Alternative Fuel Production and Distribution from Woody Biomass in the Inland Northwest: A Profit Analysis

1 Introduction

Alternative sources of fuel have received much attention recently, particularly with the advent of the Renewable Fuel Standard and concerns over climate change. One relatively new source of fuel is created from slash, which is the "leftover" woody biomass and historically not marketable. In the heavily-forested region of northern Idaho, north-eastern Washington, and western Montana region, these slash piles are burned, releasing both carbon and pollution into the air. A process known as pyrolysis can convert these slash piles into fuel for either automobiles or airplanes. An alternative solution to the problem of leftover biomass involves converting slash into wood pellets, a proven technology, which can be burned to create electricity, a growing market in China as the country attempts to find alternatives to coal. Since pyrolosis generally utilizes pellets in order to convert biomass into fuel, these pellets can be considered both an intermediate and final good. While the technology to create fuel from biomass has been in existence since the days of Henry Ford, whose Model T was designed to run on hemp-derived biofuel (Biofuel, 2015), many studies have found them to be generally unprofitable (Sorensen, 2010; Polagye, 2005). These studies involved the production of a type of natural gas from woody biomass. However, a new technological development includes the development of "drop-in" biofuel and bioaviation fuel, which can be mixed directly with conventional gasoline and aviation fuel.

In this study, we analyze the profitability of converting woody biomass into energy sources over a range of prices for biofuel, bioaviation fuel, and wood pellets. We consider three scenarios, with production occuring in the Inland Northwest region plus parts of Montana. In the first two scenarios, biofuel and bioaviation fuel is used locally or regionally. In the third scenario, wood pellets are shipped to China.

$$\max \sum_{r=1}^{20} P_r^p * Q_r^{s,p} - \sum_{r=1}^{20} VC * Q_r^{s,p} - \sum_{r=1}^{20} FC \tag{8}$$

where superscript p equals pellets. The production capacity now equals

$$Q_r^{s,p} \leq 285,000.$$

These optimization problems were solved utilizing the nonlinear approach in the GAMS software.

4 Data and Calibration

This section describes the data used in the objective functions and constraints. Unless stated otherwise, data on costs and biomass availability come from Jacobsen et al. (2015) as well as discussions with Jacobsen.

For TBM, logging locations were selected from the area surrounding each plant location. Using Arc GIS and Python, all quantities of biomass available in the region were mapped. For each scenario, the programs found the necessary logging region required for every plant location to reach the plant capacity in each scenario. The area required varied greatly by location and scenario. For instance, a relatively small region was selected around Sandpoint in the biofuel scenario as the area is heavily forested and the biofuel scenario only required 200,000 tons of biomass. For Laurel, even the biofuel scenario required a relatively large area. For the bioaviation scenario, a much larger area was required around Sandpoint to reach the 800,000 ton capacity of the bioaviation plant. The pellet scenario, which uses a maximum of 300,000 tons of biomass, required an area between the size of the biofuel and bioaviation fuel scenario.

From equation 1 for biofuel, prices were obtained from GasBuddy.com, a site that obtains gasoline price information directly from consumers on a daily basis. Due to the volatility of gas prices, we considered a range of prices at each location. Since gas prices at the time of collection were low compared to prices over the previous years, these prices are treated as the lower bound of prices. At each location, the price ranges from its upper bound with fifteen increments of $0.20 each to an lower bound, which is $3.00 lower than the lower bound. For locations with numerous gas stations (i.e., Spokane), the median price was selected. In addition, state and federal taxes (Washington, $0.559 per gallon, Idaho, $0.434 per gallon and Montana, $0.462) and the retail markup (an average of $0.15 per gallon) were subtracted (American Petroleum Institute, 2015). Plummer, which is located on the Coeur d'Alene Tribal Reservation, is exempt from state fuel taxes.

For quantity demanded, we used the average yearly quantity sold for gas stations in Idaho and Washington times the number of gas stations in each location (American Automobile Association, 2014). The majority of demand amounts were not binding since each production location can only produce a maximum of 10 million gallons per year. However, since our model does not require that biofuel produced locally be sold locally, this constraint was potentially necessary to prevent all fuel from being sold in a region with high prices but low demand, such as Plummer. See Table 1 for prices and quantity demanded for the biofuel scenario.

For bioaviation fuel and wood pellets, the same twenty production sites are considered but the demand centers are regional airports, with an upper-bound price of $8.71 after accounting for federal taxes. For this scenario, we consider 20 price increments of $0.20 each, which leads to the lower-bound price of $4.71, which is $1.00 more than the price of fuel when the data was collected. All airports were based off of Spokane jet fuel prices (Air Navigation, 2014). This price incorporates the aviation fuel tax for commercial flights, which is $0.044 per gallon rather than the tax used on private aircraft, which is much higher at $0.219 per gallon (American Petroleum Institute, 2015). Given that many smaller aircraft use a different type of fuel and the vastly different fuel tax structures, we include only commercial flights in our demand analysis, using data from the FAA which lists the percentages of flights that are private and commercial for each airport. While biofuel for vehicles can be used to completely substitute for gasoline, presently bioaviation fuel must be mixed with jet fuel. As noted in the introduction, Spokane's Geiger Airport estimates it can use a 50-50 ratio of jet fuel and bioaviation fuel (Deshais, 2011). Hence, our demand estimates are only half of the amount used by the airports every year. These demand estimates were based on an airport's size relative to Spokane's Geiger Airport since demand quantities were not readily available for each individual airport. Table 2 shows the demand quantities for each airport.

Both the biofuel and bioaviation fuel scenarios create biochar as a marketable by-production. For biofuel, the upper-bound price was $150.00/ton and the lower-bound price was $0.00/ton, with 15 increments of ten dollars. For bioaviation fuel, we started with an upper bound of $200.00 per ton and decreased this amount by ten dollars a total of 20 times, thus creating a range of prices from $200.00-0.00 per ton. Since biochar is a new and relatively untested industry, ideally the two scenarios would not depend upon biochar for profitability.

The third use of biomass is to produce wood pellets, which are a substitute for coal in generating energy. Pellets are formed by feeding wood material through a press in order to compress the wood into small shapes. The act of pressing the wood into a pellet causes the temperature of the wood to increase, which activates lignin, a substance in wood that acts like glue when heated (Walker et al., 2010). Finding the data for prices of wood pellets sold in China proved difficult. Hence, we start with an upper bound price of $300/ton and decreased that price by 15 increments of $10.00, meaning the lower bound price is $150/ton. We assume that all pellets produced can be sold at a given price, which is a reasonable assumption for a plant that operates in a competitive environment.

Quantity of the different fuels supplied depends on tons of biomass and the conversion factor. For biofuel (bioaviation fuel), 1 ton of woody biomass can produce 50 (86) gallons of fuel. In addition, each ton of biomass yields 200 pounds, or 0.10 tons, of biochar. For wood pellets, one ton of biomass generates 0.95 tons of pellets.

4.1 Costs for the Biofuel, Bioaviation Fuel, and Pellet Scenarios

With the constraints on demand as well as potential supply quantities and prices known, we now investigate the cost components. Fixed costs at the logging site, which are identical for all locations across all three scenarios, include capital costs for chippers, dryers, grinders, transportation, and harvesting equipment as well as fixed operating costs. One advantage of these scenarios is that logging sites are already owned or rented by logging companies. Thus, land rent is not included as a fixed cost in this analysis. Following Parker (2007), we utilize the capital recovery factor (CRF), which is typically used in annuity calculations, as an estimate of the yearly fee paid on the capital. The CRF function is

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}, \tag{9}$$

where n is the lifetime of the equipment and i is the interest rate. We selected 3% as the interest rate for this paper. Fixed operating and maintenance costs ($O\&M$) can be simplified as a multiplier of the capital costs. Thus, the fixed cost of the CRF and $O\&M$, which are equivalent to rental rate, is defined as a proportion of total capital cost: $Fixed\ Costs = (CRF + O\&M) * Total\ Capital\ Cost$ (Parker, 2007). Table 3 shows the CRF, $O\&M$, and total fixed costs for each piece of capital equipment over its lifetime, as well as the annual cost of each piece of capital. While most fixed costs are identical regardless of the scenario, the reactor (or plant) costs differ substantially, in particular the bioaviation reactor which is significantly more expensive than the reactors for both the biofuel and pellet scenarios.

Having accounted for fixed costs, we now detail the variable costs for the different stages of production (VC_r), which include wages, costs to run the plant, and harvesting costs for biomass, including transportation costs from the field to the production center. Additionally, the pellet scenario includes all transportation costs (from field to plant and plant to final destination) since the end location (China) is identical for each plant location.

Table 4 presents the variable costs of each location for the biofuel, bioaviation fuel, and pellet scenario.

As demonstrated in Table 4, certain areas have substantially lower costs than others. The variation in variable costs comes largely from costs in procuring biomass. For the biofuel scenario, which requires less biomass than the remaining two scenarios, variable costs are relatively uniform, ranging from \$3.64/*gal* in Coeur d'Alene to \$4.09/*gal* in Great Falls. The bioaviation fuel scenario, which requires the most biomass, has the largest range, with the lowest cost of \$4.03/*gal* in Sandpoint and the highest cost of \$8.77/*gal* in Laurel since Laurel must procure biomass from a large area to have enough biomass for production. For pellets, the location with the lowest variable cost is Spokane (\$124.84/*ton*) while the highest cost is, again, Laurel (\$195.62/*ton*). Additionally, transportation costs are included under variable costs for the pellet scenario.

The final cost is transportation costs from the plant the demand locations for the biofuel and bioaviation scenarios since, as already discussed, these costs are already accounted for in the pellet scenario. For the biofuel (bioaviation) scenario, we considered a cost of \$0.02/*gal*/*mile* (\$0.015/*gal*/*mile*)for transportation from the plant to demand centers. For the pellet scenario, pellets are shipped by train to the Seattle port and are barged to China.

5 Results

This section presents the results for each scenarios, showing the profits or losses for each plant location. For the most profitable solutions, we also list the quantity of fuel shipped to individual demand centers for the biofuel and bioaviation scenarios.

5.1 Biofuel Scenario

The profit-maximizing solution for the upper bound prices of biofuel and biochar (approximately \$4.60/*gal* and \$150/*ton*, respectively) found that all but two plants were profitable and most utilized all available biomass. However, the scenarios rapidly became unprofitable as prices for biofuel and biochar declined. In Table 5, we list the profits from the upper-bound biofuel and biochar prices.

The three most profitable scenarios are St. Maries (\$6.36 million), Plummer (\$5.60 million) and Colville (\$5.15 million). For Plummer, 4.6 million gallons are sold in Plummer and 5.4 million in St. Maries while for St. Maries, 9.2 mil. gallons are sold locally and 0.8 mil. gallons are sold in Plummer. Lastly, in Colville all 10 million gallons are consumed locally. The second output (biochar) was necessary for these high profits. For example, if biochar could not be sold, the profits in Colville would decline to \$2.15 million, with similar reductions in profit for St Maries and Plummer. For several scenarios (i.e., Deary, Grangeville, Kalispell, Kamiah, Orofino, and Pierce), if biochar cannot be sold, profits are negative even at the highest biofuel prices.

The least profitable scenarios are, in descending order, Kamiah ($\$48,568.36$), Orofino ($-\$3.68$ million), and Pierce ($-\$7.62$ million). These three location are all situated in north-central Idaho, which is far from large population centers. These locations were unprofitable largely due to the transportation costs of shipping from the plant to demand centers. For the Kamiah plant, 4.6 million gallons were consumed locally and the remaining gallons were shipped to Grangeville and Orofino. For the Orofino and Pierce scenarios, all biofuel was utilized in Orofino, Pierce, and Kamiah. Of these three locations, only Kamiah produced the to the plant's capacity of 10 million gallons. Orofino and Pierce both produced only 9.2 million gallons of biofuel and 18,432 tons of biochar. In general, of the remaining scenarios, the more profitable locations sold all fuel locally. The primary exception to this is Coeur d'Alene, which ships 4.6 million gallons to Plummer despite having ample local demand. This result occurs because Coeur d'Alene has some of the lowest fuel prices in the region while Plummer has the highest.

Unfortunately, only high prices were profitable. Even the most profitable location (Colville) became unprofitable once fuel prices dropped $\$0.60/gal$, to $\$4.007/gal$. At this price, with biochar remaining at $\$150/ton$, Colville experiences a loss of $\$848,743.64$. For most other locations, profits became negative when prices dropped between $\$0.20/gal$ and $\$0.40/gal$. As of late 2015, gas prices were approximately $\$0.40/gal$ higher than the lower-bound prices, implying that no location would be profitable. As a result, we conclude that without large subsidies, a dramatic upward shift in prices, or very high prices of biochar, none of the biofuel scenarios are feasible. However, as biofuel technology continues to improve and variable costs diminish, this scenario could be re-examined.

5.2 Bioaviation Scenario

Originally, the intention was to follow the biofuel scenario by having the upper-bound price be $\$3.00/gal$ above the lower-bound price. However, at this price of $\$6.71/gal$, the most profitable solution was for each plant to produce nothing and instead face only the substantial annual fixed costs. As a result, we increased the upper-bound price bioaviation fuel price to $\$8.71/gal$ and the biochar price to $\$200/ton$, with lower-bound prices for bioaviation fuel (biochar) of $\$4.71/gal$ ($\$0.00/ton$). Even at these high prices, none of the scenarios are profitable, though most still produce as their losses from producing are less than the fixed costs. Table 6 records the losses for each plant at the upper-bound prices.

For the bioaviation fuel scenario, the three most "profitable" (i.e., smallest loss) locations are the three sites closest to the Spokane airports; Coeur d'Alene ($-\$36.46$ million), Spokane ($-\$37.49$ million), and Newport ($-\$42.52$ million). Coeur d'Alene ships to all regional airports except Billings and Great Falls. The remaining two (Spokane and Newport) do not ship to Billings, Great Falls, or Helena. In every scenario, if a plant ships to an airport, it ships the maximum allowed under the demand constraint. The three least profitable scenarios are as follows: Kalispell ($-\$90.93$ million), Great Falls ($-\$93.83$ million), and Laurel ($-\$94,69$ million). In the case of Laurel, the most profitable solution is to produce nothing and instead absorb the fixed costs.

This scenario fairs badly for two reasons: 1) high fixed costs and 2) the inability of airports to utilize all the bioaviation fuel produced. The sum of demand for all fourteen airports is only $14,034,985.90$ gallons despite a plant capacity of $68,800,000$ gallons. While biofuel can be used interchangeably with gasoline, bioaviation fuel must be blended with regular aviation fuel, which substantially limits demand. As an experiment, we tested the profitability if the fixed costs decline using the original upper-bound prices of $\$6.71/gal$ and $\$150/ton$ for bioaviation fuel and biochar, respectively. When fixed costs decline to \$30 million from the original \$94.7 million, Coeur d'Alene experiences profits of $\$421,228.36$. Using the original fixed costs, bioaviation fuel prices must be above $\$11.00/gal$ to make Coeur d'Alene profitable. Unless technology significantly improves or prices skyrocket, a large bioaviation fuel plant does not seem viable. However, a smaller plant with a lower capacity could be a viable solution. Using the biofuel plant as a template, the higher price of aviation fuel would yield profits if production costs were be similar for bioaviation and biofuel.

5.3 Pellet Scenario

The final scenario to examine is wood pellets, where these pellets are sold to China. Unlike the previous two scenarios, biochar is not produced. The upper-bound pellet price of $\$300/ton$ is highly profitable for each plant location. In table 7, we list the plants' profits for high ($\$300/ton$), medium ($\$200/ton$), and low ($\$150/ton$) prices. In the final column, locations where the most profitable solution was to produce nothing and pay the fixed costs are represented by a dash.

For the bioaviation scenario, the three most profitable locations for the mid-range price of $\$200/ton$ are Coeur d'Alene (\$13.76 million), Spokane (\$13.63 million), and Deary (\$13.44 million). The least profitable locations are Kalispell (\$4.13 million), Great Falls (\$2.95 million), and Laurel ($-\$6.54$ million), where only Laurel has negative profits. As in the bioaviation scenario, the least profitable locations are located in Montana. In the pellet scenario, this is primarily due to higher transportation costs to Seattle in addition to greater harvesting costs, particularly for Laurel.

The pellet scenario offers the great opportunity due to the greater range of prices that allow for positive profits. In particular, this profitability is due to 1) the lower fixed costs relative to the bioaviation fuel scenario and 2) lower variable/transportation costs compared to the price of the final good. Most importantly, this scenario can be profitable without subsidies for a greater range of price.

6 Implications and Conclusions

In summary, bioaviation fuel is the least profitable scenario. Even at prices $\$4.00/gal$ higher than the current price per gallon as well as the selling of biochar at a high price, every scenario operated in the red, with losses ranging from $\$35-94$ million. These losses resulted from the high fixed costs of producing a large plant as well as an inability to meet demand requirements. The plant was too large to meet the needs of this Inland Northwest region. The biofuel scenario was profitable at the upper-bound biofuel prices, though it depended upon a high price for biochar. At the upper-bound prices for biofuel and biochar, profits ranged from \$6.4 to $-\$7.6$ million. Proximity to a sufficient number of gas stations to meet demand, the price of gasoline, and variable costs of production were vital in determining the profitability of a particular plant. Finally, pellet production was the most profitable scenario. All locations had profits at the upper-bound price level ($\$300/ton$) and 19 out of 20 were profitable for the medium-range price ($\$200/ton$). The best location was Coeur d'Alene though nearly all locations offered similar profits.

While two of the three scenarios were generally unprofitable, the pellet scenario can be profitable at reasonable prices. While biofuel and bioaviation fuel are not yet profitable, it is important to consider additional costs caused by the burning of slash, particularly the release of greenhouse gases as well as increased air pollution. Springsteen et al. (2011) determined that converting woody biomass into fuel reduces particulate matter emissions by

98%, nitrogen oxide by 54%, carbon monoxide by 97%, and carbon dioxide by 17%. Should air pollution, including greenhouse gas emissions, become monetized, each scenario could potentially be profitable. However, without that monetization, the production of biofuel and bioaviation fuel is too costly to be considered viable options.

Despite two scenarios being too costly at current production costs and output prices, the pellet scenario was viable. An added benefit of the pellet scenario is the lower risk, as pellets are an established product with a sure consumer base. The biofuel and bioaviation fuel scenarios were highly dependent on the sale of biochar, which is still in its infancy. In addition, the pellet industry is already established. While Coeur d'Alene has the highest profits ($42.26 million at the upper-bound price), all locations except Laurel have profits in the $32 − 42 million range. As a result, so long as logging regions do not overlap, several pellet plants could open and run profitably. While there is a great deal of discussion about biofuels, currently these scenarios would require substantial subsidies to be viable. However, a proven alternative is still available in the form of pellets. By producing pellets, less slash will be burned and China will have an alternative to coal. Additionally, since pellets are used in the pyrolosis process, pellet facilities could supply the intermediate input for biofuel facilities in the future as technology improves.

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Table 1: Biofuel Scenario Prices and Demand

Location	Price, \$/gal	Gasoline Demanded, gal	TBM available
Bonners Ferry	1.632	$4,608,000$	$287,713$
Coeur d'Alene	1.592	$46,080,000$	$293,709$
Colville	1.607	$10,752,000$	$238,504$
Deary	1.672	$3,072,000$	$243,825$
Grangeville	1.672	$10,752,000$	$263,197$
Great Falls	1.572	$16,896,000$	$217,273$
Kalispell	1.522	$15,360,000$	$209,414$
Kamiah	1.671	$4,608,000$	$263,014$
Laurel	1.529	$10,752,000$	$311,595$
Lewiston	1.652	$35,328,000$	$243,825$
Missoula	1.551	$18,432,000$	$298,644$
Moyie Springs	1.632	$1,536,000$	$287,879$
Newport	1.617	$3,072,000$	$207,832$
Orofino	1.664	$3,072,000$	$263,197$
Pierce	1.582	$1,536,000$	$263,197$
Plummer	1.956	$4,608,000$	$291,299$
Priest River	1.672	$7,680,000$	$218,110$
Sandpoint	1.635	$12,288,000$	$270,032$
Spokane	1.597	$44,544,000$	$207,832$
St. Maries	1.772	$9,216,000$	$291,299$

Table 2: Bioaviation Demand

Airport Location	Gasoline Demanded, gal
Billings	$359,661.97$
Coeur d'Alene	$531,605.63$
Deer Park	$99,380.28$
Fairchild	$1,500,000.00$
Glacier	$224,000.00$
Great Falls	$178,253.52$
Helena	$75,718.31$
Kalispell	$178,253.52$
Lewiston	$153,014.08$
Missoula	$157,746.48$
Pullman	$126,197.18$
Sandpoint	$127,774.65$
Spokane, Geiger	$10,000,000.00$
Spokane, Felts Field	$323,380.28$

Table 3: Fixed Costs for Each Scenario

Equipment	Lifetime	CRF	O&M	Total Cost	Annualized Fixed Costs
				in $	in $
Harvest	5	23%	5%	450,000	120,759
Chipper	5	23%	5%	500,000	134,177
Grinder	5	23%	5%	615,850	165,266
Dryer	10	13%	5%	2,000,000	334,461
Reactor, Biofuel	20	6.7%	5%	56,000,000	6,564,079
Reactor, Bioaviation	20	6.7%	5%	800,000,000	93,772,566
Reactor, Pellets	20	6.7%	5%	60,000,000	7,032,942
Transportation	3	37%	5%	2,250,000	907,943

Table 4: Variable Costs for Each Scenario

Location	Biofuel VC_r	Bioaviation VC_r	Pellet VC_r
	in $\$/gal$		in $\$/ton$
Bonners Ferry	3.82	4.33	152.40
Coeur d'Alene	3.64	4.29	124.41
Colville	3.85	4.80	144.66
Deary	3.85	4.53	125.53
Grangeville	4.01	5.11	137.86
Great Falls	4.09	6.81	162.31
Kalispell	4.03	5.17	158.18
Kamiah	3.93	4.93	133.20
Laurel	3.95	8.77	195.62
Lewiston	3.85	4.74	127.62
Missoula	3.79	5.29	137.85
Moyie Springs	3.85	4.40	153.37
Newport	3.94	4.11	136.58
Orofino	3.89	4.75	127.98
Pierce	3.99	4.99	135.08
Plummer	3.65	4.30	130.49
Priest River	3.91	4.10	136.40
Sandpoint	3.80	4.03	130.69
Spokane	3.94	4.37	124.84
St. Maries	3.67	4.37	127.40

Table 5: Biofuel Results for Upper-Bound Prices

Location	Biofuel Price	Biochar price	Profits
	in $\$/gal$	in $\$/ton$	in $
Bonners Ferry	4.632	150	964,056.36
Coeur d'Alene	4.592	150	3,683,368.36
Colville	4.607	150	5,151,256.36
Deary	4.672	150	952,168.36
Grangeville	4.672	150	2,101,256.36
Great Falls	4.572	150	301,256.36
Kalispell	4.522	150	401,256.36
Kamiah	4.671	150	48,568.36
Laurel	4.529	150	1,271,256.36
Lewiston	4.652	150	2,501,256.36
Missoula	4.551	150	3,091,256.36
Moyie Springs	4.632	150	2,654,360.36
Newport	4.617	150	1,856,360.36
Orofino	4.664	150	−3,682,295.64
Pierce	4.582	150	−7,616,055.64
Plummer	4.956	150	5,597,224.36
Priest River	4.672	150	2,713,816.36
Sandpoint	4.635	150	3,831,256.36
Spokane	4.597	150	2,051,256.36
St. Maries	4.772	150	6,361,704.36

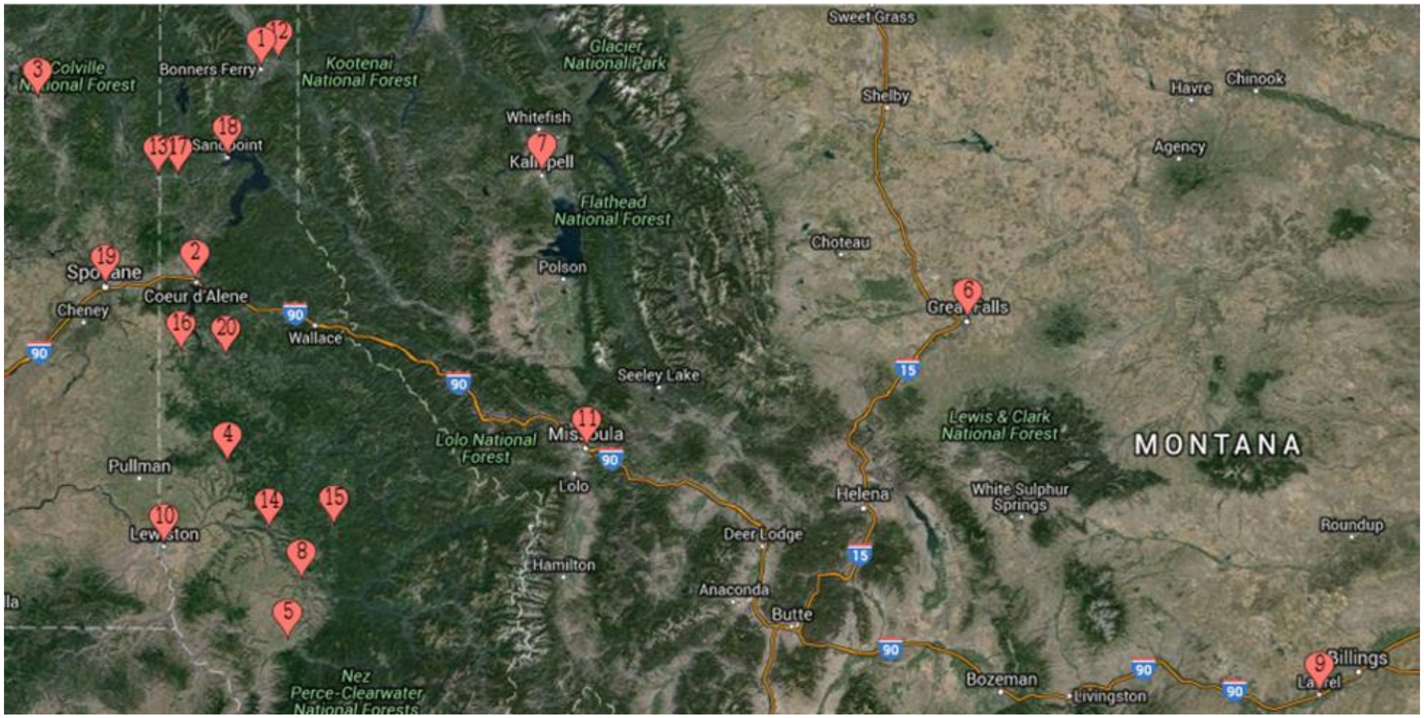
Table 6: Bioaviation Fuel Results for Upper-Bound Prices

Location	Biofuel Price	Biochar price	Profits
	in $\$/gal$	in $\$/ton$	in \$
Bonners Ferry	8.71	200	$-55,329,829.23$
Coeur d'Alene	8.71	200	$-36,485,090.42$
Colville	8.71	200	$-57,079,155.71$
Deary	8.71	200	$-56,961,120.03$
Grangeville	8.71	200	$-79,201,498.49$
Great Falls	8.71	200	$-93,832,624.49$
Kalispell	8.71	200	$-90,928,628.75$
Kamiah	8.71	200	$-75,434,611.53$
Laurel	8.71	200	$-94,685,173.00$
Lewiston	8.71	200	$-61,358,158.14$
Missoula	8.71	200	$-85,175,482.30$
Moyie Springs	8.71	200	$-58,019,623.08$
Newport	8.71	200	$-42,523,474.59$
Orofino	8.71	200	$-68,862,171.91$
Pierce	8.71	200	$-78,946,290.04$
Plummer	8.71	200	$-44,030,036.60$
Priest River	8.71	200	$-43,516,904.96$
Sandpoint	8.71	200	$-45,317,639.71$
Spokane	8.71	200	$-37,488,592.82$
St. Maries	8.71	200	$-48,461,662.31$

Table 7: Pellet Results for High, Medium, and Low Pellet Prices

Location	Pellet Price		
	$300/*ton*	$200/*ton*	$150/*ton*
Bonners Ferry	34,278,393.53	5,778,393.53	–
Coeur d'Alene	42,255,543.53	13,755,543.53	−494,456.47
Colville	36,484,293.53	7,984,293.53	−6,265,706.47
Deary	41,936,343.53	13,436,343.53	−813,656.47
Grangeville	38,422,293.53	9,922,293.53	−4,327,706.47
Great Falls	31,454,043.53	2,954,043.53	–
Kalispell	32,631,093.53	4,131,093.53	–
Kamiah	39,750,393.53	11,250,393.53	−2,999,606.47
Laurel	21,960,693.53	−6,539,306.47	–
Lewiston	41,340,693.53	12,840,693.53	−1,409,306.47
Missoula	38,425,143.53	9,925,143.53	−4,324,856.47
Moyie Springs	34,001,943.53	5,501,943.53	–
Newport	38,787,093.53	10,287,093.53	−3,962,906.47
Orofino	41,238,093.53	12,738,093.53	−1,511,906.47
Pierce	39,214,593.53	10,714,593.53	−3,535,406.47
Plummer	40,522,743.53	12,022,743.53	−2,227,256.47
Priest River	38,838,393.53	10,338,393.53	−3,911,606.47
Sandpoint	40,465,743.53	11,965,743.53	−2,284,256.47
Spokane	42,132,993.53	13,632,993.53	−617,006.47
St. Maries	41,403,393.53	12,903,393.53	−1,346,606.47

Figure 1: Production Locations



Key

1. Bonners Ferry, ID
2. Coeur d’Alene, ID
3. Colville, WA
4. Deary, ID
5. Grangeville, ID
6. Great Falls, MT
7. Kalispell, MT
8. Kamiah, ID
9. Laurel, MT
10. Lewiston, ID
11. Missoula, MT
12. Moyie Springs, ID
13. Newport, WA
14. Orofino, ID
15. Pierce, ID
16. Plummer, ID
17. Priest River, ID
18. Sandpoint, ID
19. Spokane, WA
20. St Maries, ID