Straw Manufacturing in Alberta

Alberta

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Straw in Alberta

After grain harvesting, crop residues are often left on the field. However, in some cases crop residue is used for bedding, insulation, livestock feed, and mulching. In the prairie provinces, a large amount of straw is baled as feed and bedding for dairy and beef cattle. [1]

'Surplus straw' is the straw that is available after livestock requirements and soil conservation needs have been met[2]. In many cases, the amount of straw a producer is willing to remove and sell to an industrial supplier is associated with that particular producer's perceived value of straw.[2]

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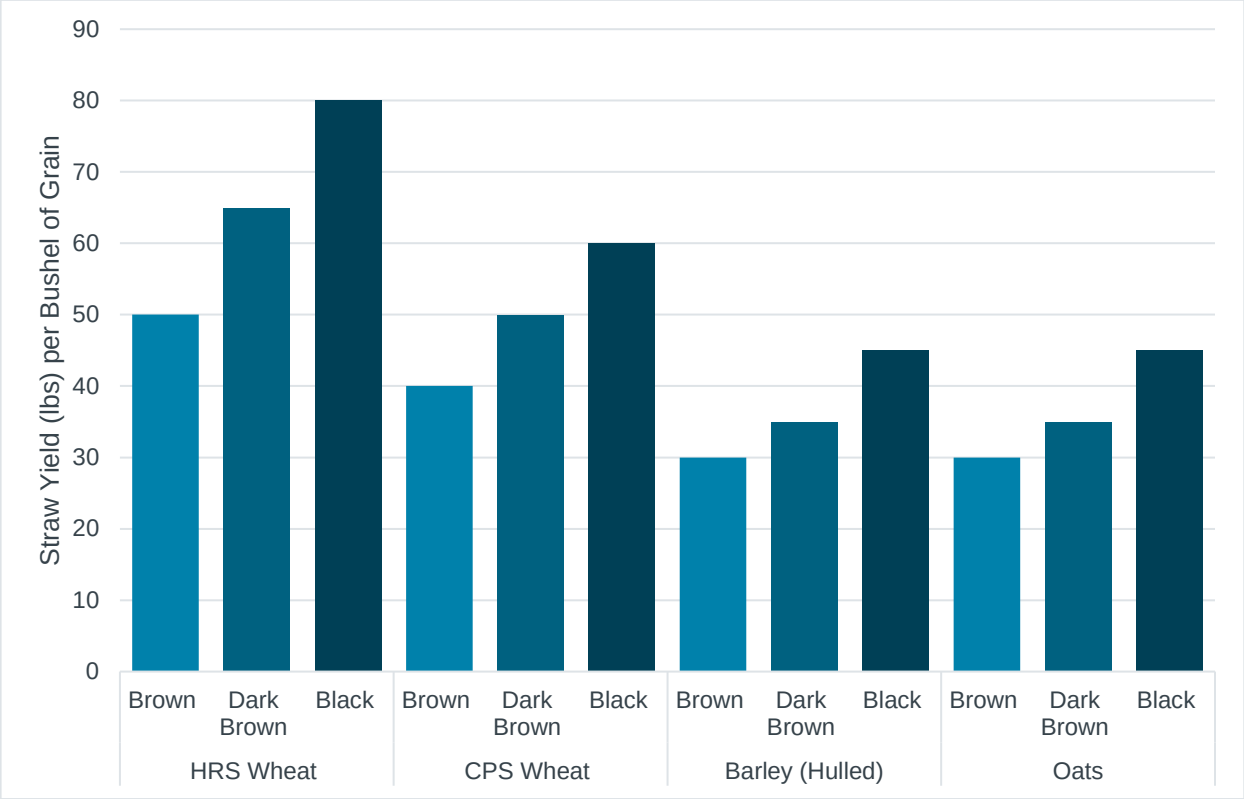
Straw Yield

According to Alberta Agriculture, Food and Rural Development's report, *Increasing Cow/Calf Profitability using Chaff and Chaff/Straw Feedstuffs*, the average pounds of straw per bushel of grain is depends on the type of grain that is grown. [3] Figure 1 shows the pounds of straw per bushel of grain also depends on soil type (i.e. brown, dark brown, or black). In Alberta, regardless of the grain, straw yields are expected to be highest on black soil. Furthermore, wheat is expected to have the highest straw yield per bushel of grain followed by barley (hulled) and then oats.

[1] Sokhansanj et al. (2006). Production and distribution of cereal straw on the Canadian prairies
[2] CIS. 2004. Alberta straw availability survey. Final report for Alberta Agriculture, Food, and Rural Development. Prepared by the Customs Information Systems Research Center, Edmonton AB.
[3] Alberta Agriculture, Food and Rural Development, *Increasing Cow/Calf Profitability using Chaff and Chaff/Straw Feedstuffs*

Figure 1. Straw Yield per Bushel of Grain, by Soil Zone



Source: Alberta Agriculture, Food and Rural Development, *Increasing Cow/Calf Profitability using Chaff and Chaff/Straw Feedstuffs*

Figure 2 displays the estimated grain production in Alberta between 2012 and 2019. Straw production estimates are then generated from data found in the publication *Increasing Cow/Calf Profitability using Chaff and Chaff/Straw Feedstuffs.* Grain yield data was taken from Statistics Canada's Small Data Area Regions. Data specific to smaller regions was required as straw yield is highly dependent on soil type. For this analysis, it is assumed that Census Divisions 3, 4A, 4B, and 5 are composed mostly of black soils, Census Divisions 2 is composed mostly of dark brown soils, and Census Division 1 is composed mostly of brown soils. A map of the soil zones in Alberta and a map of Alberta's Census Divisions is shown in Appendix A with Figure A and Figure B.

As shown in Figure 2, wheat production is the highest among the grains, followed by barley and then oats. However, on an average bushel per acre basis, oats typically has the highest yield followed by barley and then wheat. Therefore, it may be assumed that the high production of wheat is due to the crop's relatively large seeded acreage.

Furthermore, production is highest for grains grown on black soil. Regardless of soil type, oats typically has the highest bushel per acre yield, followed by barley and then wheat.

Figure 2. Estimated Production (x 1000) and Average Bushel per Acre of Barley, Oats, and Wheat, 2014-2018

Average Bushel per Acre, by Soil Type, 2014-2018

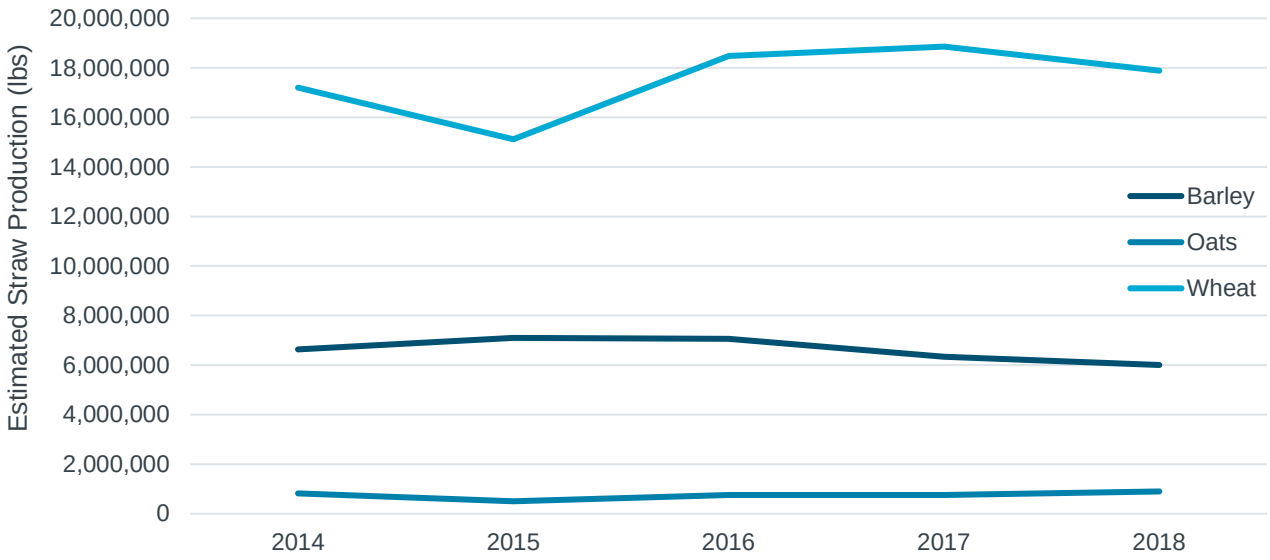
	2014	2015	2016	2017	2018
Black Soil					
Wheat	56	50	61	58	53
Barley	67	69	78	75	70
Oats	80	81	95	94	86
Dark Brown Soil					
Wheat	51	47	57	53	47
Barley	66	70	74	71	57
Oats	53	45	71	33	82
Brown Soil					
Wheat	44	31	51	34	35
Barley	57	47	66	45	45
Oats	53	45	71	33	82

Source: Statistics Canada. Table 32-10-0002-01, Estimated areas, yield and production of principal field crops by Small Area Data Regions, in metric and imperial units (x 1,000)

Note: Black Soil includes Census Divisions 3, 4A, 4B, and 5; Dark Brown includes Census Division 2; Brown includes Census Division 1

Figure 3 provides estimated straw production for barley, oats, and wheat based grain yield and accounting for the difference in seeded area of each crop. As shown, the estimated straw production in Alberta is highest for wheat, followed by barley and oats.

Figure 3. Estimated Straw Production (x 1000), 2014-2018



Estimated Straw Production in Pounds (x 1000), by Grain Type, 2014-2018

	2014	2015	2016	2017	2018
Wheat	17,198,000	15,116,250	18,485,000	18,858,000	17,890,403
Barley	6,628,065	7,098,015	7,055,510	6,336,470	6,003,925
Oats	822,485	502,075	753,545	751,345	898,390

Source: Statistics Canada. Table 32-10-0002-01, Estimated areas, yield and production of principal field crops by Small Area Data Regions, in metric and imperial units (x 1,000); Alberta Agriculture, Food and Rural Development, *Increasing Cow/Calf Profitability using Chaff and Chaff/Straw Feedstuffs*

Note: Black Soil includes Census Divisions 3, 4A, 4B, and 5; Dark Brown includes Census Division 2; Brown includes Census Division 1

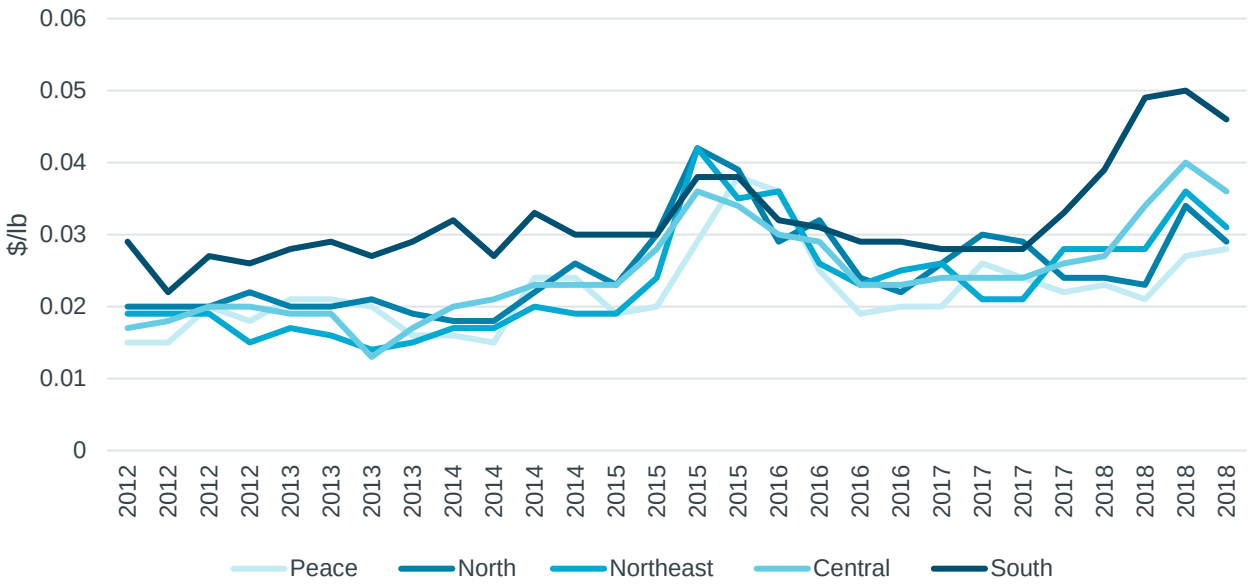
Pricing

Figure 4 depicts the trend in straw pricing ($/lb.) between 2012 and 2018. Data from the Agriculture Financial Services Corporation (AFSC) suggests that the price of straw differs across Alberta. [4] Furthermore, the data suggests that producers in Southern Alberta tend to receive a

[4] AFSC Commodity Pricing

higher price for straw – with the exception of 2015. Straw prices peaked in 2015 and this may be associated with lower yields – as shown in Figure 3.

Figure 4. Straw Price in Alberta, 2012-2018



Straw Price, by Region, 2012-2018 ($/lb)

	Peace	North	Northeast	Central	South
2012	$ 0.017	$ 0.021	$ 0.018	$ 0.019	$ 0.026
2013	$ 0.020	$ 0.020	$ 0.016	$ 0.017	$ 0.028
2014	$ 0.020	$ 0.021	$ 0.018	$ 0.022	$ 0.031
2015	$ 0.027	$ 0.034	$ 0.030	$ 0.030	$ 0.034
2016	$ 0.025	$ 0.027	$ 0.028	$ 0.026	$ 0.030
2017	$ 0.023	$ 0.027	$ 0.024	$ 0.025	$ 0.029
2018	$ 0.025	$ 0.028	$ 0.031	$ 0.034	$ 0.046

Source: AFSC Commodity Prices

Baling

Figures 5 and 6 describe the advantages and disadvantages to producers in retaining or removing straw.

Figure 5. Advantages and Disadvantages of Retaining Straw[5]

Advantages of Retaining Straw	Disadvantages of Retaining Straw
Addition of organic matter to soil – may help improve structure	Extra fuel required to chop straw
Returns nutrients to the soil	Extra operation to spread straw
Potential to reduce nitrate loss	Potential to increase disease problems
No structural damage to soil due to baling and carting straw in wet conditions	Competition with crop for available nitrogen in the spring
No delay from baling and carting	Possible incorporation difficulties with some soil types
Lower labour equipment required (unless baling and carting done by contractor)	No additional direct income

Figure 6. Advantages and Disadvantages to Removing and Selling Straw[5]

Advantages of Removing and Selling Straw	Disadvantages of Removing and Selling Straw
Income from sale of straw	Cost of baling and hauling straw, unless purchased by contractor or buyer
Potentially easier and faster establishment of crop	Significant nutrient removal from the soil
Possibly fewer disease problems	Possible structural damage if soils are wet during baling and hauling
	Income from sale of straw may not cover cost of operations and nutrients that are removed

[5]Weir. (2015). Factors to weigh when debating whether to bale straw. *The Western Producer.*

Producing Straw: Other Factors

Baling straw is different from baling hay. It is a common practice for balers to follow the combine as the grain is harvested. The costs associated with baling straw do not include mowing, raking, or tedding. However, there are costs associated with handling bales in the field, transporting bales to market, and the potential value of nutrients lost due to removing straw from the field.[6]

According to data from the 2011 *Census of Agriculture*, a total of 22,557 farms in Alberta reported having a baler and 30,697 balers were reported in total. A total of 43,234 farms were included in the farm capital reports for the 2011 *Census of Agriculture*, therefore it may indicate that only 50 percent of farms engage in some sort of baling activity. **Estimates on the percent of straw that is baled versus the percent that is chopped and left in the field is not readily available**. As such, it may be assumed that the percentage baled in any given year depends on market conditions and straw yield that is specific to a particular crop.

Alberta Agriculture and Forestry's report titled *Custom Rate Survey 2017* may be used to estimate what producers are being charged to bale straw. Table 1 describes the costs associated with baling hay – which may serve as an estimate cost for baling straw. Taking the midpoint of the most common price in 2016, the costs associated with baling a small square is around $0.78/bale, a large square is about $14.50/bale, and a large round is approximately $12.88/bale.

Table 1. Cost of Baling Straw

Bale Type	Region	Most Common in 2015	Most Common in 2016
Baling – small square	Alberta	$0.55-1/bale	$0.55-1/bale
Baling – large square	Alberta	$11-18/bale	$11-18/bale
Baling – large round	South	$12-15/bale	$12-15/bale
	Central	$11-16/bale	$11-16/bale
	North	$10-12/bale	$10-13/bale
	Peace	$13/bale*	$13/bale*

Source: *Custom Rate Survey 2017,* Alberta Agriculture and Forestry

*Indicates one report received

Table 2 describes the costs that the *Custom Rate Survey 2017* associates with stacking and hauling different bale types. Taking the midpoint of the most common price in 2016, a small

[6] Shockley, J. (2018). Economics of Baling Wheat Straw. KYGrains.

square costs approximately $0.78/bale and a large round or large square is estimated to cost approximately $3.75/bale. Straw bales are often stacked on the field instead of being taken to the producer's yard before it is shipped to a buyer. Producers with cattle sometimes haul straw bales from the field to the home yard or will stack the bales near a winter feed lot.

Table 2. Cost of Field Hauling and Stacking Straw

Bale Type	Region	Most Common in 2015	Most Common in 2016
Stacking & hauling - small square	Alberta	$0.55-1/bale	$0.55-1/bale
Stacking & hauling - large round & large square	Alberta	$2.50-5/bale	$2.50-5/bale

Source: *Custom Rate Survey 2017,* Alberta Agriculture and Forestry

Nutrient Value

Straw offers nutrients and minerals to crop land. Therefore, a producer may want to estimate the nutrient value of straw before they decide whether to sell it. If chemical fertilizer prices are high, a producer may be more reluctant to sell straw. Using data from Agriculture and Forestry's *2019 Cropping Alternatives Report.* An estimate is provided for nutrient values of wheat, barley, and oat straw based on a combination of fall 2018 "pre-purchase" fertilizer prices, which provide a reasonable cost indication for spring 2019. These calculations are described in Appendix B with Table A and Table B. When evaluating the nutrient value of straw for a 2,000 lb. bale, oat straw has the highest estimated nutrient value ($27.24), followed by barley straw ($24.12) and then wheat straw ($21.58).

It should be noted that the main cause of variation in the nutrient value of straw samples appears to be attributed to climatic factors. As such, straw should be baled as quickly as possible after harvest to hedge against the negative effects of weathering.

Cost of Baling, Stacking, and the Nutrient Value of Straw

By taking into account the various costs associated with straw production, a fuller estimate of total cost relative to its value may be calculated by summing the cost of baling, cost of stacking and field hauling. Then add on the material's estimated nutrient value. Table 4 shows that estimated straw "value" depends, to a large extent, on bale size and straw type.

Table 4. Estimated Costs of Baling, Stacking, and the Nutrient Value of Straw

Bale Size	40lb small square	1,000lb large square	1,000lb large round
Wheat Straw	$1.99/bale	$29.04/bale	$27.42/bale
Barley Straw	$2.04/bale	$30.31/bale	$25.69/bale
Oat Straw	$2.10/bale	$31.87/bale	$30.25/bale

Source: *Custom Rate Survey 2017,* Alberta Agriculture and Forestry

The price of straw in any given year is determined by supply and demand. Although various costs may be estimated, the extent to which differences in value between types of straw actually occur is influenced by the market. For instance, in a year with widespread drought conditions, transactions at values higher than these calculations may occur. Some articles on straw valuation suggest that non-nutrient value (organic matter) may be equal to the nutrients itself. This study does not attempt to factor in any value for organic matter, only the material's nutrient value is taken into consideration as it breaks down in the soil over time. Ultimately, the decision to bale often comes down to whether or not the volume of straw on a particular field is likely to cause problems for seeding, germination or crop growth in the following year.

Road Hauling

An additional consideration is the cost of hauling straw bales to the production facility. It is important to consider road hauling charges as this associated cost is significant. It may be beneficial for a large purchaser of straw to locate in area where straw production is high. A survey of industry experts revealed that most bale hauling companies charge hourly when hauling over shorter distances. On average, a hauling company may charge $150 per hour for the loading, unloading, and hauling of 44 large bales. The loading and unloading process takes approximately two hours – effectively this approaches $300 per load or $6.81 per bale. Transporting bales within a 50 kilometer radius would take approximately 45 minutes, which would be approximately $112.50 per load or $2.56 per bale. In total, the approximate cost of loading, unloading, and hauling 44 bales of straw 50 kilometers would cost about $412.50 per load or $9.38 per bale. The

cost of loading, unloading, and hauling straw to a production facility is most likely paid for by the purchaser of the straw. Therefore, this is a cost that should be considered carefully when a production facility uses straw as a primary input for production.

MDF Manufacturing

Medium Density Fiberboard (MDF) is traditionally wood-based. Therefore, industry information on wood-based MDF products may help provide insight into the market for straw-based MDF. Figure 7 describes the Producer Price Index (PPI), or the average change over time in the selling prices received by domestic producers for their output. As shown, the PPI for wood-based MDF has increased steadily over time and has even done considerably well during recession years in the United States.

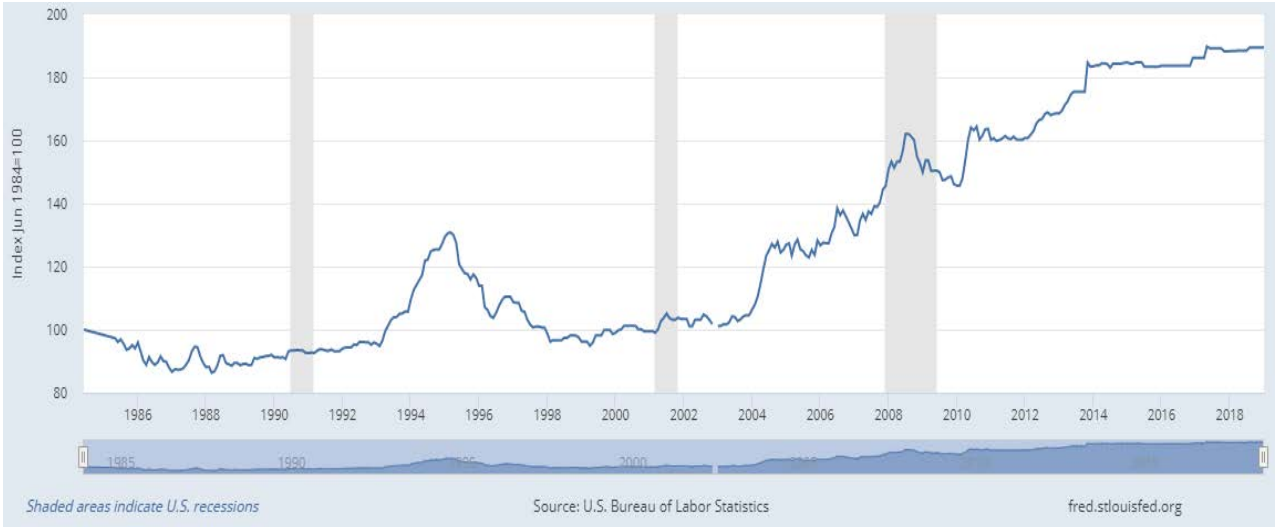
What is the difference between fiberboard and particleboard? [8]

Conventional Fiberboard: wood-based composite board pressed under high temperature and pressure with a resin binder

Particleboard: generic term for a composite panel composed of cellulosic particles (i.e., fiber pieces) and a binder

Medium Density Fiberboard (MDF): composite panel product composed primarily cellulosic fibers and resin

Figure 7. Producer Price Index by Industry: Reconstituted Wood Product Manufacturing: MDF made from MDF Produced at the Same Location



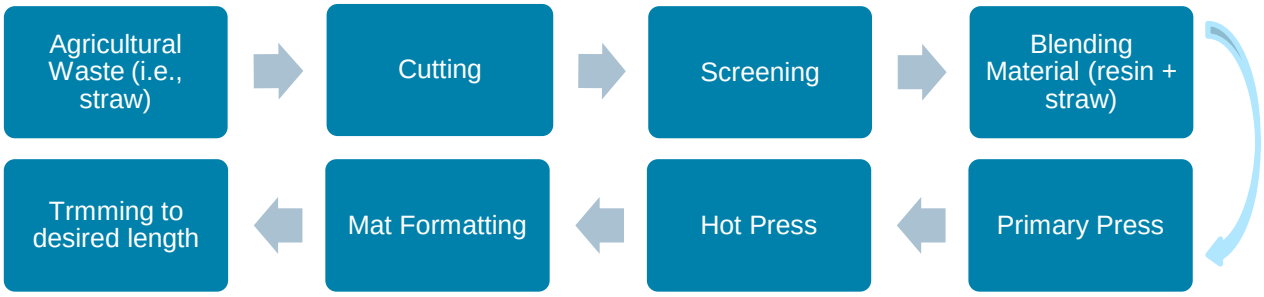
Source: Federal Reserve Bank of St. Louis; U.S. Bureau of Labor Statistics

Straw Manufacturing Industry

Regardless of the material being used, the demand for particleboard and fiberboard for consumers and for construction applications has increased. This may be attributed to economic factors and other desirable properties such as dimensional stability and strength that these products hold. [7] Demand for a product that uses a wood alternatives such as straw will depend on the level of market acceptance that can be reached and on the price point that can be achieved for the final product in a particular market.

Figure 8 describes the process by which particleboard is manufactured. Many manufacturers begin by bringing bales into the plant and to break them apart. From there, the straw is chopped into long strips and debris (i.e., dirt, rocks, etc.) are removed. The straw is dried and then converted into fibers. Often, finer fibers are used for the surface of the board while the coarser fibers are used for the core. A polyurethane resin, methyl di-isocyanate (MDI), is added to the mixture of straw and the mixture is pressed into mats. The mats are then lightly sanded and then cut to size

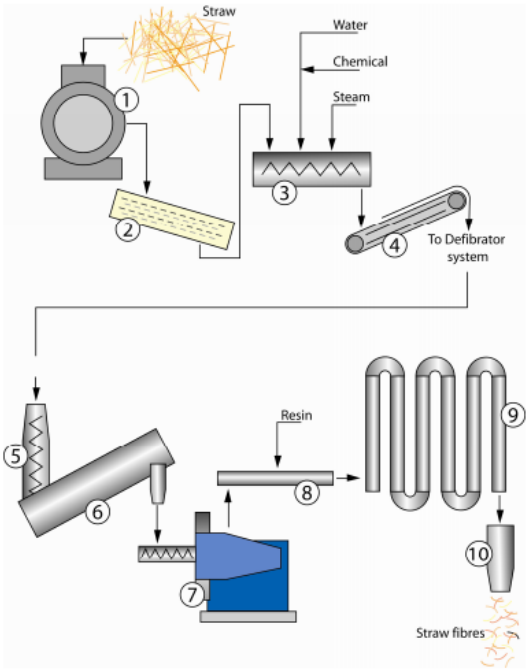
Figure 8. Particleboard Manufacturing Process[8]



For wood-based products, lumber is debarked, chipped, screened, and washed before a defibreation process. On the other hand, the preparation of straw-based products begins directly after harvest as straw must be dried and then either stored loose or in bales. As such, there are unique challenges to straw production that include storing large quantities in dry conditions. Figure 9 describes how straw is prepared for MDF production: (1) hammer mill, (2) dry screen, (3) pre-treatment screw, (4) conveyer, (5) infeed screw, (6) pre-heater (digester), (7) defibrator (refiner), (8) blowline, (9) dryer, and (10) fiber outlet (cyclone).

[7] Sitz, E. (2016). Processing And Manufacture Of Soybean And Wheat Straw Medium Density Fiberboard Utilizing Epoxidized Sucrose Soyate Resin
[8] Hussein, Zakia, et al. "Rice Straw and Flax Fiber Particleboards as a Product of Agricultural Waste: An Evaluation of Technical Properties." Applied Sciences 9.18 (2019): 3878.

Figure 9. Straw Fiber Preparation[9]



Source: Halvarsson, S. Manufacture of Straw MDF and Fibreboards[9]

Cost of Production for MDF

A cost profile for this industry is not readily available. However, there are many costs that must be considered when producing strawboard. One major cost that must be considered is resin – or the bonding/adhesive agent.

Research shows that the generation of fines must be considered when producing fibers from hammer milling. Fines are generated from milling and are small particles that have been reduced to a particular size.[8] Milling tools can become worn from fines and a screening processes is necessary in order to remove larger fibers.[9] Research on wheat straw has concluded that high levels of silica and ash can cause wear on tools.[9]

[9] S. Halvarsson, H. Edlund and M. Norgren, "Wheat straw as raw material for manufacture of medium density fiberboard (MDF)," BioResources, vol. 5, no. 2, pp. 1215-1231, 2010.

Conclusion

Straw is often thought of as a residual by-product of grain harvesting. Straw is typically used as bedding material for livestock or even as feed in certain situations. It may also be baled and sold to the market for a number or reasons, including for MDF manufacturing.

Many farmers value retaining the nutrients for crop production and will simply let the combine chop and spread the straw on the field. Producers consider various factors when making a determination on whether straw should be sold or used within their own operations. The decision depends on market conditions (i.e., straw price and availability) but also on the costs associated with baling, stacking, hauling, as well as the estimated nutrient value of the straw.

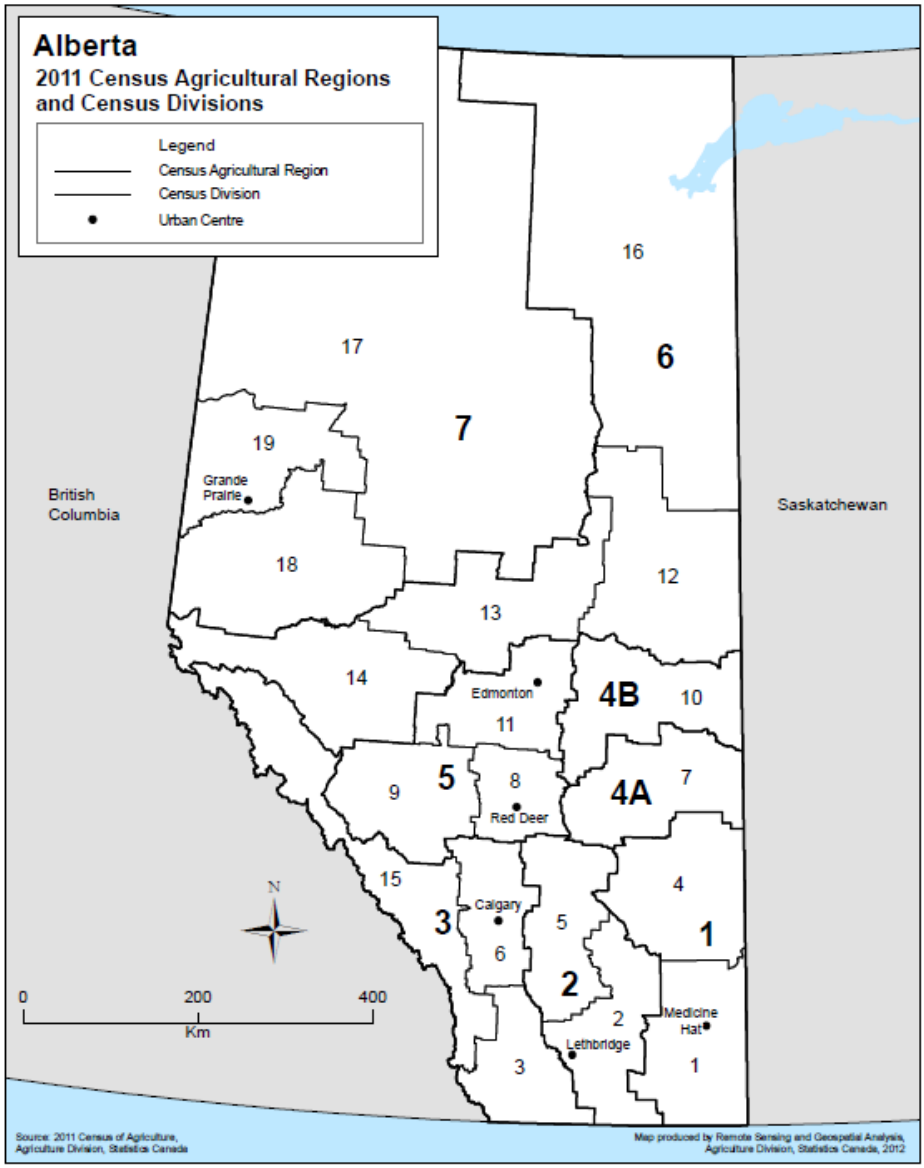
There is plenty of straw generated in Alberta each year. However, some grain farms do not own a baler, or they may need to invest in a newer model or perhaps seek out the services of a custom operator, if they want to get into the business of selling straw.

Securing a reliable supply will come down to offering a price that is attractive to producers. It might also require the purchaser to enter into contracts with farmers to avoid potential problems with variable production volumes of baled straw from year-to-year.

Appendix

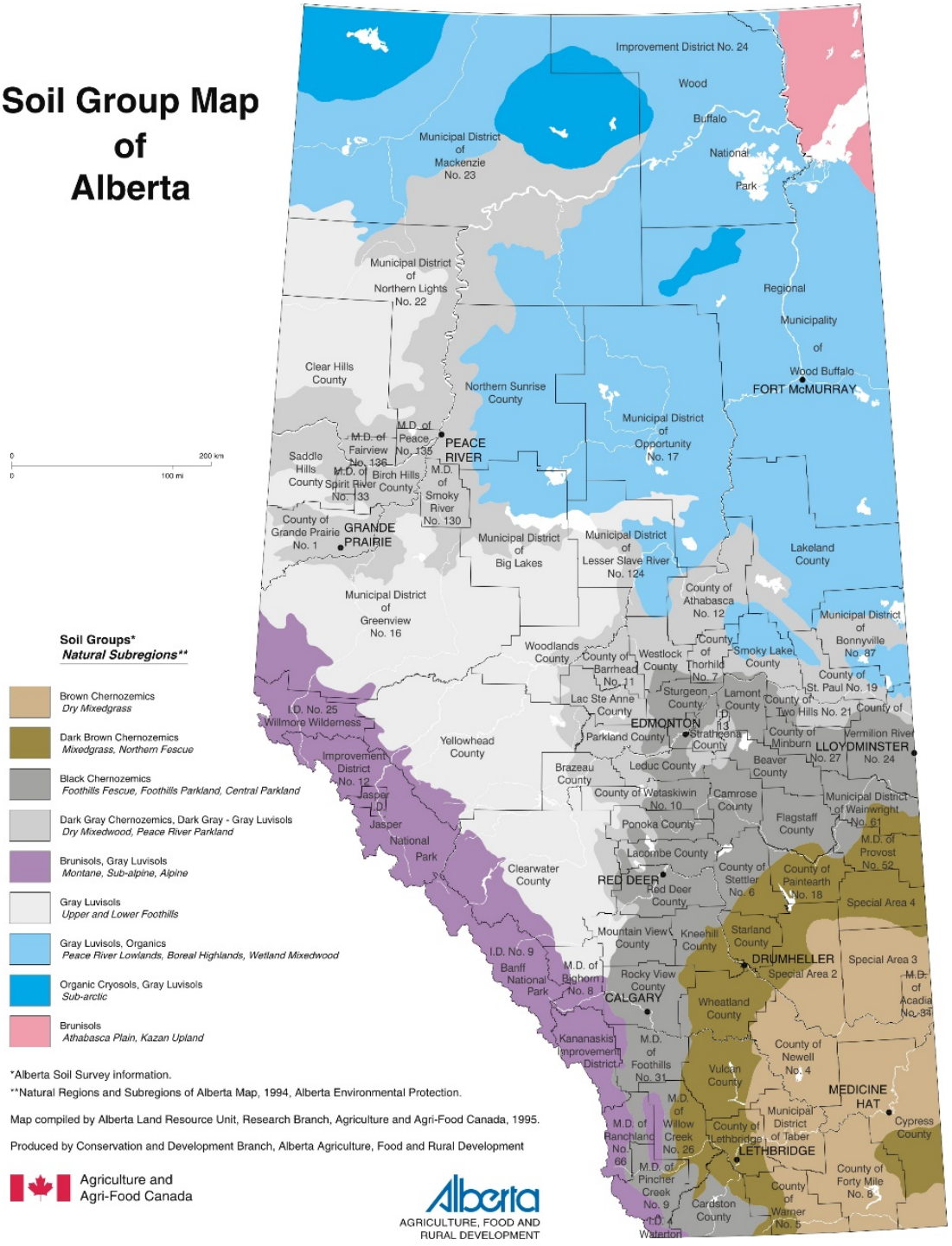
Appendix A. Soil Area and Small Data Area Regions Maps

Figure A. 2011 Census Agricultural Regions and Census Divisions



Source: 2011 Census of Agriculture, Agriculture Division, Statistics Canada

Figure B. Soil Group Map of Alberta



Source: Alberta Land Resource Unit, Research Branch, Agriculture and Agri-Food Canada

Appendix B. Calculating the Nutrient Value of Wheat, Barley, and Oat Straw

Table A. Average Nutrient Content of Straw* (not including chaff or pick-up)

Crop Type	Wheat	Barley	Oat
Moisture (%)	11.3	10.7	10.4
Crude Protein (%)	4.8	4.8	4.9
Nitrogen (%)	0.77	0.77	0.78
Phosphorous (%)	0.08	0.08	0.09
Potassium (%)	1.03	1.3	1.6
Sulphur (%)	0.14	0.14	0.16
Calcium (%)	0.21	0.31	0.29

Source: Alberta Agriculture and Forestry

Table B. Average Fertilizer Prices

Fertilizer	$/tonne	N/lb	P_2O_5/lb	K_2O/lb	S/lb
46-0-0	560.00	0.55	x	x	x
11-51-0	760.00	x	0.56	x	x
0-0-60	510.00	x	x	0.39	x
20-0-0-24	515.00	x	x	x	0.51

Source: *2019 Cropping Alternatives*, Alberta Agriculture and Forestry

Calculations A: Calculating the Nutrient Value of Wheat, Barley, and Oat Straw

WHEAT STRAW		**Value/ton**
Nitrogen	2000 lb. @ .77% = 15.4 lb. @ $.55/lb. =	$ 8.47
Phosphorus	2000 lb. @ .08% = 1.6 lb. P X 2.29 = 3.66 lb. P_2O_5 @ $.56/lb.=	$ 2.05
Potassium	2000 lb. @ 1.03% = 20.6 lb. K X 1.2 = 24.7 lb. K_2O @ $ .39/lb. =	$ 9.63
Sulphur	2000 lb. @ .14% = 2.8 lb. S @ $.51/lb. =	$ 1.43
Total of nutrients evaluated		**$21.58**

BARLEY STRAW		**Value/ton**
Nitrogen	2000 lb. @ .77% = 15.4 lb. @ $.55/lb. =	$ 8.47
Phosphorus	2000 lb. @ .08% = 1.6 lb. P X 2.29 = 3.66 lb. P_2O_5 @ $.56/lb.=	$ 2.05
Potassium	2000 lb. @ 1.3% = 26 lb. K X 1.2 = 31.2 lb. K_2O @ $ .39/lb. =	$ 12.17
Sulphur	2000 lb. @ .14% = 2.8 lb. S @ $.51/lb. =	$ 1.43
Total of nutrients evaluated		**$24.12**

OAT STRAW		**Value/ton**
Nitrogen	2000 lb. @ .78% = 15.6 lb. @ $.55/lb. =	$ 8.58
Phosphorus	2000 lb. @ 0.11% = 2.2 lb. P X 2.29 = 3.66 lb. P_2O_5 @ $.56/lb.=	$ 2.05
Potassium	2000 lb. @ 1.6% = 32 lb. K X 1.2 = 38.4 lb. K_2O @ $ .39/lb. =	$ 14.98
Sulphur	2000 lb. @ .16% = 3.2 lb. S @ $.51/lb. =	$ 1.63
Total of nutrients evaluated		**$27.24**