Feasibility of Camelina as a Biofuels Feedstock in Washington

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Executive Summary

The Biomass Crop Assistance Program (BCAP) was designed to provide financial incentives to eligible landowners and operators to grow camelina in California, Oregon and Washington. Annual payments were offered as incentives (subject to deductions) to eligible operators to produce biomass crops for heat, power, bio-based products and advanced biofuels. A contract length of 5 years was offered under the condition that producers provide evidence of a camelina production contract agreement with a third party biomass conversion facility. The enrollment period was August 8-September 16, 2011.

Not a single operator from Washington enrolled in the program. Policymakers are currently asking for a rationale of this behavior and for observations about the program. Suggested reasons for no enrollment include specifics of contract terms, timing of enrollment, agronomic concerns, yield and price risk concerns, inadequate market and production information, as well as complexity of the contracts themselves.

Farmers' profitability and other barriers to BCAP enrollment were examined by Washington State University. The analysis demonstrated that Washington dryland farmers were rational to decline participation in the 2011 BCAP camelina program. The findings of the report provide several important observations:

- Most importantly, operators maintained higher profit levels by remaining with their traditional rotations of soft white winter wheat, edible pulses, and summer fallow. Rotations that included camelina (with or without participation in the BCAP) did not economically compete with traditional rotations in Washington.
- The combination of the expected price offered for camelina under a production contract and the BCAP subsidies were insufficient incentives to induce operators to participate in the program. For example, breakeven prices for low rainfall regions in Washington were double in magnitude relative to the 2011 price offer (see Table 3).
- USDA incentives in the form of crop insurance and direct payments for competing crops, and farmers' lack of knowledge about growing camelina provided powerful risk aversion incentives to remain with traditional crop rotations.
- Additional barriers to BCAP participation were the timing, length, incentive structure, and lack of clarity of the contracts offered to farmers.
- Washington's experience was not unique. Montana's earlier failure to stimulate camelina production should be interpreted as a signal for Washington and provides instructive lessons learned.
- If the BCAP is to be revised, not only are incentives to farmers relevant, but also relevant are delivery logistics/costs and the downstream capacity/profitability of crushing and processing firms.

Introduction

The Biomass Crop Assistance Program (BCAP) was designed to provide financial incentives to eligible landowners and operators to grow camelina in California, Oregon and Washington. Annual payments were offered as incentives (subject to deductions) to eligible operators to produce biomass crops for heat, power, bio-based products and advanced biofuels. A contract length of 5 years was offered under the condition that producers provide evidence of a camelina production contract agreement with a third party biomass conversion facility. The enrollment period was August 8-September 16, 2011 and subsequently extended to September 23, 2011. Not a single operator from Washington enrolled in the program. Policymakers are currently asking for a rationale of this behavior and for observations about the program. Suggested reasons for no enrollment include specifics of contract terms, timing of enrollment, agronomic concerns, yield and price risk concerns, inadequate market and production information, as well as complexity of the contracts themselves.

The Washington State University School of Economic Sciences (WSU/SES) has previously examined the feasibility of Washington farmers growing crop feedstocks for biofuels (Yoder et al., 2009; Yoder, et al., 2010; Galinato et al., 2011). These analyses relied upon subregion-specific historic yields, production costs, and feedstock crop prices. The observed feedstock crop prices would have been favorably influenced by tax credits and other incentives for biofuels. Results showed that canola as a biodiesel feedstock, and corn or sugar beets as ethanol feedstocks, failed to compete profitably with Washington farmers' rich portfolio of alternative crops including wheat, barley, peas, lentils, garbanzos, apples, potatoes, wine grapes, and specialty crops. The results were not surprising as Washington has contributed a small share of the nation's corn and oilseeds. In contrast, Washington, because of agronomic and economic comparative advantages, has been a major producer of the often higher-value crops enumerated above. These traditional crops contribute both to Washington's high agricultural income and to the nation's international trade balance.

WSU/SES' crop feedstock supply projections were reinforced by a disappointing history of the ethanol and biodiesel industry in Washington and other western states (Young, 2009). Two case studies illustrate these difficulties. Pacific Ethanol (PE) built six 40-million-gallon/year corn ethanol plants in California, Oregon, Idaho, and Colorado. Due to high costs of imported Midwestern corn and volatile prices of ethanol, PE's stock price fell from $44.50/share in 2006 to $0.20/share in 2009. PE filed for Chapter 11 bankruptcy on May 18, 2009. The bankruptcy court subsequently authorized reopening, but by February 3, 2012 its share price had recovered to only $1.09.

Imperium Renewables (IP), located in Gray's Harbor, Washington, possesses biodiesel production capacity of 100 million gallons per year and is the nation's second largest biodiesel refiner (Imperium Renewables, 2009). IP initially purchased Canadian canola and other oil while exporting most of its biodiesel to Europe (Galbraith, K. *The New York Times*, May 14, 2009, green.blogs.nytimes.com/2009/05/14/a-biodiesel-makers-tale-of-woe/?pagemode=print;). IP's Hawaiian refinery proposed palm oil from Malaysia as the primary feedstock (IP Draft Environmental Assessment (www.lifeofthelandhawaii.org/Imperium.html).Of course, these feedstock sources and export destinations did not contribute to state or national energy independence. International trade rulings, volatile petroleum-diesel prices, and rising feedstock prices forced IP to shut down production in 2009 (Buckman, 2009). By mid-2011, however, IP was financially recovering by producing biodiesel from Canadian canola for markets in Oregon and Canada. These nearby markets mandated a minimum percentage blend of biodiesel (Associated Press, 2011; *The Seattle Times*, 2011).

Previous WSU/SES research has not considered use of camelina as a biofuel feedstock in Washington, nor has WSU research evaluated the Biomass Crop Assistance Program (BCAP) for motivating Washington growers to contract for camelina production during late-summer 2011. The objective of this report is to examine economic and BCAP contract barriers to camelina production by Washington farmers.

<u>Camelina and BCAP background</u>

Camelina has somewhat lower oil content than canola, but can grow on low-precipitation marginal farmland, albeit with relatively low yields (Ehrsening and Guy, 2008; Schahczenski and Griffith, 2009). Prior to the 2011 BCAP incentive program, Montana growers were offered government incentives to grow camelina, but planted acreage in Montana declined from 22,500 in 2007 to 9,400 in 2010 despite hopes that Montana would become the nation's premier camelina producer.

BCAP was established by the Food, Conservation and Energy Act of 2008 (P.L. 110-246). The USDA/Farm Services Agency announced on July 26, 2011 that it would accept applications from Washington, Montana and California farmers to grow camelina for biofuel contracts. The signup period was August 8, 2011 through September 23, 2011 (with an extension) closely followed or overlapped with harvest in the Pacific Northwest. It was alleged to be too short by some growers (Cantwell, 2011). The USDA-Farm Services Agency (FSA) offered annual subsidies for contract signers equal to average land rental rates. In Washington, these incentives equaled \$102/ac in Spokane County, \$99.50/ac in Whitman County, \$91/ac in Garfield County, \$64/ac in Adams County, and \$56/ac in Franklin County (communication from R. Hamilton, FSA-Spokane, WA). Larger annual incentives were offered to counties with higher annual precipitation, wheat yields, and corresponding land rental rates. Sustainable Oils sponsor production contracts in fall of 2011 for the BCAP with which to contract operators in Washington for camelina planting. Despite what would appear to be sizeable incentives, no Washington farmer signed a camelina BCAP contract in 2011.

This report will explore two explanations for eastern Washington farmers' lack of participation in the 2011 BCAP sign-up. The first examines the farm-level profitability of camelina versus other crops. The second relates to operator concerns regarding the BCAP as determined by a late-January 2012 survey of eastern Washington famers.

Profitability Comparisons

The profitability analysis is conducted for four separate state dryland subregions. The geographic disaggregation is necessary because each subregion possesses distinct alternative crops and has different yields and production costs for camelina and alternative crops. By descending range of annual average inches precipitation (ppt/yr), the subregions are HIGH (>17”), MEDIUM (15”-17”), LOW (12”-15”), and ARID (7”-12”). Respective cropland acres available for the cultivated crops in this study in the HIGH, MEDIUM, LOW, and ARID subregions are 846,854; 550,668; 886,367; and 2,881,414 (Yoder et al., 2010). For reasons related to weed, disease, fertility, and soil moisture management, dryland farmers grow crops in agronomically sound rotations. Table 1 lists appropriate rotations by subregion.

Table 1. Crop rotations for profitability comparisons by subregion

Subregion	**Rotations**
HIGH	WW-SW-P, WW-SB-P, WW-SW-L, WW-SB-L, WW-SW-G, WW-SB-G, WW-SW-SC, WW-SB-SC, WW-SW-C, WW-SB-C
MEDIUM	WW-HRSW-SF, WW-SB-SF, WW-SC-SF, WW-C-SF
LOW	WW-SF, WC-SF, WW-C-SF, [CRP]
ARID	WW-SF, WW-C-SF, [CRP]

Definitions: WW=soft white winter wheat, SW=soft white spring wheat, P=spring dry peas, SB=spring feed barley, L=spring lentils, G=spring garbanzo beans, SC=spring canola, C=spring camelina, HRSW=hard red spring wheat, SF=summer fallow, WC=winter canola, [CRP]= Conservation Reserve Program. CRP is planted to perennial grass for 10 years to prevent soil erosion in return for annual payments from USDA.

Table 1 shows cropping frequency declines with available precipitation. Currently, virtually all land in the large LOW and ARID zones is in a WW-SF rotation; however, recent agronomic experiments have examined growing winter canola, spring canola, and camelina in these regions.

Crop prices, except for minor transportation adjustments, are the same across subregions, but costs and yields vary. This analysis utilizes returns over variable costs as the farmer’s profit objective during the 2011 BCAP signup. The reason is that fixed costs in machinery and land will continue regardless of the short-run cropping plan. Of course, for long-run decisions to continue farming the farmer will consider returns over total costs. Furthermore, we assume that given the short duration of the BCAP application period, farmers would utilize their readily available 2011 crop prices, variable costs, and yields.

Table 2 lists our data-based estimates of crop prices, crop yields, and crop variable costs by subregion. Camelina prices are transportation-adjusted average 2011 prices of Willamette Biomass Processors (WBP), Rickreall, Oregon. WBP’s daily offer prices float at 73% Chicago Board of Trade soybean futures for November delivery. Clearly WBP’s average 2011 market price of $15.12/cwt (footnote in Table 2) was higher and was market based. The camelina yields in Table 2 are based on the *only* camelina field trials that have been conducted in Washington (Schillinger et al., 2012). Most yields are 3-year averages and represent best planting dates and methods. Montana researchers have conducted several camelina field trials, but yields obtained east of the Rocky Mountains where summer rainfall is significant are not representative of eastern Washington's dry summers. Camelina 2011 variable costs/ac were obtained from 2011 precipitation zone-specific camelina enterprise budgets for Washington and Idaho (Stein, 2011). In addition to the "convenience argument" related to the short signup period, 2011 prices were used because this BCAP year represented very favorable prices of oilseeds relative to grains.

Table 2. Crop prices, yields and variable costs by precipitation zone.

Zone	Crop	Unit	Price ($/unit)	Yield (units/ac)	Var. Costs ($/ac)
HIGH	SW winter wheat	bu	6.63	86.14	256.74
	SW spring wheat	bu	6.63	68.29	231.58
	Sp Barley	ton	196.67	2.14	198.72
	Peas	cwt	12.00	20.24	212.55
	Lentils	cwt	28.50	12.42	166.59
	Garbanzos	cwt	31.00	13.39	226.07
	Canola	cwt	20.50	19.28	274.10
	Camelina	cwt	12.10	16.35	142.00
MEDIUM	SWW wheat	bu	6.63	75.64	192.42
	HRS wheat	bu	7.92	44.12	174.14
	Sp Barley	ton	196.67	1.61	140.80
	Canola	cwt	20.50	13.92	206.83
	Camelina	cwt	12.10	13.53	149.00
	Sum. Fallow	ac	0.00	0.00	128.84
LOW	SWW wheat	bu	6.63	57.78	105.80
	W. Canola	cwt	20.50	10.71	205.46
	Camelina	cwt	12.10	8.96	149.00
	Sum. Fallow	ac	0.00	0.00	128.84
	CRP	ac	60.00	0.00	0.00
ARID	SWW wheat	bu	6.63	42.27	105.80
	Camelina	cwt	12.10	4.40	134.00
	Sum. Fallow	ac	0.00	0.00	128.84
	CRP	ac	60.00	0.00	0.00

Notes: Sources of data for camelina are described in the text. Camelina price is risk discounted by 20% (i.e., price is decreased by 20% to proxy a risk discount). The pre-discount transportation-adjusted average price for 2011 was $15.12/cwt. Variable costs and yields for all other crops are trend updates to 2011 from Yoder et al.'s (2010) 2008 estimates, except HIGH ppt variable costs for SW winter and spring wheat and Sp Barley are from Painter (2011). Average 2011 prices for wheat are from Union Elevator, Lind WA; for barley from USDA-NASS 2011 Agricultural Prices; and for edible pulses from Brocke and Sons, Kendrick, Idaho.

Soybean prices are highly correlated with both canola and camelina prices so the ratio of national soybean prices to national soft white wheat prices were computed from 2003 to 2011. Year 2011 displayed the highest ratio equaling 2.17. In 2007, the ratio was only 1.40. Although not planned, offering BCAP incentives in 2011 represented a favorable period for camelina and other oilseed profitability.

The 20% price discount for camelina noted in the footnote to Table 2 is due to (a) the unique absence of crop insurance for camelina,[1] (b) the lack of USDA direct payments for camelina compared to wheat and barley, and (c) farmers' lack of knowledge and experience in growing camelina. Crop revenue insurance offered by USDA's Risk Management Agency (RMA) is generous. For wheat, the established insurance price for the 2011/2012 crop year in Washington is $8.05/bu. This price substantially exceeds early-February 2012 farm gate spot prices of around $6/bu. Farmers receive an insurance payment if their wheat gross revenue falls below target insured revenue. For example, considering MEDIUM zone SWW: Target insured revenue = $8.05/bu (80%)(75.64 bu/ac) = $487.12/ac, where 80% is the farmer's selected yield coverage level and 75.64 bu/ac (from Table 2) is established or historical yield. Most farmers select 80% coverage level because it is subsidized by taxpayers at 80%. Note that $487.12/ac exceeds expected actual gross revenue if the farmer sells 75.64 bu/ac at $6/bu = $453.84/ac yielding an insurance claim of $33.28/ac ($487.12 - $453.84). The target revenue guarantee is well over double the MEDIUM SWWW variable costs of $192.42/ac. Some crop insurance specialists conclude favorable RMA revenue guarantees often exceed variable costs and sometimes total costs throughout the country (C. Walters, Agricultural Economist, U. Kentucky, email correspondence, February 6, 2012). Other economists have criticized the program for very high costs during an era of federal budget deficits (Babcock, 2011). Endicott (personal communication, January 27, 2012) cited favorable insurance treatment of wheat as a major deterrent to attracting more oilseeds to the Willamette Valley Processors refinery.

Grain growers, but not oilseed or pulse growers, receive USDA direct payments based on historical acreage and yields. For the MEDIUM zone example, direct payment/ac wheat is: (75.64 bu/ac)(0.33)(0.85)($0.52/bu) = $11.03/ac, where 75.64 bu/ac (from Table 2) is the assumed established yield, 0.33 is the historical proportion of acreage in wheat for a typical WW-SB-SF rotation, 0.85 is the USDA's payment ratio, and $0.52/bu is the direct payment legislated by Congress. Direct payments are decoupled from current yields and prices so farmers receive these every year regardless of land use. Farmers receive direct payments in addition to any crop insurance claims. Crop revenue receipts in excess of direct payments, as in the preceding MEDIUM zone example, are relatively common currently (C. Walters, Agricultural Economist, U. Kentucky, email correspondence, February 6, 2012).

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[1] RMA offers a pilot camelina crop insurance program in Montana and North Dakota with an established price of $16/cwt. This pilot program is not available in Washington, nor is its duration known. Camelina prices calculated in Table 2 are nearly identical to contract prices reportedly offered to operators.

The third reason for the camelina price risk discount, farmers' lack of knowledge and experience in growing camelina, may be equally important in the short run. A subsequent section of this report presents evidence from a survey of E. Washington farmers regarding agronomic concerns for growing camelina.

Selecting economically preferred options from the cropping alternatives in Table 1 requires comparing returns over variable costs (R_{VC}) of *rotational acres*. For example, R_{VC} of WW-SW-L includes R_{VC} of 1/3 ac each of WW, SW, and L. We will utilize a simple computer tool called linear programming (LP) to accomplish this (see Appendix A for a generic description of LP). An introduction to the general choice process can be illustrated by a simplified example. Assume a HIGH zone farmer has predetermined that WW-SW-spring crop is economically preferable, but is unsure of which spring crop among peas, lentils, garbanzos, canola, or camelina should complete the rotation. Using the data in Table 2, R_{VC} = (Price x Yield) – (Var. Costs) = \$30.33/ac for peas, \$187.38/ac for lentils, and \$189.02/ac for garbanzos, \$121.14/ac for canola, and \$55.84/ac for camelina. A farmer who desires to maximize R_{VC} will select either lentils or garbanzos which have nearly equal net returns.

The data in Table 2 can also distinguish between different concepts of the term "breakeven". The first determines the price that permits an individual crop to breakeven with its variable or total costs. P_{BE} for a particular crop is derived from (1) R_{VC} = (P_{BE} x Yield) – (Var. Costs) = 0. Setting R_{VC} = 0 permits gross revenue to breakeven with variable costs. Solving (1) for breakeven price implies (2) P_{BE} = Var Costs/Yield. For example, P_{BE} for HIGH zone camelina, equals \$142/16.35 = \$8.69/cwt.

However, \$8.69/cwt is *not* the relevant breakeven price for farmers deciding whether or not to grow camelina (or more accurately camelina rotations) in the BCAP program. These growers desire a P_{BE*} that permits camelina to breakeven with the R_{VC} of garbanzos, its stiffest competitor. From the data in Table 2, (3) R_{VC} *for garbanzos* = ($Price_{garbanzos}$ x $Yield_{garbanzos}$) – (Var. $Costs_{garbanzos}$) = \$189.02/ac. To solve for $P_{BE*camelina,}$ set (4) R_{VC} *for camelina* = ($P_{BE*camelina}$) (Yield $_{camelina\,=}$) – Var. $Costs_{camelina}$ = \$189.02/ac. This implies (5) $P_{BE*camelina}$ = (Var. $Costs_{camelina}$ + \$189.02)/ Yield $_{camelina}$. Inserting values for the HIGH zone, $P_{BE*camelina}$ = (\$142 + \$189.02)/16.35 = \$20.25/cwt. As noted earlier, farmers will consider camelina prices to include a 20% risk discount, consequently camelina's price prior to a 20% risk discount would have to equal \$20.25/(1-0.20) = \$25.31. These crop vs crop (or rotation vs rotation) breakevens are efficiently identified by LP.

Both concepts of "breakeven" require the assumption that other variables, except the breakeven variable, remain constant. For example, in the $P_{BE*camelina}$ example, it is assumed that R_{VC} of garbanzos, $Yield_{camelina,}$ and Var. $Costs_{camelina}$ all remain constant. This is a mathematical condition for defining a breakeven adjustment for a single variable.

LP results revealed that WW-SB-G, WW-SB-SF, WW-SF, and WW-SF rotations maximized farmers R_{VC} in the HIGH, MEDIUM, LOW, and ARID zones, respectively. The most competitive, albeit unprofitable, camelina rotations, along with their profit impacts/acre if grown from LP results, were HIGH, WW-SB-C (-$44.30/ac); MEDIUM, WW-C-SF (-$45.03/ac); LOW, WW-C-SF (-$38.23/ac); ARID, WW-C-SF (-$40.02/ac). Expanding the negative profit impacts over the entire E. Washington cropping area yields an annual foregone profit to Washington dryland farmers of $211.5 million. This is likely a conservative estimate because 2011 was a favorable price year for oilseeds.

Table 3 reports P_{BE*}'s, Y_{BE*}'s, and VC_{BE*}'s identified by LP to induce the most competitive camelina rotation to enter the cropping plan by ppt zone. Initially, consider results for the HIGH zone. Table 3 shows the camelina risk-discounted price would need to rise from $12.10/cwt to $20.23/cwt for the best camelina rotation to compete with the overall preferred WW-SB-G rotation. Alternatively, camelina yields would need to grow from 16.35 cwt/ac to 27.36 cwt/ac for the best camelina rotation to breakeven with its competition. Recall BCAP payments averaged $60/ac in LOW and ARID Adams and Franklin Counties and $97.50/ac in HIGH and MEDIUM Spokane, Whitman, and Garfield counties. These subsidies would leave the HIGH zone farmer shouldering only $44.50/ac variable costs ($142 -$97.50). However, Table 3 reports that variable costs should descend to $8.82/ac to enable the most competitive camelina rotation to breakeven with WW-SB-G. The "generous" BCAP subsidy falls short of breakeven by $36.68 ($44.50-$8.82). Given current technology and historic price relationships, the breakeven adjustments in camelina prices, yields, or variable costs seem unlikely.

Table 3. Breakeven (BE*) camelina prices, yields and variable costs from LP

Zone (av. in. ppt/yr)	Price ($/cwt)		Yield (cwt/ac)		Variable Cost ($/ac)		
	Base	P_{BE*}	Base	Y_{BE*}	Base	VC_{BE*}	Base VC - BCAP
HIGH (>17")	12.10	20.23	16.35	27.36	142	8.82	44.50
MEDIUM (15"-17")	12.10	22.08	13.53	26.85	149	-12.13	51.50
LOW (12"-15")	12.10	24.89	8.96	18.45	149	34.20	89.00
ARID (7"-12")	12.10	39.32	4.40	12.96	134	30.43	74.00

Note: BCAP subsidy was $97.50/ac for HIGH and MEDIUM zones and $60/ac for the two drier zones.

Breakeven prices and yields also fall short of the base levels listed in Table 3 for the remaining ppt zones. The ratio P_{BE*}/Base Price rises from 1.67 in the HIGH zone to 3.25 in the ARID zone. Given a rapid descent in base yields as precipitation declines, the ratio (Y_{BE*}/ Base Yield) grows from 1.67 to 2.95 from the HIGH to the ARID zone. The negative VC_{BE*} in the MEDIUM zone implies a grower would require a subsidy in excess of variable costs to compete with the relatively profitable SWWW-SB-SF rotation. In no subregion does subtracting the

BCAP subsidy from base variable costs drive these costs down to VC_{BE*}. This implies that farmers with sharp pencils would remain with their current rotations to maximize net returns despite the seemingly generous BCAP subsidies. This result shows that pure economic considerations explain the lack of participation by Washington farmers in the 2011 BCAP. Furthermore, to overcome farmer risk aversion, camelina prices, yields, and variable costs might have to improve substantially beyond breakeven levels.

Farmer concerns regarding BCAP contracts

To better understand concerns and barriers to enrolling into the BCAP, informal questionnaires were provided to operators at two oilseed conferences held at Odessa and Colfax, WA on January 24 and 26, 2012. Operators were asked to rate their reasons for not participating in the BCAP program in 2011. The primary concerns were the length and complexity of the BCAP, unfamiliarity with the BCAP program at signup, low contract price, lack of confidence in available markets, and other agronomic problems. Operators were also asked to rate their concern about growing camelina in general (without BCAP). The primary concerns were low market prices, lack of confidence in available markets, and various agronomic problems. These concerns, especially those related to prices/markets and yield limitations related to agronomic problems, support the results of the profitability analysis in the preceding section.

Summary and Conclusions

Policymakers and the public have understandable concerns regarding energy substitutes for fossil fuels. These include desires for greater energy independence, stimulation of local economic growth and employment from new investments including biofuel refining, potential growth in state tax revenues, and reduction in greenhouse gasses. However, market intervention to achieve these goals through crop-based biofuels has had a difficult history in terms of farmer acceptance of crop feedstocks, variable business success of biofuel refiners, taxpayer costs, possible disruption in trade relationships based on comparative advantages, and possible reductions in total economic welfare.

Washington's 2011 BCAP program adds another instructive case study. This analysis demonstrated that Washington dryland farmers were rational to decline participation in the BCAP camelina program. They could make more money by remaining with their traditional rotations of soft white winter wheat, edible pulses, and summer fallow. The BCAP subsidies were insufficient to reverse that conclusion. Furthermore, USDA incentives in the form of crop insurance and direct payments for competing crops, and farmers' lack of knowledge for growing camelina, provided powerful risk aversion incentives to remain with traditional crops. Further barriers to BCAP participation were added by the timing, structure, and lack of clarity of the contracts offered to farmers.

This concluding section will provide an illustrative example to trace some of the regional implications of the results of this study. As previously mentioned, "forcing" camelina rotations throughout the cropping area would have caused Washington dryland farmers to forego, without considering BCAP payments, $211.5 million in 2011. Of course, neither farmers nor policy makers would seriously consider such wide scale adoption of camelina. A more reasonable scenario would convert just one region to a camelina rotation. The LOW ppt region is a good candidate because it showed the lowest profit penalty, namely -$38.23/ac, for switching to a camelina rotation. The 2.9 million acre ARID region is a poor candidate because Schillinger et al.'s (2012) results showed a virtual camelina crop failure in the driest of three years production in that region. Switching all 886,367 acres in the LOW region to a SWWW-Camelina-SF rotation would gross ((886,367 ac)/3)*(8.96 cwt/ac) = 2,647,283 cwt/yr. Focusing on biodiesel, for example, at 21 lbs camelina/gal biodiesel (Schahczenski and Griffith, 2009), this production would yield 12,606,110 gallons of biodiesel. This would satisfy 1.26% of Washington's 1 billion gal/yr diesel consumption. Taxpayers would need to compensate farmers *at least* (886,367 ac)*($38.23/ac) = $33,885,810 to induce this production. Further subsidies might be required to overcome farmer risk aversion and to stimulate refinery capacity.

Reviewing a post mortem of Montana's earlier failure to stimulate camelina production is instructive for Washington. Schahczenski and Griffith (2009) enumerated five general barriers to development of a biofuels industry in Montana. (1) There were not sufficiently high oilseed prices for farmers to switch away from their traditional crops. (2) Increases in oilseed prices to induce production could cause offsetting adjustments in niche markets for oilseeds in culinary and cosmetic uses. (3) The "learning curve" to grow a risky new crop is difficult and slow. (4) Government risk management and commodity policies favored traditional crops. (5) Large fluctuations in oilseed prices make it difficult for refiners to plan for future production and sale of biofuels and byproducts.

Eastern Washington possesses some additional disadvantages. Lacking summer rainfall, spring camelina exhibits more yield risk in Washington than in Montana. Secondly, Washington has no biodiesel refineries with camelina experience.[2] The perceived failure of the 2011 camelina BCAP program might provoke lingering doubts among some Washington growers.

Overall, our observations are that for operators in Washington to enroll in the BCAP, the initial step is to provide financial terms that make camelina production profitable to Washington farmers. However, even with enrollment in the BCAP program, sustainability and success of such a program is not guaranteed (as evident by the Montana experience). This is because there remain significant concerns about agronomic problems, risk management, market uncertainties, delivery logistics, and processing capacity/location. Finally, investment in camelina as a feedstock should be tempered by its potential as a feedstock of the future relative to other technologies in development (i.e., algea).

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[2] Fortenbery et al. 2012 report that biodiesel refineries are attracted to larger output markets rather than input supplies.

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Appendix A: Economic Theory Underlying Linear Programming

(Source: Chapter 4, Yoder et al., 2010).

Figure 1 illustrates, for a simple two-crop example, how LP identifies growers' profit maximizing response to market- and/or policy-induced economic incentives. The heavy dark line, C^*-W^*, represents all feasible combinations of canola and wheat that farmers can produce with current technology and resource supplies. Economists refer to this as a short run "production possibilities curve." The 2008 Equal Profit Line in Figure 1 shows hypothetical combinations of canola and wheat that will generate an equal level of profit given current profit margins/unit for each crop. These profit margins/unit are jointly determined by crop prices and production costs. The intersection of the 2008 Equal Profit Line with the vertical axis displays the quantity of all canola that will provide this level of profit. The intersection of this line with the horizontal axis shows the quantity of all wheat that will provide the same profit. Of course, these crop allocations would be infeasible with current technology and resource supplies. They lie outside the hypothetical production possibility curve. Profit in 2008 would be maximized at

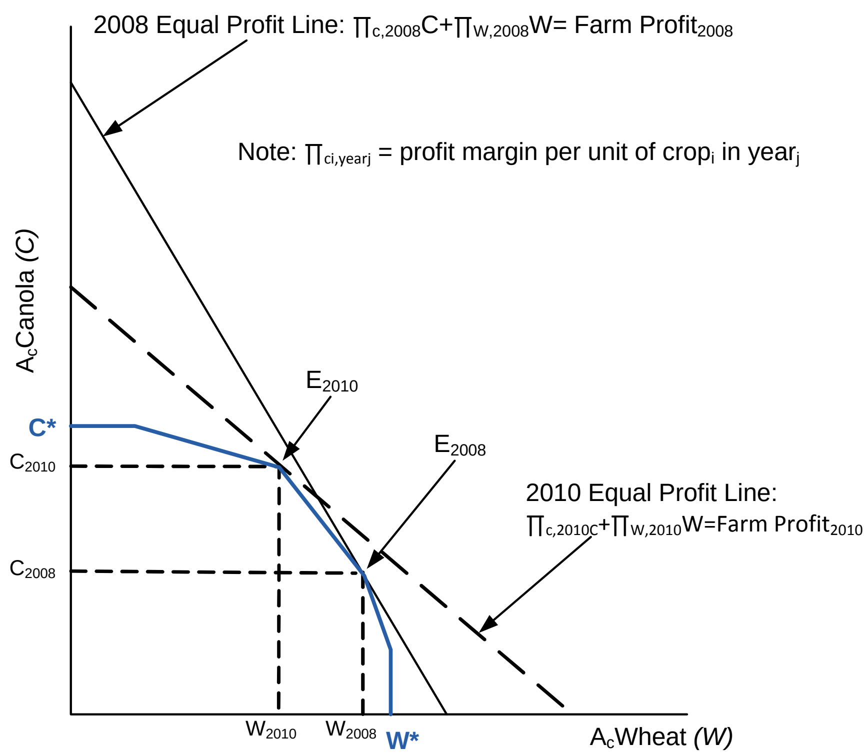

Figure 1: Profit maximizing crop mixtures selected by linear programming for two years with different crop profit margins, but constant technologies and resource supplies

crop mix $E_{2008,}$ with C_{2008} acres of canola and W_{2008} acres of wheat. The 2008 Equal Profit Line is the highest (most northeasterly) profit line that touches the production possibilities curve.

Consider the possibility that by 2010, relative profit margins for canola and wheat move to favor canola. As shown by the intersection of a hypothetical 2010 Equal Profit Line with the vertical axis, it would take fewer acres of the more profitable canola to produce an equal level of profit with only canola. Alternatively, more acres of 100% wheat would be required because wheat becomes less profitable per unit. Like the 2008 case, the scenarios with only one crop don't provide the greatest profit. Profit would be maximized at E_{2010} with a crop mix more heavily weighted to canola.

Figure 1 is simplified by showing a constant production possibilities curve for 2008 and 2010. This might be true for such a short interval of time. However, improvements in production efficiency or expansion of land (e.g., by release from the USDA's Conservation Reserve Program [CRP]) would cause the production possibilities curve to shift outward over part or all of its range. LP can also identify profit-maximizing crop mixes involving many candidate crops and multiple agronomic, marketing, and/or policy limitations to particular crop levels.