School of Economic Sciences

Working Paper Series
WP 2009-24

Will Washington Provide Its Own Feedstocks for Biofuels?

By

Suzette P. Galinato, Douglas L. Young, Craig S. Frear and Jonathan K. Yoder

December 2009

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Will Washington Provide Its Own Feedstocks for Biofuels?

Suzette P. Galinato, Douglas L. Young, Craig S. Frear and Jonathan K. Yoder*

Abstract

The study finds that Washington State's field corn, sugar beet and canola production could satisfy only a small percentage of the State's annual gasoline or diesel consumption. Linear programming projections for 2008 showed a relatively close match between projected and actual production. Projections for 2009-2011 showed no increase in the State's capacity to increase biofuel crop feedstocks. In comparison to crop feedstocks, Washington's total annual lignocellulosic biomass is abundant. However, only a fraction of the biomass could be converted to biofuel due to high costs of collection and processing, competing markets for some biomass, and limitations in current technology.

Key Words: biofuels, biofuel feedstocks, canola, cellulosic inventories, grain corn, linear programming, Washington State

JEL Classifications: C61, Q15, Q42

---

* Suzette P. Galinato is Research Associate (IMPACT Center), Douglas L. Young is Emeritus Professor and Jonathan K. Yoder is Associate Professor, in the School of Economic Sciences, Washington State University, Pullman, Washington. Craig S. Frear is Research Associate in the Department of Biological Systems Engineering, Washington State University, Pullman, Washington.

This paper is modified and substantially condensed from Young, D., C. Frear, K. Painter and S. Galinato, Chapter 4, "Feedstock availability and economic potential for Washington State", *Biofuel Economics and Policy for Washington*, Washington State University Agricultural Research Center Research Bulletin XB1047E (forthcoming), College of Agricultural, Human, and Natural Resource Sciences, Washington State University, Pullman, Washington. This research was mandated and funded by Washington State House Bill H2SB 1303, section 402. The Washington Agricultural Research Center provided additional funding and support under project number WNP00539.

Introduction

Interest in biofuel market development has exploded due to a broad set of concerns and opportunities related to our reliance on fossil energy sources. Some of these issues are high oil and gasoline prices, energy security in the face of geopolitical instability in oil-producing regions, and the potential for domestic rural economic development through biofuel production. In response to these concerns, the state of Washington and many other states have enacted laws and regulations designed to promote biofuel market development at the state level (U.S. Dept. of Energy 2009).

Corn and sugar beets are among the potential ethanol feedstocks in Washington State, but the state produced only 0.15% of the nation's grain corn in recent years (USDA-NASS 2008). Washington lacks the high 24-hour temperatures and summer precipitation of the Midwest that permits profitable corn production without irrigation. Consequently, large Pacific Northwest ethanol producers such as Pacific Ethanol's former plants at Boardman, Oregon and Burley, Idaho imported corn from the Midwest. Only about 1,600 acres of sugar beets have been produced recently in Washington. However, a recent report concludes that 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. 2009a). U.S. sugar beets are converted to sugar instead of ethanol.

Oilseeds are a favored biodiesel crop feedstock, but Washington produced less than 1% of the nation's oilseeds, and of its canola, during the last two agricultural censuses (USDA-NASS 2002, 2007). North Dakota produced over 90% of America's canola in this period. With limited oilseed production, most Washington biodiesel plants import soy oil from the U.S. Midwest and canola from Canada, or use local recycled cooking oils (Lyons 2008).

Because they are minor crops in Washington, the U.S. Dept. of Agriculture-National Agricultural Statistics Service (USDA-NASS) does not report annual production statistics for most oilseeds in the state. However, the USDA-NASS Agricultural Census reports state-wide harvested oilseed acreages and other statistics every five years (USDA-NASS 1997, 2002, 2007). The census data show an average of 17,577 acres for all oilseeds (including canola/rapeseed, mustard, flaxseed, and safflower) over 1997, 2002, and 2007 with an average of 10,448 acres of canola alone (Table 1). The relatively high 2002 oilseed acreage represented only 0.25% of Washington's cropland. Washington's oilseeds are used for cooking oils, food condiments, cover crops, and animal feed.

Table 2 provides a sharper measure of the adequacy of Washington's current canola, grain corn, and hypothetical sugar beet production in relation to specified biofuel targets. 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 might 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 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 were 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.

There currently are no commercial cellulosic ethanol plants in Washington (Yoder et al. 2009b). However, substantial research is underway to develop commercially feasible technology to convert cellulosic sources to biofuel. Two major examples are Pacific Ethanol's pilot plant funded by the U.S. Department of Energy and Washington State University's Center for Bioproducts and Bioenergy at its Richland campus. As biofuel conversion technologies mature, these sources could provide potentially large biomass feedstock for Washington. The inventory of Washington's potential cellulosic feedstocks in this study is a first step in answering important questions for policy-makers, business people and researchers concerning future research and development.

Previous state-level studies have estimated the stand-alone profitability of crop biofuel feedstocks. Most utilized enterprise budgeting to calculate the revenues (income), costs, and profits associated with the production of a particular crop such as oilseeds in the U.S Southeast (De La Torre Ugarte et al. 1999), Oregon's Willamette Valley (Jaeger and Siegel 2008), and in Maine (Sexton 2003). Stebbins (2008) found that farm-scale cultivation of oilseeds in Vermont was technically feasible using this approach. A major limitation of single-crop budgeting analyses is that they do not allow for product-product competition for land and other resources. Timmons et al. (2008) provided a regional economic feasibility analysis of cellulosic feedstocks, particularly willow and switchgrass in five western counties of Massachusetts. This study also failed to consider product-product competition. Our study, however, allows for economic allocation decisions across the important crop categories.

Most published 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 et al. 2008). No study was found that modeled the economic feasibility of the production of biofuel feedstocks at the sub-state level that accounted for the competing uses of agricultural land.[1] Nor did we find any studies where biofuel feedstock and other crop acreage projections which were compared (validated) against actual acreages. In contrast, our study allows for crop acreage allocation to change in response to economic incentives. In addition, we perform *ex post* robustness based on final published acreage data.

The objectives of this study are two-fold. First, using subregional linear programming models, we assess the incentives for producing crop feedstocks for biodiesel and ethanol in Washington State. Specifically, we forecast the acreages of crop feedstocks and competing crops by subregion for two periods: year 2008; and a medium-run period of 2009-2011 under projected market scenarios. The crop feedstock availability projections are based on specified market/policy conditions and agro-climatic potential. The 2008 state-level projections based on spring forecasted or contract prices are compared to actual crop acreages for that year. Second, we assess the inventories of cellulosic feedstocks in Washington; however, the processing of biofuels from cellulosic feedstocks is less technologically and economically mature than for crop feedstocks, so no firm predictions are possible about the economic feasibility of conversion of these feedstocks to biofuels.

The remainder of the paper proceeds as follows. The next section explains our methodology. Section 3 summarizes the data, Sections 4 and 5 provide our results regarding crop feedstocks and cellulosic feedstocks, respectively, and Section 6 concludes.

Methodology

Crop feedstock projection: Linear programming models

Profit-maximizing linear programming (LP) models were used to project crop acreages, diesel and nitrogen use, breakeven prices for biofuel feedstock crops, and grain straw supply for five Washington production regions and two lengths of run. The models calculated farmers' profit maximizing land use, input use, and technology selection subject to technology, price expectations, quantity and quality of their land and other resources, agro-climatic conditions, and policy constraints.

Some assumptions underlying the feedstock projection model merit highlighting. First, the model includes activities for all typical crops and land use activities, such as fallow and Conservation Reserve Program (CRP) in the regions. Total regional cropland acreage is constrained at current 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, so 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 (Table 1), represents all oilseeds in the projections. Past canola research successes such as “Roundup© ready” canola and greater research funding for canola are likely to sustain its dominance. Fourth, the economic profitability of producing a given crop is measured by the total returns over total cost of production because, given the common machinery complements for the candidate set of crops, analysis generally showed the same results for returns over variable and total costs.

Crop acreage in the irrigated region is typically dictated by processing plant contracts and by relative current profitability, so there is less adherence to strict agronomic rotations. For example, wheat or corn can substitute as a rotation crop with potatoes. Consequently, individual crops are modeled within historic percent of total acreage bounds.

Cellulosic feedstock projection

The potential supplies of Washington's cellulosic feedstocks are studied through an inventory analysis rather than an optimization analysis as for the crop feedstocks. There are three reasons why an inventory rather than economic optimization approach is appropriate for analyzing Washington's cellulosic feedstocks:

- Cellulosic feedstock sources like forestry residues and municipal waste do not compete for a common land resource as in the LP profit maximizing methodology described above.[2]
- Some cellulosic sources like grain straw and food processing residue can be derived from the crop projections in the previous section, plus end use allocation.
- The technologies to convert cellulosic feedstocks to biofuels are less mature making it difficult or impossible to obtain demand prices for these feedstocks.

To make the inventories more valuable as an assessment of the likely cellulosic biofuel feedstock supply in this study, the original inventory has been modified in several important respects (Frear 2008):

- Because biofuel production facilities will undoubtedly face economies of scale, producers will need reliable sources of feedstock within reasonable transportation distances. Consequently, quantities of cellulosic biomass that are too distant from potential biofuel production facilities were excluded.
- The forest thinning inventory was revised based on work conducted at Oregon State University through their contract for the second version of the Billion Ton Report (Skog et al. 2008).
- The potential for cellulosic biomass from dedicated energy crops was added. The cellulosic energy crops inventoried were switchgrass and poplar.

These modifications provided important refinements to the inventory of in-state cellulosic biofuel feedstocks. However, it is important to note that important limitations remain in the biomass inventory. For example, it does not account for environmental impacts of biomass removal. The inventory is county- rather than mileage-based. Also, it does not account for the economics of competing markets and ignores a number of issues on collection, pre-treatment and transportation.

Data

Crop feedstock production

We examine the feasibility of crop production in five regions and under two periods: short run, year 2008; and medium run, 2009 to 2011. Four eastern Washington dryland farming regions were classified according to their annual precipitation levels — high averaging 17-22 inches/year; medium averaging 15-17 inches/year; low averaging 12-15 inches/year; and arid averaging 7-12 inches/year. A fifth region includes Washington's irrigated farmland. A sixth region comprising the 19 counties entirely or partially west of the Cascade Mountain Range was not modeled because its current and past production of crop biofuel feedstocks has been miniscule (USDA-NASS multiple years). Furthermore, western Washington experimental oilseed production results have been disappointing due to agro- climatic conditions (Miller, T., personal communication and experiment reports, 2008). The cool and moist summers in western Washington hinder the maturation and harvesting of oilseeds. Currently, pasture, hay, silage, cane berries and other high value fruit and vegetable crops are dominant crops in this region. Finally, field crop acreage has been ceding to urban development in some western Washington counties. However, as will be discussed later in this study, cellulosic feedstock projections from forestry residues, municipal waste, and other non-food or feed sources are promising for western Washington.

Enterprise budgets of various crops grown in Washington State subregions were used to specify production functions incorporated in the linear programming (LP) model projection (Yoder et al. 2009b). Enterprise budgets provide input-output ratios for crop production. Input prices are specified at 2008 levels for the short-run analysis and are adjusted for estimated inflation for the medium-run analysis.

For the short-run scenario, we use the 2008 spring contract crop prices for autumn harvest in all regions. Exceptions to the pricing assumptions occur for land retained in the Conservation Reserve Program (CRP), or planted to a crop with which most growers have no experience. 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 et al. 1977; Barry 1977). Because CRP rents are guaranteed by the U.S. Treasury and thereby have zero risk, they receive a 20% price bonus in the model. Because new crops generally present farmers and scientists with a risky learning curve (Zaikin et al. 2008; Young, F. and C. Hennings, personal communications, 2008), expected canola price is discounted by 20% as a conservative estimate to account for added yield risk and risk aversion of crop producers.

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. Canola and CRP which 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. Historically, agricultural commodity price booms have been followed by a return to long-run real price trends, or sometimes depressed prices, as a result of vigorous supply response. Some commentators have argued that the combined momentum of increasing demands from the Chinese and Indian economies and world thirst for biofuels would perpetuate the extremely high agricultural commodity prices of late 2007 and early 2008 ("The End of Cheap Food," *The Economist*, December 6, 2007). However, our study assumes that price patterns will follow historic cyclical patterns, albeit with return to a higher plateau. 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. This late-2008 wheat price was still somewhat above historic levels. 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.

Cellulosic feedstocks

Data on cellulosic feedstock inventories are obtained from Frear et al. (2005), Frear (2008), the Oregon State University Billion Ton Report (Skog et al. 2008) and Western Governors' Association Report (WGA 2008).

Results: Crop feedstock projections

Short-run (year 2008) projections and validations

Table 3 presents 2008 projections of profitable feedstock crop acreage, straw production, 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.

In dryland eastern Washington, as expected, no biofuel crops typically irrigated (i.e., grain corn and sugar beets) are projected in 2008. Of greater importance, no canola production is projected in the short run for these zones. Small canola acreages at recent levels (Table 1) can be expected to continue being grown to meet rotational needs, special contracts, or agro-climatic niches. But on the whole, canola rotations do 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 are $33.68/cwt and $146.31/cwt, respectively.[3] These compare to a risk discounted 2008 spring contract price of $21.10/cwt. How realistic are these low 2008 canola acreage forecasts? USDA-FSA (2008) showed planted acreage of canola was down in 2008 compared to 2007. Some other oilseeds were higher, but most of these are destined as condiment food crops or cover crops. USDA-NASS 2008 surveys also report that wheat plantings, a competing crop, were up in 2008.

No canola is projected in 2008 for the irrigated zone, but the oilseed is somewhat more competitive there. The breakeven price falls 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 (Schibel, J., personal communication, 2008). The “wait and see” attitude of farmers with respect to 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 is $43.32/ton, which is about $5 more than its projected price.

Table 3 also shows a projected 105,000 acres of irrigated grain corn in 2008. This compares to only 90,000 harvested acres that the USDA reported for Washington grain corn growers in 2008 (Table 4). Clearly, our model over-projected grain corn acreage due to the short-lived high contract corn price used in the analysis. Our projection for wheat is about 16% less than the planted acres reported by the USDA during the 2008 calendar year. The projection is affected by the unprecedented variability of soft white prices, ranging from $4.30/bu to $15.12/bu during the 2008 calendar year (Union Elevator 2009). In general, however, the match between projections and data reported by the USDA is considered reasonably close (i.e., less than 20% difference for most) given the nature of LP projections and the unprecedented variability of 2008 grain and legume prices.

Harvestable grain straw production is tabulated as a potential cellulosic source of ethanol. However, some agricultural scientists discourage removing any straw because of the adverse effects on long-run soil quality (Kennedy 2008). Projected energy utilization in the form of diesel and fertilizer are consistent with the crop rotations selected for the different regions (Table 3).

Potential feedstock availability: Medium-run (2009-2011) projections

Table 5 presents projections for the 2009-2011 medium run. Again, canola and sugar beets fail to compete profitably with other Washington crops. Due to the cyclical downturn in projected 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. With crop prices falling, and costs increasing, Washington agriculture shows a return to the historical "cost-price squeeze" in the medium run. The deteriorating profit outlook reduces projected grain corn production from 105,000 acres in 2008 to only 55,000 acres in the medium run (Table 3 and Table 5). This is consistent with Washington's history of wide swings for grain corn acreage (USDA-NASS several years).

Despite the discouraging prospects for canola and other oilseeds in Washington, it is important to recognize that oilseeds have received little or no previous agronomic and genetic research to make these crops regionally adaptable. This stands in stark contrast to the 100 years of focused research on wheat and potatoes in the Pacific Northwest. The projections in this study do not incorporate potential future oilseed research breakthroughs that could improve their economic competitiveness.

What about sugar beets and grain corn? Washington has struggled to maintain profitable sugar beet processing facilities over the past three decades. Nonetheless, production records from the 1970s in the irrigated Columbia Basin show that Washington growers have the capacity to grow large quantities of sugar beets if economic incentives return. However, Yoder et al. (2009a) finds that the development of a Washington sugar beet market specifically for ethanol production is quite unlikely.

Washington produces only 0.15% of the nation's grain corn. Lacking the favorable climate of the Corn Belt for dryland corn production, and possessing a portfolio of higher value crops for its irrigated cropland, it is likely that Washington will continue to be a small grain corn producer.

Results: Cellulosic feedstock inventories

The inventory of cellulosic feedstocks for Washington State is summarized in Figure 1 and is sub-divided into four main categories: municipal waste, forestry biomass, field residue, and dedicated energy crops. The total available lignocellulosic biomass in Washington is estimated to be approximately 17 million dry tons, with 66% of this coming from forestry residues. A considerable portion of this biomass, though, is unlikely to be economically useful to a future biofuels industry primarily because of transportation and collection/conversion costs. In addition, new and existing uses will compete for the available tonnage in the marketplace.

The key findings of the cellulosic inventory are that:

- Washington is rich in annual production of under-utilized cellulosic biomass (~17 million dry tons/yr);
- The 17 million dry tons inventoried substantially exceeds that reported by the Department of Energy/Oak Ridge National Laboratory (DOE ORNL) Billion Ton Report (<10 million dry tons/yr); and
- Cellulosic material represents the overwhelming majority of the total inventory (~85%).

The promise of lignocellulosic biomass inventories to potentially supply biofuel needs from this Washington State study are similar to those in Walsh et al. (2007). Her study projected that cellulose feedstocks from the eastern half of the U.S. could supply 25% of the nation’s projected transportation fuels in 2025 while meeting other needs (e.g., food or feed for domestic consumption and export). Figure 2 shows a substantial concentration of the lignocellulosic biomass per year in King and other counties with large urban populations and/or forest resources. If one assumes a rough conversion factor of 75 gallons of ethanol/dry ton of lignocellulosic biomass utilized, the biofuel potential represented by this biomass amounts to 1.275 billion gallons of ethanol, or 47% of Washington's 2.7 billion gal/yr consumption (Frear 2008). This is a large number, but there are several challenges to overcome. First, the cost of collection, transportation and distribution of such disperse, energy-dilute biomass could be quite high. Second, there are many scientific and engineering hurdles yet to be overcome involving pre-treatment, fermentation, thermal processing, distillation, catalysis, purification and mass distribution. Third, existing and new markets for some biomass, such as fiber board for wood products and recycled paper and co-generation for mill residues, will reduce quantities available for biofuel production. Finally, water and nutrient usage may limit conversion of some biomass to biofuels. These constraints will permit utilizing only some fraction of this biomass for biofuels. There also remains the need to assess supply, collection, transportation, and distribution costs, as well as competitive markets for these feedstock sources. Despite these challenges, our assessment is that vigorous ongoing research, such as that previously mentioned about the Department of Energy's pilot plant at Boardman, Oregon and at Washington State University's Richland campus, has excellent potential to solve the engineering, biochemical, and logistics problems to exploit Washington's abundant lignocellulosic feedstock sources. However, the time required to solve these problems is difficult to predict.

Conclusions

Unique aspects of the biofuel crop feedstock projections in this analysis included consideration of product-product competition within agro-climatically distinct subregions of Washington State.

Furthermore, linear programming projections of 2008 crop acreage were validated against actual reported acreages.

With respect to crop feedstocks such as oilseeds, sugar beets, and grain corn, the results of this study indicate Washington State growers are likely to provide only a very small fraction of the state's fuel needs given current and medium run expected prices and technology. Current in-state production of oilseeds and sugar beets is extremely small by national standards and 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 feedstocks.

This is not to say that Washington agriculture is impoverished. Quite the contrary: Washington is the second largest agricultural state by value in the Pacific and Mountain regions, after national leader California, and 11th in the nation. Washington is recognized worldwide for its high quality apples, cherries, potatoes, hops, wheat, sweet corn, wine grapes, and livestock products. These high value products with a local comparative advantage maximize income to Washington's farmers and ranchers. Based on competitive markets, the gains from producing and exporting these crops to the rest of the country and the world maximize the state's agricultural income.

The potential for exceeding a 2% ethanol blend target in gasoline is less demanding. Indeed, Washington's ethanol consumption has in the recent past exceeded 7%, and Washington's 2007 grain corn production could satisfy a 1.99% ethanol blend if it were all diverted to biofuels. However, local livestock feeders might outbid ethanol producers for local grain corn. Similarly, sugar beet acreage at 1970's levels with trend increases in yields would provide a 2.64% ethanol blend if beets were diverted entirely to biofuels. Of course, increases in sugar beets imply decreases in some other crop. The biodiesel picture is less promising since the state's 2007 canola acreage would meet only 0.09% of the state's diesel consumption as biodiesel.

In comparison to crop biofuel feedstocks, the long-run potential for biofuel production from lignocellulosic biomass is more promising. The Western Governors' Association (2008) reports that Washington ranked fourth after California, Texas, and Oregon among 19 western states in available biomass. Our study finds that the total annual lignocellulosic biomass in Washington State is estimated to be approximately 17 million dry tons. This biomass could theoretically produce an estimated 1.275 billion gal/yr of ethanol or 47% of Washington's gasoline consumption per year. In practice, however, only a fraction of this biomass would be converted to biofuel in the current technological environment due to the high costs of collection and processing. In addition, competing and existing markets for some biomass such as fiberboard from forestry residues and recycling of paper and other municipal wastes would reduce the available tonnage for biofuels.

On the whole, the outlook for Washington's self sufficiency in biofuel feedstocks is not optimistic for the near and medium run. The state lacks an innate comparative advantage for corn and oilseed feedstocks. While lignocellulosic feedstocks are more promising for the long run, technological barriers, competing uses, and collection costs are likely to delay short term uses of these sources for biofuels.

[1] This conclusion is based on searches of the AgEcon Search, EconLit, and 2009 AAEA Proceedings data bases.

[2] However, they compete with other land uses; hence, care must be made to avoid imputation of potential output when it would require changes in land use. Note also that the inventory approach measures the technically feasible quantities, and hence does not speak to what might be economically possible.

[3] Breakeven prices are viewed in a multiple crop context. 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.

References

Anderson, J.R., J.J. Dillon, and J.B. Hardaker. 1977. Agricultural Decision Analysis. Ames, IA: Iowa State University Press.

Barry, P.J. (ed.). 1977. Management of Risk in Agriculture. Ames, IA: Iowa State University Press.

De La Torre Ugarte, D.G., R.L. White, S.P. Slinsky, A. Turhollow, D.E. Ray, K.H. Tiller, and D.D. Bagwell. 1999. Assessment of Biodiesel Production Potential in the Southeast U.S.: Final Report. Prepared for the Southeast Regional Biomass Energy Program. University of Tennessee Agricultural Policy Analysis Center (APAC), Knoxville, TN.

Franken, J.R.V. and J.L. Parcell. 2003. "Cash Ethanol Cross-Hedging Opportunities." Journal of Agricultural and Applied Economics, 35(3): 509-516.

Frear, C. 2008. "Cellulosic Feedstock Availability by County in Washington State." Working Paper. Department of Biosystems Engineering, Washington State University, Pullman, WA.

Frear, C. B. Zhao, G. Fu, M. Richardson, S. Chen and M. Fuchs. 2005. "Biomass Inventory and Bioenergy Assessment: An Evaluation of Organic Material Resources for Bioenergy Production in Washington State." Washington Department of Ecology Publication No. 05-07- 047.

Jaeger, W.K. and R. Siegel. 2008. "Economics of Oilseed Crops and Their Biodiesel Potential in Oregon's Willamette Valley." Special Report 1081. Oregon State University, Corvallis, OR.

Kenkel, P. and R.B. Holcomb. 2006. "Challenges to Producer Ownership of Ethanol and Biodiesel Production Facilities." Journal of Agricultural and Applied Economics, 38(2): 369-375.

Kennedy, A. 2008. Cited in "Wheat residue too valuable for biofuels." Seattle Post-Intelligencer.

Lambert, D. M., M. Wilcox, A. English and L. Stewart. 2008. "Ethanol Plant Location Determinants and County Comparative Advantage." Journal of Agricultural and Applied Economics, 40(1): 117-135.

Lyons, K. 2008. Biofuel Development in Washington. WSU Extension Energy Program, Washington State University, Pullman, WA.

Mattson, J.W., W.W. Wilson and C. Duchsherer. 2007. Structure of the Canola and Biodiesel Industries. Agribusiness & Applied Economics Report No. 606. Center of Excellence for Agbiotechnology: Oilseed Development - Department of Agribusiness & Applied Economics, North Dakota State Univ. August. http://ageconsearch.umn.edu/handle/7644

Painter, K.M. and D.L. Young. 2008. "A Rising Price Tide Has Raised All Commodities, but Winter Canola Still Nets Less than Soft White Winter Wheat in the Irrigated Columbia

Basin." Abstract in 2008 Dryland Field Day Abstracts: Highlights of Research Progress. CSS Technical Report 08-1, pp. 20- 21. Washington State University, Pullman, WA.

Parcell, J.L. and P. Westhoff. 2006. "Economic Effects of Biofuel Production on States and Rural Communities." Journal of Agricultural and Applied Economics, 38(2): 377-387.

Salassi, M.E. 2007. "The Economic Feasibility of Ethanol Production from Sugar Crops." Louisiana Agriculture Magazine, Winter. http://www.environment.hawaiiresourcelibrary.com/EthanolSugarFeasiUSDA.pdf.

Sexton, P. 2003. "Potato Facts: Spring Canola, An Oilseed Crop for Potato Growers." Extension Bulletin No. 2438. The University of Maine Cooperative Extension, Orono, ME. Available at http://www.umext.maine.edu/onlinepubs/htmpubs/2438.htm.

Skog, K.E., D. Dykstra and R. Perlack. 2008. Preliminary Estimates of Wood Biomass Supply from U.S. forests for the Revision to the USDOE/ USDA Billion Ton Biomass Supply Report.

Stebbins, E.J. 2008. The Market Potential of Farm-Scale Oilseed Crop Products in Vermont. A study prepared for the Vermont Sustainable Jobs Fund and the Vermont Biofuels Association. Department of Community Development & Applied Economics, University of Vermont.

Susanto, D., C.P. Rosson and D. Hudson. 2008. "Impacts of Expanded Ethanol Production on Southern Agriculture." Journal of Agricultural and Applied Economics, 40(2): 581-592.

The Economist. December 6, 2007. "The End of Cheap Food."

Timmons, D., G. Allen, and D. Damery. 2008. Biomass Energy Crops: Massachusetts' Potential. A report prepared for the Massachusetts Division of Energy Resources and Massachusetts Department of Conservation & Recreation. Department of Resource Economics, University of Massachusetts, Amherst, MA.

Union Elevator. 2009. Union Elevator Graphs. Available at: http://www.unionelevator.com/index.cfm?show=10&mid=38.

U.S. Dept. of Agriculture, Farm Service Agency (USDA-FSA). 2008. 2007 Planted Acreage of Oilseeds in Washington State. Spokane, WA. Available at http://www.fsa.usda.gov/FSA/stateoffapp?mystate=wa&area=home&subject=landing&topic=landing.

U.S. Dept. of Agriculture, National Agricultural Statistics Service (USDA-NASS). 1997. 1997 Census of Agriculture Volume 1 National, State and County Data. Washington, D.C. Available at http://www.nass.usda.gov/census/census97/volume1/vol1pubs.htm.

U.S. Dept. of Agriculture, National Agricultural Statistics Service (USDA-NASS). 2002. 2002 Census of Agriculture Volume 1, Chapter 2: Washington County Level Data. Washington, D.C. Available at http://www.nass.usda.gov/census/census02/volume1/wa/index2.htm.

U.S. Dept. of Agriculture, National Agricultural Statistics Service (USDA-NAS S). 2007. 2007 Census of Agriculture Volume 1, Chapter 2: Washington County Level Data. Washington, D.C. Available at http://www.nass.usda.gov/census/census07/volume1/wa/index2.htm.

U.S. Dept. of Agriculture, National Agricultural Statistics Service (USDA- NASS). 2008. 1960-2008 Quick Stats: Agricultural Statistics Data Base. Washington D.C. Available at http://www.nass.usda.gov/index.asp.

U.S. Dept. of Energy. 2009. "State and Federal Incentives and Laws." Alternative Fuels and Advanced Vehicles Data Center. Available at http://www.afdc.energy.gov/afdc/incentives_laws.html [Accessed August 2009].

Walsh, M.E., D.G. De La Torre Ugarte, B.C. English, K. Jensen, C. Hellwinckel, R.J. Menard and R.G. Nelson. 2007. "Agricultural Impacts of Biofuels Production." Journal of Agricultural and Applied Economics, 39(2): 365-372.

Western Governors' Association (WGA) with Kansas State University and the U.S. Forest Service. 2008. Strategic Assessment of Bioenergy Development in the West: Biomass Resource Assessment and Supply Analysis for the WGA Region: Final Report. Available at http://www.westgov.org/wga/initiatives/transfuels/Task%204.pdf.

Yoder, Jonathan K., Douglas Young, Kathleen Painter, Jie Chen, Joan Davenport, and Suzette Galinato. 2009a. Potential for a Sugar Beet Ethanol Industry in Washington State. A report submitted to the Washington State Department of Agriculture. 43 pp.

Yoder, J., C. R. Shumway, P. Wandschneider, D. Young, H. Chouinard, A. Espinola-Arredondo, S. Galinato, C. Frear, D. Holland, E. Jessup, J. LaFrance, K. Lyons, M. McCullough, K. Painter, L. Stodick. 2009b. "Biofuel Economics and Policy for Washington State." Washington State University Agricultural Research Center Research Bulletin XB1047E (forthcoming). College of Agricultural, Human, and Natural Resource Sciences, Washington State University, Pullman, Washington.

Zaikin, A.A., D.L. Young and W.F. Schillinger. 2008. Economics of an Irrigated No-till Crop Rotation with Alternative Stubble Management Systems Versus Continuous Irrigated Winter Wheat with Burning and Plowing of Stubble, Lind, WA, 2001-2006. Washington State University, Pullman, Washington.

Table 1. Washington State Harvested Acreage of Canola[a] and Other Oilseeds[b]

Year	WA oilseeds	WA canola	Canola as % of WA oilseeds
1997	16,791	13,239	79
2002	20,379	7,776	38
2007	15,561	10,449	67
Average	17,577	10,448	61

[a] Canola and rapeseed, nearly all canola
[b] Mustard seed, flaxseed, and safflower
Source: USDA-NASS Agricultural Censuses (1997, 2002, 2007).

Table 2. Adequacy of Washington Canola, Sugar Beet and Corn Production to Meet Specified Demands

Item	Canola	Sugar beets	Corn
WA 2007-2008 acres for canola and corn, but 1970-1978 average acres for sugar beets	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 are from the 2007 Ag. Census. The estimated Washington (WA) average yield of 1,629 lbs/ac is a 2008 trend projection from Agricultural Census data. Biodiesel from canola requires 18.3 lbs canola/gal biodiesel (Mattson et al. 2007). The WA sugar beet acreage is based on the1970-1978 average when the state produced sugar beets extensively. The estimated 2008 WA sugar beet yield of 74,600 lbs/ac assumes yield growth proportionate to Idaho. Ethanol from sugar beets requires 80.6 lbs sugar beets/gal ethanol (Salassi 2007). The WA average yield of 215 bu/ac is a 2008 trend projection from USDA-NASS (2008) data; the 2008 corn ac are from the same source. Ethanol from grain corn requires 0.36 bu corn/gal ethanol (Lyons 2008). MGY is million gallons per year. Washington consumes about 1 and 2.7 billion gal/yr of diesel and gasoline, respectively.

Table 3. Projected Profitable Biofuel Feedstock Acres, Energy and Fertilizer Use and Harvestable Grain Straw by Geographic Region, 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)	Harvest-able Grain Straw (tons)
	------------acres------------						
Dryland Zones							
High (17-22 in/yr)	0	0	0	4,074	47,267	0	552,773
Med (15-17 in/yr)	0	0	0	1,509	23,608	0	330,521
Low (12-15 in/yr)	0	0	0	2,276	18,143	0	0
Arid (7-12 in/yr)	0	0	0	2,754	44,422	0	0
Irrigated	0	105,000	0	8,221	82,155	81,454	203,347
WA Total	0	105,000	0	18,334	215,595	81,454	1,086,641

Notes: “N” refers to nitrogen fertilizer. Crop prices used for projections were May-June contract offers for August 2008. 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). Harvestable straw is from wheat and barley.

Table 4. Washington State-wide Projected and USDA Reported Crop Acres for 2008 (Short Run)

Results	Alfalfa hay	Asparagus	All barley	Edible legumes	Canola	Grain corn	Hops
	acres						
Projected	460,998	7,793	336,873	246,141	0	105,000	29,850
Reported	425,000	7,000	190,000	208,400	10,449	90,000	30,595
% diff. from projected	*-8%*	*-10%*	*-44%*	*-15%*	--	*-14%*	*3%*
	Mint	Onions, storage	Orchards & vineyards	Potatoes	Sugar beets	Sweet corn	Wheat
	acres						
Projected	27,925	17,704	310,403	134,207	0	68,575	1,951,383
Reported	29,900	20,000	360,250	155,000	1,600	78,100	2,260,000
% diff. from projected	*7%*	*13%*	*16%*	*15%*	--	*14%*	*16%*
	Other Dryland	Irrigated Unaccounted	Summer fallow	CRP	Total		
	acres						
Projected	563,441	236,968	1,139,246	1,538,165	7,174,672		
Reported	N/A	N/A	1,295,750	1,538,165	N/A		
% diff. from projected	--	--	*14%*	*0%*	--		

Notes: Table includes three sections of results. The second section is shaded. Reported acres are from USDA-NASS, late 2008. USDA reports of canola, orchards and vineyards and summer fallow are from 2007 Ag. Census. Projected orchard and vineyard acres were set at 2002 Ag. Census levels as 2007 results were not available at time of analysis. Reported acres of perennial crops including asparagus, hops, alfalfa and mint are 2008 harvested acres. Edible legumes consist of dry grain legumes, dry edible beans-Pinto and green peas. Reported and projected CRP acres from USDA-Farm Service Agency are identical as there were no CRP bid rounds in the state during 2008. The "Other Dryland" projection includes hay, cropland in pasture, and failed/unharvested cropland. "Irrigated Unaccounted" includes all irrigated crops not included in the LP model. N/A means data were not available.

Table 5. Projected Profitable Biofuel Feedstock Acres, Energy and Fertilizer Use and Harvestable Grain Straw by Geographic Region, 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)	Harvest-able Grain Straw (tons)
	------------acres------------						
Dryland Zones							
High (17-22 in/yr)	0	0	0	4,074	40,821	0	552,773
Med (15-17 in/yr)	0	0	0	1,509	23,608	0	330,522
Low (12-15 in/yr)	0	0	0	964	15,551	0	0
Arid (7-12 in/yr)	0	0	0	2,754	44,427	0	0
Irrigated	0	55,000	0	7,824	74,655	73,954	203,347
WA Total	0	55,000	0	17,125	199,062	73,954	1,086,642

Notes: Crop prices used for projections were 2006-2008 averages. These were $5.18/bu for grain corn, $38.5/ton for sugar beets, and $12.45/cwt for canola. The canola projection used a contract price of $15.56/cwt with a 20% risk discount. Harvestable straw is from wheat and barley.

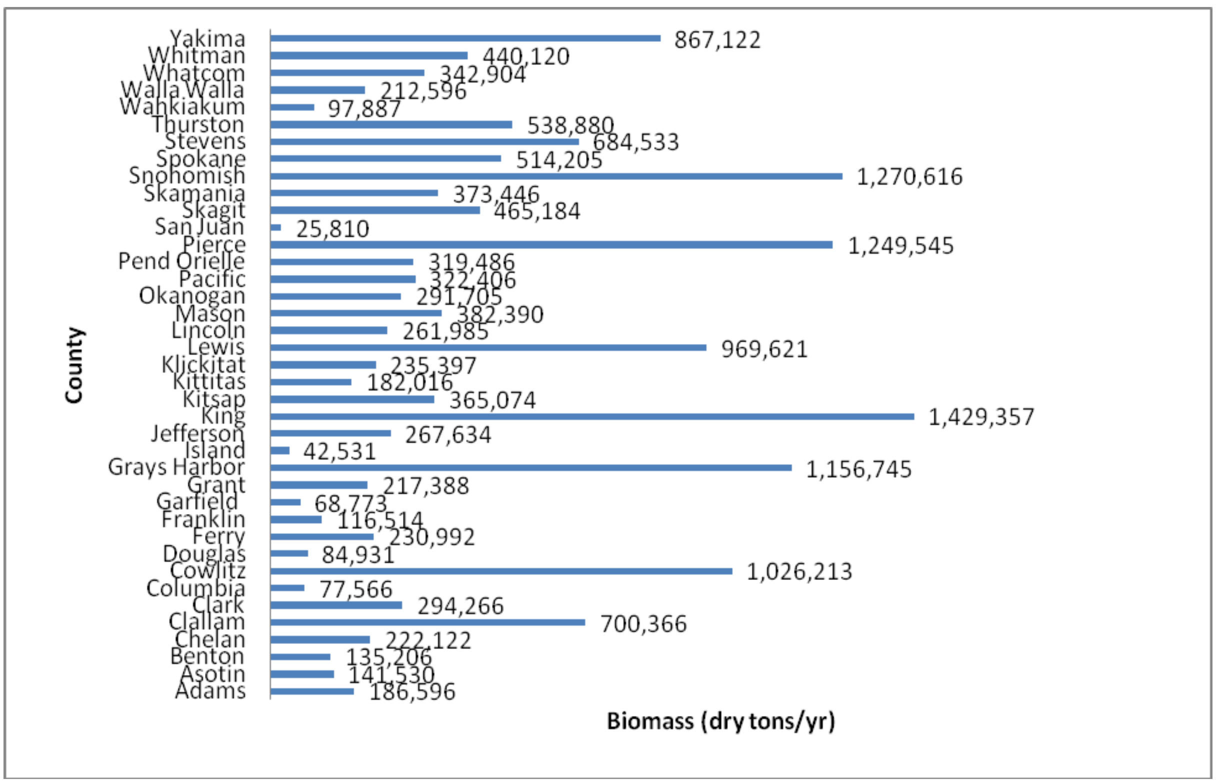

Figure 1. Washington's Potential Biomass and Bioenergy by Group (Source: Frear et al. 2005)

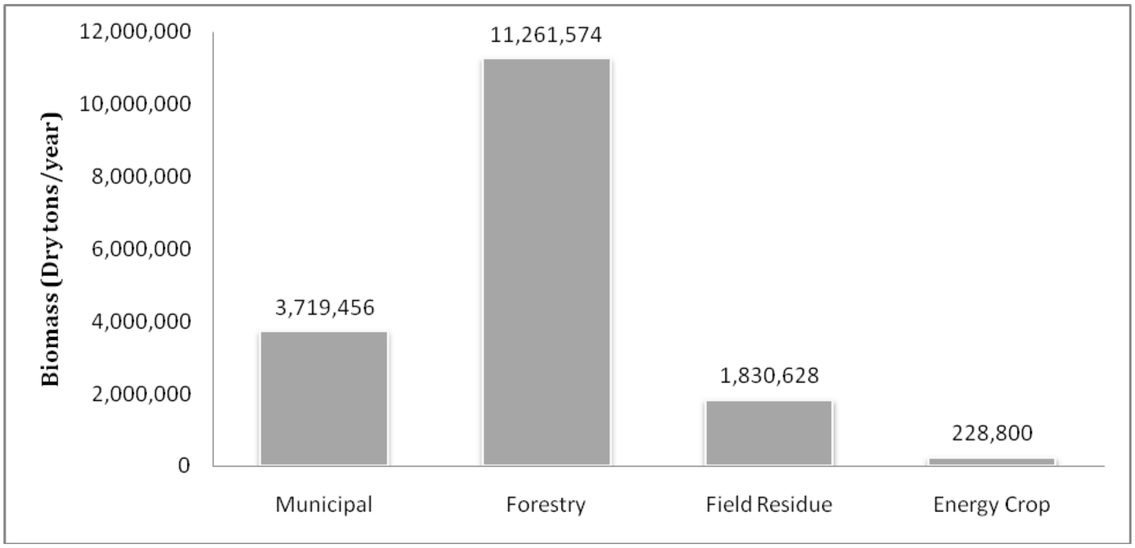

Figure 2. Lignocellulosic Biomass by County (tons/year) — Statewide Total of 17,040,458 tons/yr (Source: Frear 2008)