Will Washington Provide Its Own Crop Feedstocks for Biofuels?

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Introduction

Interest in biofuels has remained high due to concerns about the nation's reliance on potentially unstable fossil energy sources. American states and communities have also welcomed the potential for economic growth from biofuel plants. In response to these concerns, Washington and other states have enacted laws and regulations designed to promote biofuel development (U.S. Dept. of Energy, 2009).

Corn and sugar beets are among the potential ethanol feedstocks in Washington; however, Washington accounted for only 0.15% of the nation's grain corn (NASS, 2008). Consequently, large Pacific Northwest ethanol producers, such as Pacific Ethanol's plants at Boardman, Oregon and Burley, Idaho imported corn from the Midwest. Sugar beets are an unlikely in-state source of ethanol due to current competition from other irrigated crops, high production costs, and transportation disadvantages (Yoder et al., 2009). Only 1,600 acres of sugar beets have been produced recently in Washington. Sugar beets grown in other states are converted to sugar instead of ethanol.

Oilseeds are a favored biodiesel crop feedstock, but they are minor crops in Washington. Washington averaged 17,577 acres per year for all oilseeds (including canola/rapeseed, mustard, flaxseed, and safflower) over 1997, 2002, and 2007. Canola acreage averaged 10,448 acres per year for these three census years (NASS, 1997, 2002, 2007). The relatively high 2002 oilseed acreage represented only 0.25% of Washington's cropland. Washington produces virtually no soybeans, the nation's largest biodiesel feedstock.

Table 1 measures the adequacy of Washington's current canola, grain corn, and hypothetical sugar beet production in relation to specified biofuel targets. Data show 2007-2008 acres for canola and corn, but 1970-1978 average acres for sugar beets. The state's 2007 canola acreage would meet only 0.09% of the state's diesel consumption if it were replaced entirely with biodiesel. Ethanol from Washington's grain corn could satisfy 1.99% of the state's gasoline consumption. However, local livestock feeders often outbid ethanol producers for local grain corn. Ethanol from sugar beets at the high 1970's acreage could provide 2.64% of the state's

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gasoline consumption. Again, sugar producers might outbid ethanol producers for sugar beets. Current Washington grain corn and historical sugar beet production could supply less than two 40-million-gallon-per-year (MGY) plants each if the entire production was diverted to this purpose. Only 0.02% of the feedstock requirements of a 40 MGY biodiesel plant could be met by current in-state canola production. Undoubtedly, a different set of relative prices would be necessary to encourage production of biofuel crops to meet the state's fuel needs.

Table 1. Adequacy of Washington Canola, Sugar Beet and Corn Production to Meet Specified Demands

Item	Canola	Sugar beets	Corn
Acres of crops planted in Washington	10,449	76,911	90,000
In-state production as % of WA diesel or gasoline consumption per year	0.09	2.64	1.99
Number of 40 MGY plants supplied by in-state production	0.02	1.78	1.34

Notes: Canola acres and trend yield are derived from the 2007 Ag. Census. Biofuel conversion ratios are from Mattson, Wilson and Duchsherer 2007; Salassi 2007; and Lyons 2008. Historic WA sugar beet acreage and updated trend yields are from NASS (2008). MGY is million gallons per year. Washington consumes about 1 and 2.7 billion gal/yr of diesel and gasoline, respectively.

The objective of this study is to assess the economic feasibility of producing biofuel crop feedstocks within Washington State assuming infrastructure and biofuel production capacity were developed. We project profitable acreages of Washington’s crop feedstocks for 2008 in the short run and for the midpoint of a 2009-2011 medium term period using subregion linear programming models. The analysis uses subregion data on production possibilities, costs, crop prices, policies and available technology. The 2008 projections, based on spring forecasted or contract prices, are compared to actual crop acreages for that year. The 2010 projections, based on moving average price projections available in 2008, are compared to 2010 planted acreage reports. Although all projections were made in mid-2008, reporting was delayed for over two years to assess their *ex post* accuracy. The delayed *ex post* validation is rare in the empirical literature.

Most studies regarding ethanol and biodiesel production have focused on agribusiness and rural development considerations rather than on the feasibility of in-state feedstock production (e.g., Franken and Parcell, 2003; Kenkel and Holcomb, 2006; Parcell and Westhoff, 2006; Lambert et al., 2008; Susanto, Rosson and Hudson, 2008). Some previous state-level studies have estimated the stand-alone profitability of crop feedstocks. Many utilized enterprise budgeting to calculate the revenues, costs, and profits associated with the production of a particular crop such as oilseeds in Oregon’s Willamette Valley (Jaeger and Siegel, 2008) and in Maine (Sexton, 2003). Stebbins (2008) uses this approach and found that farm-scale cultivation of oilseeds in Vermont was feasible. A major limitation of single-crop analyses is that they do not allow for product-product competition for land and other resources. Important exceptions are the studies by De La Torre Ugarte et al. (2003) and Walsh et al. (2007) that allowed for product-product competition in 305 independent regional linear programming models for the central and eastern U.S. These results were utilized in their national demand, regional supply, and aggregate income model. Walsh et al. (2007) projected relatively optimistic cellulosic and food crop feedstock supplies to meet year 2025 transportation fuels, food, feed and export demands with some increased crop prices. While such long term national projections are valuable, they are strongly dependent on embodied assumptions on biofuel conversion technologies and cellulosic feedstock supply functions over long time periods. Financial stress in the biofuel industry during

2008-2009 — including excess capacity, bankruptcies, and plant closures — challenges optimistic long run projections in the absence of technological breakthroughs, more generous subsidies, or markedly different relative prices (Young, 2009).

This study allows for product-product competition in response to changing economic incentives. The *ex post* robustness of crop feedstock projections is tested by comparing them with subsequent published acreage data.

Methodology

Standard profit-maximizing risk-adjusted linear programming (LP) models are used to project crop acreages, diesel and nitrogen use and breakeven prices for biofuel feedstock crops. LP is a common approach for examining the feasibility of alternative production possibilities in a partial equilibrium framework (e.g., Taylor, Adams and Miller, 1992; Jaeger, 2004; Keplinger and Hauck, 2006). We provide projections for five production regions in Washington (four dryland and one irrigated) and two time horizons (short and medium run). The models calculate profit maximizing crop choice and input use subject to prevailing technology, price expectations, quantity and quality of land and other resources, agro-climatic conditions, and policy constraints.

Some assumptions underlying the feedstock projection model merit highlighting. First, the subregional models includes activities for all major crops and land use activities, including fallow and Conservation Reserve Program (CRP), as appropriate. Total regional cropland acreage is constrained at 2007 levels, with the exception of moving land to or from CRP. Second, farmers in these regions have demonstrated that they can shift cropping patterns with relatively minor adjustments in their current machinery and labor supplies given opportunities for custom hiring; hence, these resources are not constraining. Third, the projections assume that crops grown in the dryland regions, including spring wheat, winter wheat, barley, grain legumes (peas, lentils, and garbanzos), and canola, are grown in agronomically sound rotations. Canola, which dominates oilseed production in eastern Washington, represents all oilseeds in the projections. Past canola technology successes, such as Roundup Ready© canola and greater research funding for canola, are likely to sustain its dominance. Fourth, the profitability of producing a given rotation or crop is measured by total returns over total cost. Reporting results as net returns over total costs conforms to results in typical Cooperative Extension budgets for the region. Also, given the common machinery complements for the candidate crops, analysis generally showed the same relative results for returns over variable costs and returns over total costs.

For most crops, growers in the irrigated regions do not need to adhere to specific crop rotations due to access to irrigation. For example, while potato frequency is limited by phytosanitary requirements, wheat, grain corn, sweet corn, alfalfa and other crops can serve as rotation crops with potatoes. However, some crop choices in the irrigated region are dictated by processing plant contracts, i.e., potatoes, sweet corn, asparagus. Farmers in areas with junior water rights are also limited in terms of water availability during dry years, which affects crop choice. To reflect this complexity, we model acreages over the large set of choices within 10-year historical crop-specific upper and lower acreage bounds.

Data

Four eastern Washington dryland farming subregions were classified according to their annual average precipitation: high, 17-22 inches/year; medium, 15-17 inches/year; low, 12-15 inches/year; and arid, 7-12 inches/year. A fifth region included Washington’s irrigated farmland.

A sixth region comprising the 19 counties entirely or partially west of the Cascade Mountains was not modeled because its current and past production of crop biofuel feedstocks has been miniscule (NASS, 2008).

Enterprise budgets of various crops grown in Washington State subregions were used to specify production functions incorporated in the LP projections (Yoder et al*.,* 2010). Input prices are specified at early 2008 levels for the short-run and are adjusted for the medium-run.

For the short-run, we use the 2008 spring contract crop prices for autumn harvest in all regions. These were $7.28/bu for grain corn (which was a high contract price spike at time of analysis), $38/ton for sugar beets, and $21.10/cwt for canola (including 20% risk discount). Exceptions to the pricing assumptions occur for land retained in the CRP, or planted to a crop with which most growers have no experience. These land uses receive adjustments for risk. Economic theory specifies that risk averse farmers will discount profit or price expectations for crops or land uses they perceive as more risky than average, or equivalently add a bonus to expectations for crops or land uses they see as less risky than average (Anderson, Dillon and Hardaker, 1977; Kurkalova et al., 2006). Because new crops generally present farmers and scientists with a risky learning curve, expected canola price is discounted by 20% as a conservative estimate to account for added yield risk and risk aversion of crop producers.[2] In comparison, Kurkalova et al. (2006) estimated risk premiums for wheat and other crops for conservation versus conventional tillage which were 30% to 32% of expected returns. Because CRP rents are guaranteed by the U.S. Treasury and have zero risk (Williams et al., 2010), they receive a conservative 20% price bonus.

For the medium-run scenario (2009-2011), all assumptions and data sources remain the same as those outlined for the short run, except for crop prices and production costs. We use the average of 2006, 2007 and 2008 prices as a forward projection of crop prices. These were $5.18/bu for grain corn, $38.5/ton for sugar beets, and $12.45/cwt for canola. Canola and CRP retain the same percentage risk adjustments as in the short run. The retreat of crop prices to a 3-year moving average in the medium run after the exceptionally high 2008 prices reflects historical cyclical patterns. As an example, farm gate mid-November 2008 prices for soft white wheat in eastern Washington had dropped to $5/bu from the $15/bu spike in January 2008. We also assume that all production costs, except diesel and nitrogen, will increase 7% by the 2010 medium-run midpoint compared to 2008 levels, and diesel and nitrogen will increase by 20.3% and 19.4%, respectively. Given limitations of the short-run comparative statics nature of LP results, the analysis does not consider wider variations in crop and input prices.

Projected acres from LP results are compared with reported acres from USDA-NASS data published in 2008 and 2010, unless otherwise specified. Reported canola, orchards and vineyards and summer fallow are from 2007 Ag. Census as these are not annually reported in NASS. Sugar beets and canola, as minor crops in WA, are no longer annually reported by NASS. The reported sugar beet acreage is from 2008. Edible legumes in the following tables consist of dry grain legumes, dry edible Pinto beans, and green peas.

[2] Canola prefers cooler temperatures during flowering than those prevalent in eastern Washington. WSU agronomic experiments have documented low yields of canola due to stand establishment and other problems (Yoder et al., 2010). Relative little agronomic and genetic research has been done to adapt canola to local conditions. This contrasts with 100 years of focused research on wheat and potatoes in the Pacific Northwest. Consequently, local canola growers face many challenges.

CRP acreages were based on active and expiring CRP acres in Washington subregions between 2008 and 2010 (USDA-FSA, 2008 and 2010). Historic acreages of dryland and irrigated regions are from NASS (1997, 2002, 2007). Orchard, barley, and other historic acreages are from NASS (1997, 2002, 2007, 2008).

Results of Crop Feedstock Projections

Short-run Projection and Validation

Table 2 presents 2008 projections of profitable feedstock crop acreage, and fuel and fertilizer usage for each of the five modeled production regions. Note that the projected production of a biofuel feedstock does not mean that the crop will be processed into biofuels since the output will be distributed among competing uses. Breakeven prices required for feedstock crops to be produced in a region are also reported.[3]

Table 2. Projected Profitable Biofuel Feedstock Acres and Energy Use by Subregion, Short Run (2008), Washington State

Region	Canola	Grain corn	Sugar beets	Diesel use (1000 gal)	Dry N use (1000 lbs)	Liquid N use (1000 lbs)
	------------acres------------					
Dryland Zones						
High (17-22 in/yr)	0	0	0	4,074	47,267	0
Med (15-17 in/yr)	0	0	0	1,509	23,608	0
Low (12-15 in/yr)	0	0	0	2,276	18,143	0
Arid (7-12 in/yr)	0	0	0	2,754	44,422	0
Irrigated	0	105,000	0	8,221	82,155	81,454
WA Total	0	105,000	0	18,334	215,595	81,454

In dryland eastern Washington, as expected, no typically irrigated crop feedstocks (i.e., grain corn and sugar beets) were projected in 2008 (Table 2). Of greater importance, no canola production was projected in the short run for these zones. Small canola acreages at recent levels can be expected to continue to meet rotational needs, special contracts, or agro-climatic niches. On the whole, however, canola rotations did not compete with the dominant rotations of winter wheat-spring grain-spring legumes (or fallow) in the two higher precipitation regions or with winter wheat-fallow in the two lower precipitation regions. Indeed, the breakeven prices to make spring canola profitable in the high and medium precipitation regions were $33.68/cwt and $146.31/cwt, respectively. These compare to a risk discounted 2008 spring contract price of $21.10/cwt.

No canola is projected in 2008 for the irrigated zone, but the oilseed was somewhat more

[3] The breakeven price is required to make the crop compete successfully with other candidate crops. It does not mean that the crop breaks even with its sole total costs of production.

competitive there. The breakeven price fell short of the risk discounted contract price by only $3.45/cwt ($24.55–$21.10). The low irrigated canola projections square with field reports. One canola grower reports that the number of 160-acre irrigation circles of canola in the Columbia Basin dropped from 25 in 2007 to only 7 in 2008 (J. Schibel, personal communication, 2008). The observed reluctance of farmers to grow canola, despite record prices, would seem to justify the risk discounts previously noted. More importantly, record high prices for traditional crops in this region (alfalfa, wheat, corn) discouraged production of alternative crops (Painter and Young, 2008). Similarly, no sugar beet acres were projected for the irrigated zone in 2008. The breakeven price of sugar beets was $43.32/ton, about $5 more than its projected price. On the other hand, growers were projected to continue producing high-value crops such as potatoes, sweet corn, high quality alfalfa hay, apples and wine grapes (Yoder et al., 2010).

Table 2 also shows a projected 105,000 acres of irrigated grain corn in 2008. This compares to 90,000 reported acres in 2008 (Table 3). The model over-projected grain corn acreage due to the short-lived high spring contract corn price used in the analysis. Our projection for wheat is 14% less than the 2008 reported acres (Table 3). This projection was affected by the unprecedented variability of soft white prices, ranging from $15.12/bu to $4.30/bu during the 2008 calendar year (Union Elevator, 2009). A unique historical acreage constraint for barley, where agronomic considerations often outweigh profit maximization, contributed to the 77% over-projection for this crop. In general, however, the match between projected and actual acreages for most crops in Table 2 is considered reasonable given the variability of 2008 crop prices.

Potential Feedstock Availability: Medium-run (2009-2011) Projections

Table 4 presents projections for the midpoint of the 2009-2011 medium run. Again, canola and sugar beets fail to compete profitably with other Washington crops. Due to the projected cyclical downturn in crop prices in the medium run, breakeven prices for canola and sugar beets exceed projected market prices by a greater margin than in the short run. Again, the price shortfall for canola is smallest in the irrigated region with a breakeven of $27/cwt compared to a risk adjusted expected price of $12.45/cwt. The sugar beet breakeven price of $47.14/ton exceeds the projected price of $38.5/ton. A deteriorating profit outlook reduces projected grain corn production from 105,000 acres in 2008 to only 55,000 acres in the medium run (Table 2 and Table 4). No sugar beets were projected for 2010, as in 2008.

Table 3. Projected and Reported Acres for Washington, short run

Results	Alfalfa hay	Asparagus	All barley	Edible legumes	Canola	Grain corn
	- - - acres - - -					
Projected, 2008	460,998	7,793	336,873	246,141	0	105,000
Reported	425,000	7,000	190,000	208,400	10,449	90,000
Difference	*8%*	*11%*	*77%*	*18%*	--	*17%*

	Hops	Mint	Onions, storage	Orchards & vineyards	Potatoes	Sugar beets
	- - - acres - - -					
Projected, 2008	29,850	27,925	17,704	310,403	134,207	0
Reported	30,595	29,900	20,000	360,250	155,000	1,600
Difference	*-2%*	*-7%*	*-11%*	*-14%*	*-13%*	--

	Sweet corn	Wheat	Summer fallow	CRP
	- - - acres - - -			
Projected, 2008	68,575	1,951,383	1,139,246	1,538,165
Reported	78,100	2,260,000	1,295,750	1,538,165
Difference	*-12%*	*-14%*	*-12%*	*0%*

Notes: Reported acres are from USDA-NASS, late 2008, except those for canola, orchards and vineyards and summer fallow. Projected orchard and vineyard acres were exogenously set at 2002 Ag. Census levels as 2007 Census results were not available at time of analysis. Reported and projected CRP acres from USDA-Farm Service Agency are identical as there were no CRP bid rounds in the state during 2008.

Table 4. Projected Profitable Biofuel Feedstock Acres and Energy Use by Subregion, Medium Run (2009-2011), Washington State

Region	Canola	Grain corn	Sugar beets	Diesel use (1000 gal)	Dry N use (1000 lbs)	Liquid Nitrogen use (1000 lbs)
	------------acres------------					
Dryland Zones						
High (17-22 in/yr)	0	0	0	4,074	40,821	0
Med (15-17 in/yr)	0	0	0	1,509	23,608	0
Low (12-15 in/yr)	0	0	0	964	15,551	0
Arid (7-12 in/yr)	0	0	0	2,754	44,427	0
Irrigated	0	55,000	0	7,824	74,655	73,954
WA Total	0	55,000	0	17,125	199,062	73,954

Table 5 examines the *ex post* accuracy of the medium term projections at the midpoint year of 2010. Not surprisingly, the deviations of projected from reported increase for 2010 versus 2008. Again our unique historical constraint on barley acreage, unwise in retrospect, causes a large projection error for this crop. Excluding barley for both years, the mean absolute % deviation is 17 for 2010 compared to 11 in 2008 (Tables 3 and 5). The growth in forecast errors over only two years suggests caution regarding longer forecasts.

Of most interest to this study is the accuracy of projections for biofuel feedstock crops. As previously discussed from Table 4, zero production of both canola and sugar beets was again projected for 2010. This projection is reinforced by the fact that NASS no longer reports annual acreage of these two crops in Washington due to low plantings. On the other hand, the model under-projected Washington's grain corn acreage in 2010 by 73%. The discrepancy between the actual and projected corn acreage in the medium run was due to shifting price relationships not captured in our model. With falling crop prices and increasing costs in the medium run model, the deteriorating profit outlook reduced the projected grain corn production from 105,000 acres in 2008 to only 55,000 acres in the medium run. As a small corn producer with volatile production history, percentage errors in Washington's corn acreage are magnified. Because Washington's grain corn is primarily directed to livestock feed, this discrepancy is unlikely to have a large impact on supplies of in-state ethanol feedstocks.

Table 5. Projected and Reported Acres for Washington, medium run

Results	Alfalfa hay	Asparagus	All barley	Edible legumes	Canola	Grain corn
	- acres	- -				
Projected, 2010	460,998	7,793	336,873	218,347	0	55,000
Reported	430,000	6,000	85,000	212,700	10,449	205,000
Difference	*7%*	*30%*	*296%*	*3%*	--	*-73%*
	Hops	**Mint**	**Onions, storage**	**Orchards & vineyards**	**Potatoes**	**Sugar beets**
	acres					
Projected, 2010	29,850	27,925	17,704	310,403	134,207	0
Reported	24,115	N/A	22,000	360,250	135,000	1,600
Difference	*24%*	--	*-20%*	*-14%*	*-1%*	--
	Sweet corn	**Wheat**	**Summer fallow**	**CRP**		
	acres					
Projected, 2010	68,575	1,951,474	1,139,336	1,538,165		
Reported	65,900	2,310,000	1,295,750	1,445,228		
Difference	*4%*	*-16%*	*-12%*	*6%*		

Conclusions

Crop feedstock projections in this analysis included consideration of product-product competition within agro-climatically distinct subregions of Washington State. Furthermore, projections of 2008 and 2010 crop acreages included a rare comparison against *ex post* reported acreages, with reasonable results for most crops.

The results of this study indicate the infeasibility of sustaining a large-scale biofuel industry in Washington based on locally produced oilseeds, sugar beets, and grain corn given short run and medium run expected prices and technology. Our conclusions regarding the infeasibility of agricultural crops as feedstock are supported in part by a study in the neighboring state of Oregon (Graf and Koehler, 2000). The projected breakeven prices for Washington farmers to profitably produce these crops exceed current and projected prices. Large ethanol and biodiesel processors in the state import nearly all of their virgin crop feedstocks.

This sobering assessment of one western state's projected shortfall in producing its own crop feedstocks for biofuels has important implications for state-level policymakers and agricultural research directors. In an earlier multi-faceted report to the Washington Legislature (Yoder et al., 2009), the crop feedstock projections received the most critical attention from reviewers. Some politicians, biofuel entrepreneurs, and even agricultural scientists possess strong optimistic beliefs about the state's potential for self sufficiency in crop feedstocks, despite long standing comparative agronomic and economic advantages by other high value crops.

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