the system and look for ways to make the reinforcing loop the dominant one.
PASSION

LOVING BEER AND DOING WHAT WE LOVE.
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• Framework and Analysis
• Recommendations and Next Steps
• Works Cited
• Appendix
Works Cited


Contents

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• Supplier Landscape
• Framework and Analysis
• Recommendations and Next Steps
• Works Cited

• Appendix
Effects of 100% Regional Sourcing

Barley emissions reduced by 5%

Red Wheat emissions reduced by 9%

Rolled Oat emissions reduced by 18%

276 tons CO2 emissions potentially mitigated
Barley Footprint Analysis (Briess)

System Boundary

Barley Production

- Water
- Fertilizers
- Pesticides
- Field Operations
- Grain Drying

Malting Process

- Water
- Natural Gas
- Electricity

572,400 kgCO₂

Transportation

- Rail 1100 mi
- Line Haul 423 mi

45,294 kgCO₂

18,623 kgCO₂

To Allagash

GHG (fossil fuels)
GHG (fertilizers)
GHG (soil emissions)
eGHG (pesticides)
Barley Footprint Analysis (Local)

System Boundary

Barley Production
- Water
- Fertilizers
- Pesticides
- Field Operations
- Grain Drying

Malting Process
- Water
- Natural Gas
- Electricity

Transportation
- Line Haul 33 mi

To Allagash

GHG (fossil fuels)
GHG (fertilizers)
GHG (soil emissions)
eGHG (pesticides)

572,400 kg CO₂
3,615 kg CO₂
Red Wheat Footprint Analysis (Briess)
Red Wheat Footprint Analysis (Local)

System Boundary

- Red Wheat Production
  - Water
  - Fertilizers
  - Pesticides
  - Field Operations
  - Grain Drying
  - GHG (fossil fuels)
  - GHG (fertilizers)
  - GHG (soil emissions)
  - eGHG (pesticides)

Malting Process
- Water
- Natural Gas
- Electricity
- 103,548 kgCO₂
- GHG

Transportation
- Line Haul 33 mi
- 929 kgCO₂
- GHG

To Allagash
Rolled Oats Footprint Analysis (Briess)

- **System Boundary**
- **Rolled Oats Production**
  - Water
  - Fertilizers
  - Pesticides
  - Field Operations
  - Grain Drying

- **Transportation**
  - Line Haul 1250 mi
  - 21,467 kgCO₂

- **GHG**
  - GHG (fossil fuels)
  - GHG (fertilizers)
  - GHG (soil emissions)
  - eGHG (pesticides)

To Allagash
Rolled Oats Footprint Analysis (Local)

System Boundary

Rolled Oats Production
- Water
- Fertilizers
- Pesticides
- Field Operations
- Grain Drying

Transportation
- Line Haul 33 mi
- 568 kgCO₂
- GHG

To Allagash

GHG (fossil fuels)
GHG (fertilizers)
GHG (soil emissions)
eGHG (pesticides)