

**ASSESSMENT OF BIODIESEL PRODUCTION POTENTIAL IN THE SOUTHEAST:
FINAL REPORT**

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EXECUTIVE SUMMARY

The United States consumes approximately 50 billion gallons of middle distillate fuels (diesel and home heating oil) annually. Biodiesel, which can be made by chemically combining several types of natural oils or fats with an alcohol to form alkyl esters of fatty acids, can be a viable substitute for or additive to petroleum diesel.

This study assesses the role that the Southeastern region may play in supplying feedstock for biodiesel production if demand for biodiesel expands. The study estimates the potential supply of biodiesel feedstock from oilseed crops currently produced in the Southeastern region as well as from oilseed crops that could be incorporated into agricultural production in the Southeast. In addition to examining the current supply potential, the study estimates supply potential that could result from increasing the oil content of vegetable oil seed varieties. The study also estimates the potential supply of biodiesel feedstock from animal fats, based on the current state of the livestock sector in the Southeast, with particular emphasis on the poultry industry. Further the study addresses the impact that greater biodiesel demand would have on the crop and livestock sector in the Southeast as they relate to national agricultural markets in terms of price, land use, and farm income.

Using POLYSYS as the primary methodological tool, the study analyzes hypothetical increases in the demand for vegetable oils for processing up 3.85 million gallons of biodiesel. Simulations are also conducted that examine the potential impacts of introducing oilseed varieties with higher oil content. In addition to considering interactions among major crops currently produced in the Southeast, the study also incorporates introduction of two new oilseed crops in the SERBEP region: sunflower and canola.

The analysis indicates that price increases for oil crops will range between one and four percent, and any significant acreage reallocation will occur in the traditional soybean production areas. The prices of vegetable oils experience a 30 percent increase in the most aggressive scenario considered in the analysis (one percent of U.S. middle distillate fuels contributed by biodiesel). These price increases are not sufficient to bring significant production of sunflower and canola into the SERBEP region. Moreover, impacts on vegetable oil prices are greatest for the scenarios with higher demand for biodiesel and, therefore, substantial biodiesel use could, in effect, make vegetable oils a less attractive feedstock for biodiesel production.

The resulting changes in the crop sector and soybean meal prices do not result in a significant impact in the livestock sector, and therefore in the production of animal fats. However, given the expected growth in broiler production implied in the USDA baseline, significant levels of animal fat production, mainly from chickens, may be available by the year 2007. This additional supply of animal fats could sustain the production of a handful of new biodiesel facilities in the region, most notably in North Carolina, South Carolina, Georgia, and the Alabama-Mississippi-Arkansas sub-region.

The relationship between the prices of vegetable oils and animal fats is not directly addressed in this study. However, it would be fair to assume that given the inflexibility of the supply of animal fats with respect to the price of fat, the animal fat market offers relatively small opportunities to take advantage of any price swings in the vegetable oil markets. At the same time, it is hypothesized that an increase in the supply of vegetable oils – from, for example, the use of high-oil-content seed varieties – could help lower the price of animal fats through increasing the total availability of oils and fats. As prices of animal fats decline, they would become more attractive for use in biodiesel production. The SERBEP region has potential to

contribute to the growth of the biodiesel industry as the volume of animal fat from the poultry sector increases and as the total U.S. supply of vegetable oils increases.

CHAPTER 1: INTRODUCTION

The United States consumes approximately 50 billion gallons of middle distillate fuels (diesel and home heating oil) annually. Biodiesel, which can be made by chemically combining several types of natural oils or fats with an alcohol (usually methanol) to form alkyl esters of fatty acids, most commonly through a process known as transesterification, can be a viable substitute for or additive to middle distillates. Fatty acid alkyl esters that meet stringent transportation fuel quality standards are generally known as biodiesel (Sheehan, et al., 1998; MARC-IV, 1997).

Biodiesel can be used as a pure fuel (neat form) or blended with petroleum in any percentage. A blend of 20 percent by volume biodiesel with 80 percent by volume petroleum diesel (known as B20) has been demonstrated to perform comparably to petroleum diesel with significant environmental benefits and a minimum increase in cost (Howell and Weber, 1995; Franke and Reinhardt, 1998; Sparks Companies, Inc., 1995; Booz-Allen & Hamilton, Inc., 1994; National Biodiesel Board, 1998). Recent amendments to the Energy Policy Act of 1992 approved crediting use of B20 in federal, state, and some private fleets toward meeting alternative fuel vehicle acquisition requirements.

Recent research conducted by the U.S. Department of Energy and the U.S. Department of Agriculture identified a number of advantages to using biodiesel as a substitute for petroleum diesel fuel (Sheehan, et al., 1998). Substituting domestically produced, renewable biodiesel fuel for petroleum-based fuel would reduce U.S. dependence on petroleum imports and also on limited fossil fuels. Because biodiesel works in all conventional diesel engines without modifications and can be distributed through the existing industry infrastructure, it has the

potential to reduce domestic demand for petroleum with minimal investment. Biodiesel has also been shown to reduce the level of greenhouse gas emissions and emissions of particulate matter, carbon monoxide, hydrocarbons, sulfur oxides, nitrogen oxides, and air toxics, compared to petroleum fuels.

A variety of natural oils and fats can be used as biodiesel feedstock, including soybean, corn, cottonseed, peanut, rapeseed, canola, sunflower, and other oilseed crops, recycled cooking oils, and animal fats. Most of the biodiesel in Europe is made from rapeseed oil, while most of the interest in biodiesel production in the United States has focused on soybean oil due to the role of the United States as the world's largest producer of soybean oil. During the 1990s, U.S. production of the major vegetable and marine oils has ranged between 7.0 and 8.5 million metric tons; during 1993-96, soybean oil production was responsible for 75 percent of this production (U.S. Department of Agriculture, 1997a). If all domestically produced oilseeds were crushed for oil, total U.S. vegetable oil production would be approximately 30 billion pounds annually, with approximately 80 percent of all domestic vegetable oil contributed by soybeans. Further, if only 10 percent of the middle distillate fuels consumed in the United States are replaced with vegetable oils, then 35 billion pounds of vegetable oils – an amount greater than present domestic vegetable oil production – are needed. Thus, any large-scale use of vegetable oils for biodiesel can be expected to have significant impacts on crop production.

This study was conducted to assess the role that the Southeastern region may play in supplying feedstock for biodiesel production if demand for biodiesel expands. The study estimates the potential supply of biodiesel feedstock from oilseed crops currently produced in the Southeastern region as well as from oilseed crops that could be incorporated into agricultural production in the Southeast. In addition to examining the current supply potential,

the study estimates supply potential that could result from increasing the oil content of oilseed crops in the Southeast. The study also estimates the potential supply of biodiesel feedstock from animal fats, based on the current state of the livestock sector in the Southeast. Further, the study addresses the impact that greater biodiesel demand would have on the crop and livestock sector in the Southeast as they relate to national agricultural markets in terms of price, land use, and farm income. Specifically, this project provides estimates of:

1. The impacts of increased oil demand for conversion to biodiesel on the production of major crops in the Southeastern United States.
2. The potential for adoption of alternative oilseed crops (canola and sunflower) produced for conversion to biodiesel and the resulting impact on the crop sector in the Southeast.
3. The potential supply of animal fats which could be available in the Southeast region for conversion to biodiesel.

Scope and Study Region

Increasing demand for vegetable oils as a result of increasing biodiesel fuel production can be expected to dynamically affect the domestic crop sector. Further, increased oil demand can be expected to affect feed grain and livestock markets due to increased oilseed crush, which is primarily used for livestock feed. Soybean meal, for example, is the primary U.S. oilseed meal supplement fed to livestock, with cottonseed meal ranked second (Ash, 1992). On the other hand, other oilseed crops (e.g. canola, sunflower, and peanuts) have much higher vegetable oil content (40 to 50 percent) than soybeans (18 percent). Increasing the use of these oilseed crops may have a smaller impact on meal availability and vegetable oil prices than that which would occur if the direct crop market impacts of increased biodiesel production are felt only in the soybean sector.

To account for the linkages between the crop and livestock sectors and the dynamic interactions among crops, this analysis uses a simulation model of the complete agriculture sector to estimate potential impacts of increasing demand for biodiesel fuel feedstock. The crops portion of this study considers nine major crops (corn, grain sorghum, oats, barley, wheat, soybeans, cotton, rice, and peanuts) as well as two alternative oilseed crops (canola and sunflower). The animal fats portion of this study considers tallow from cattle, calves, and sheep as well as lard. The study area is the thirteen-state region comprising the Southeast Regional Biomass Energy Program’s (SERBEP) jurisdiction. The smallest geographic unit of analysis is the Agricultural Statistics District (ASD), depicted in figure 1.

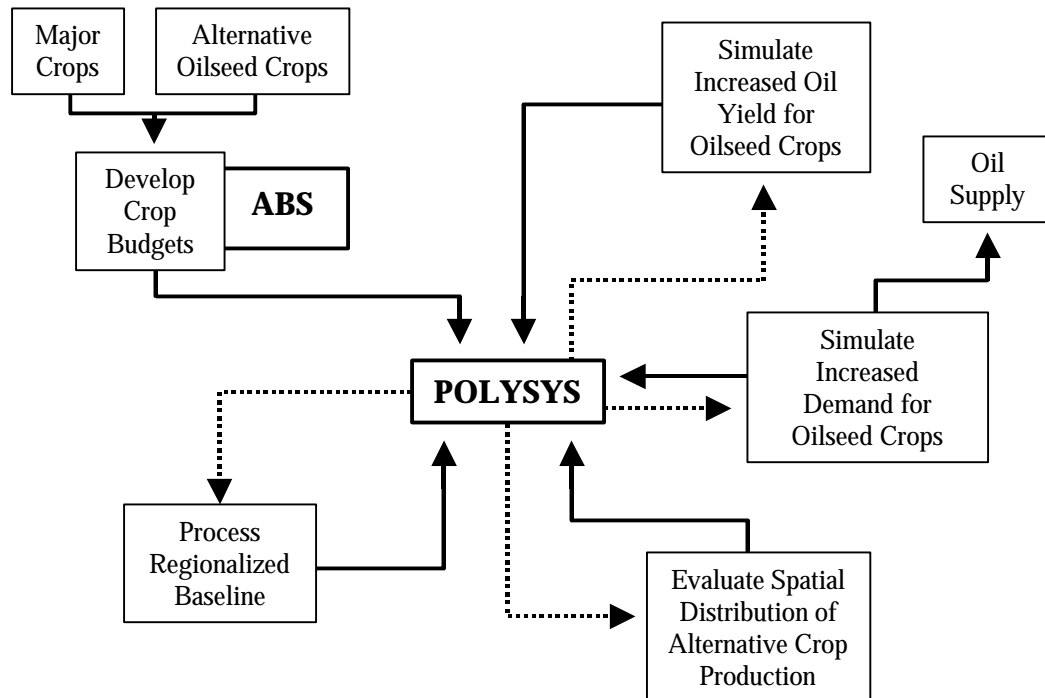
Figure 1. Geographic area included in the analysis.



CHAPTER 2: METHODOLOGY

The general methodology for the crop analysis is illustrated in figure 2. This section first presents the study's general methodological approach to the crops analysis, which begins with the development of enterprise and rotational farm budgets for all crops included in the analysis using the APAC Budgeting System (ABS). These budgets provide input data for the primary analytical model used in the analysis, the Policy Analysis System (POLYSYS) simulation model of the U.S. agriculture sector. Anchored to a baseline of regional projections for the agriculture sector, POLYSYS simulations estimate changes to the baseline that result from different levels of oil demand as well as changes in the oil content of oilseed crops. This section concludes by presenting the methodology for the animal fats portion of the analysis.

Figure 2. General methodology for the crop portion of the analysis.



Crop Sector Analysis

Developing Crop Budgets

The crops portion of this analysis requires the development of enterprise budgets for conventional crops already produced in the study region, as well as for the alternative oilseed crops to be considered: canola and sunflower. These budgets are produced using ABS for use by POLYSYS in the determination of regional crop supplies.

Detailed production information (including accounts of field activities and associated costs) is required at the substate level to support POLYSYS. To meet this need, APAC developed ABS to generate consistent enterprise and rotation budgets for each of the 305 Agricultural Statistics Districts (ASDs) in the continental United States. Several output formats are supported by ABS to meet data input-formatting requirements of various economic models and support specific research projects.

ABS differs from many budgeting systems in that it minimizes user-input requirements, is database-driven, and internalizes technical adjustments. While other budget generators often require users to input technical and cost information before budgets can be produced, ABS generates cost of production data based on detailed operation schedules. To create a budget, users are required to identify and provide ABS with daily field-level activities (e.g., operation schedules). Derived from readily updated sources, internalized databases provide the required technical and cost information that corresponds to the supplied operation schedule. These internalized databases make the process of budget generation more expedient and consistent.

Output for each ABS budget includes a cost summary sheet, operation schedule, labor schedule, and machinery cost table with all expenditures calculated on a per-acre basis. The cost summary sheet lists farm revenues, itemized variable-input costs, and fixed machinery

costs. The operation schedule allows users to readily identify specific field activities by the type of implement used on a given day in the production cycle. Associated machine and labor times are included in the operation schedule, as well as quantities of inputs applied (e.g., fertilizers, chemicals, seed, etc.). The machinery cost table reports variable and fixed costs for each machine, and the labor schedule defines labor requirements by month, quarter, and year. The schedule of operations in each regional crop and rotation budget is based on state Agricultural Extension Service publications whenever possible, and the resolution of information (state or substate level) provided in each budget varies accordingly.

Enterprise and Rotational Budgets for Conventional Crops

Budgets are developed for this study's nine conventional crops – corn, grain sorghum, oats, barley, wheat, soybeans, cotton, rice, and peanuts – for each ASD in the geographic boundaries of the study region. Budgets and other production information are available at the state and substate level and were developed from existing literature, State Extension Service publications and communications, and other sources. A complete list of sources used in development of enterprise and rotational budgets for major crops in the study region is presented in appendix A. For each crop in each region, production and operation data were processed through ABS to develop enterprise and rotational budgets.

Enterprise and Rotational Budgets for Alternative Oilseed Crops

Unlike the nine major crops considered in this study, canola and sunflower have not traditionally been produced in the study region and currently lack a substantial production base. Production characteristics for these alternative crops are provided in table 1. Because of the lack of production data in this region, developing enterprise and rotational budgets for the alternative oilseed crops included in this analysis is somewhat less straightforward.

Table 1. Canola and sunflower area, production, and yield in the study region, 1992.

State	Canola				Sunflower			
	Farms <i>Number</i>	Area <i>Acres</i>	Production <i>Million Lbs.</i>	Yield <i>Lbs/acre</i>	Farms <i>Number</i>	Area <i>Acres</i>	Production <i>Lbs.</i>	Yield <i>Lbs/acre</i>
Alabama	18	2,284	3.43	1,502	4	6	4,000	667
Arkansas	3	na	na	na	7	851	912,610	1,072
Georgia	39	3,141	3.56	1,135	19	985	891,100	905
Kentucky	9	631	0.66	1,050	4	11	na	na
Louisiana	–	–	–	–	6	3,855	5,020,560	1,302
Missouri	11	317	0.24	745	26	1,117	1,177,493	1,054
North Carolina	21	1,303	1.26	968	8	137	105,563	771
South Carolina	19	1,078	1.45	1,348	11	718	642,300	895
Tennessee	7	407	0.43	1,053	5	88	71,121	808
Virginia	12	691	0.95	1,370	6	9	12,300	1,367
Total	139	9,852	11.98	1,216	96	7,777	88,37,047	1,136

Source: 1992 Census of Agriculture

Developing Canola Budgets

In the Southeast, canola is planted in the fall and harvested in late spring/early summer in the northern portion of the region and is a fall-planted annual in the region's southernmost areas (Raymer et al., 1990). Research is under way to develop varieties better suited to the Southeast and, in 1996-97, variety trials were conducted in Alabama, Arkansas, Georgia, Mississippi, Missouri, and Virginia (Rife, 1998). A number of publications are available to help develop crop rotations and budgets for canola in the Southeast (Allelix; Fribourg et al., 1989; Raymer et al., 1990; Rife, 1998; Johnson, 1991). From these sources, state-level budgetary data were obtained for Missouri, Tennessee, Georgia, South Carolina, and Kentucky.

For canola in the study region, the ASDs were evaluated according to (a) the availability of regional data, (b) shared climatic zones, (c) common soil characteristics, and (d) commonality of production methods. From this evaluation, ASDs were aggregated into eight Alternative Crop Production Regions (ACPR), which are illustrated in figure 3.

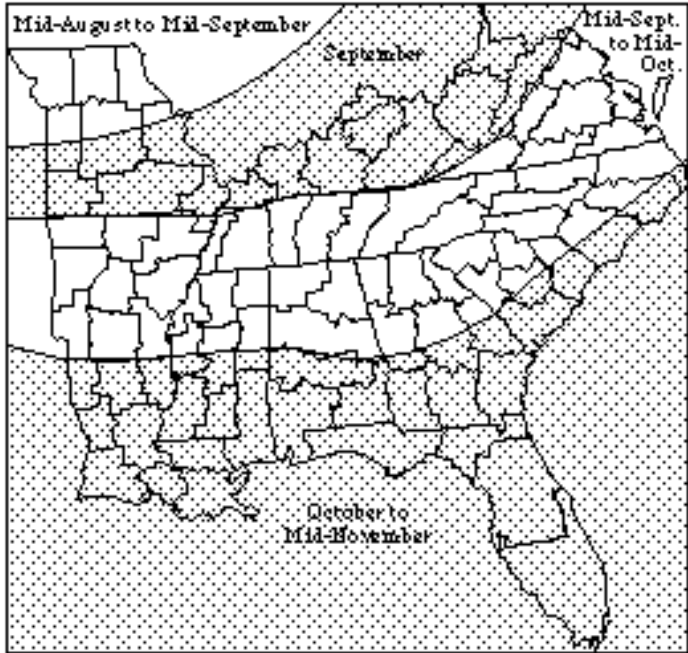
Figure 3. Alternative canola production regions (ACPRs).



For those regions without specific canola information, canola budgets for clay and sandy or loamy soils (Johnson, 1991; Rife, 1998) were used in conjunction with winter wheat budgets as a starting point for budgetary development. Canola yields were regionalized using information provided by Raymer (1998). From the wheat budgets, relative levels of nitrogen, phosphorus, and potassium fertilizer applications are drawn and adjusted upward by 20 percent to 25 percent as suggested by Rife and Salgado (1996).¹ Also, the winter wheat budgets, when adjusted for canola's earlier planting and harvesting time, provide planting and harvesting dates. General canola planting dates are illustrated in figure 4.

¹ In addition to these adjustments, sulfur is added to canola production regimes in the form of a spring application of ammonia sulfate. Boron applications are included in regions with sandy soils.

Figure 4. General canola planting dates in the study region.



Sources: Raymer et al., 1990; Rife and Salgado, 1996; Johnson, 1991; Rife, 1998

In addition to the budgets developed for canola, it has been shown that two factors limit how closely canola and other crops may be grown in rotation (Rife, 1997; 1998). Diseases affecting canola are common to many other crops which could be grown in rotation with canola. Herbicide residual from canola production also limits how closely in time certain crops may be grown in rotation with canola. These factors are not considered in the development of canola budgets; instead these limitations are handled as LP constraints within POLYSYS' crop supply module. An example of a canola budget developed for this study is presented as table 2.

Table 2. Example of a canola enterprise budget.

Commodity	Canola	Tillage	Conventional without Moldboard Plow	Data Year	1996
Previous Crop	Canola	Farm Size	Large	Irrigation	Dry
Region Type	POLYSYS	Region ID	SC-71	Alternate Nutrients	None
Practices	N.A.	N.A.	N.A.		
Category	Name	Units	Quantity	Price/Unit	Amount
Revenue					
Revenue	Canola	LB	3,145.00	0.11	355.38
Subtotal					355.38
Variable Costs					
Seed	Canola Seed	LB	5	3	15
Subtotal					15
Fertilizer & Lime	Urea (44%-46% N)	LB	356	0.175	62.35
--	Muriate of Potash (60% K2O)	LB	166	0.077	12.78
--	Sulfate of Ammonia (20.5%-21.0% N)	LB	7.1	0.093	0.66
Subtotal					75.79
Herbicides	Treflan 4E (Trifluralin)	PT	2	3.71	7.43
--	Poast 1.5L (Sethoxydim)	PT	1	12.49	12.49
Subtotal					19.92
Other	Interest on Operating Capital	AC	1	3.24	3.24
Subtotal					3.24
Machinery	Repairs, Fuel, and Lube	AC	1	20.57	20.57
Subtotal					20.57
Total Variable Expenses					131.28
Returns Above Variable Expenses					224.11
Machinery Fixed					
Machinery Fixed	Depreciation, Interest, Insurance and Housing	AC	1	39.35	39.35
Returns to Land, Labor, Management, and Risk					184.76
Labor					
Labor	Machine Operation (includes setup, etc.)	HR	1.2	5	6.02
Subtotal					6.02
Returns to Land, Management, and Risk					178.74

Table 2, Continued. Example of a canola enterprise budget.

Operation Schedule													
Date		Machine	Tractor	Machine	Labor	Fertilizer		Chemical				Other Inputs	
Mo.	Day	Name	Name	Time	Time	Name	Lbs	Name	Rate	Units	AI/ac	Name	Rate
10	5	Chisel Plow GT15ft	Tractor 2wd 85 hp (diesel)	0.083	0.0913								
10	10	Tandem Disk (reg) 14-18ft	Tractor 2wd 85 hp (diesel)	0.1611	0.2014								
10	10	Spike-tooth Harrow GT25ft	Multiple Operation	0.1611	0								
10	15	Chem Applicator GE30ft (trailer mtd)	Tractor 2wd 85 hp (diesel)	0.0391	0.043			Treflan 4E (Trifluralin)		2 PT	0		
10	20	Dry Fert Spreader (trailer mtd)	Tractor 2wd 85 hp (diesel)	0.0873	0.096	Urea (44%-46% N)	89						
10	20	Dry Fert Spreader (trailer mtd)	--	0	0	Muriate of Potash (60% K2O)	166						
10	20	Dry Fert Spreader (trailer mtd)	--	0	0	Sulfate of Ammonia (20.5%-21.0% N)	5.6						
10	30	Press/Disc or Hoe Drill	Tractor 2wd 85 hp (diesel)	0.1786	0.1964							Canola Seed	5
2	25	Dry Fert Spreader (trailer mtd)	Tractor 2wd 85 hp (diesel)	0.0873	0.096	Urea (44%-46% N)	267						
2	25	Dry Fert Spreader (trailer mtd)	--	0	0	Sulfate of Ammonia (20.5%-21.0% N)	1.5						
3	3	Chem Applicator GE30ft (trailer mtd)	Tractor 2wd 85 hp (diesel)	0.0391	0.043			Poast 1.5L (Sethoxydim)		1 PT	0		
6	24	Combine-2wd (self-prop)	Combine-2wd (self-prop)	0.1984	0.2183								
6	24	Single-axle Truck 2 ton (gas) (self-prop)	Harvest Operation	0.1984	0.2183								

Table 2, Continued. Example of a canola enterprise budget.

Labor Usage			
Month	Labor (hrs/acre)	Month	Labor (hrs/acre)
January	0	April	0
February	0.096	May	0
March	0.043	June	0.436
First Quarter	0.139	Second Quarter	0.436
July	0	October	0.628
August	0	November	0
September	0	December	0
Third Quarter	0	Fourth Quarter	0.628
Year Total			1.204

Table 2, Continued. Example of a canola enterprise budget.

Machine Name	Total Hours Per Acre	Repair Cost Per Hour	Machinery Costs				Cost Per Acre	
			Fuel Cost Per Hour	Lube Cost Per Hour	Cost Per Hour		Fixed	Variable
					Fixed	Variable		
Combine-2wd (self-prop)	0.20	32.75	6.49	0.97	108.33	40.22	21.49	7.98
Spike-tooth Harrow GT25ft	0.16	0.48	0.00	0.00	5.37	0.48	0.87	0.08
Press/Disc or Hoe Drill	0.18	8.87	0.00	0.00	25.62	8.87	4.57	1.58
Chem Applicator GE30ft (trailer mtd)	0.08	3.05	0.00	0.00	11.39	3.05	0.89	0.24
Dry Fert Spreader (trailer mtd)	0.18	1.02	0.00	0.00	4.11	1.02	0.72	0.18
Chisel Plow GT15ft	0.08	4.26	0.00	0.00	11.00	4.26	0.91	0.35
Tractor 2wd 85 hp (diesel)	0.68	2.95	4.75	0.71	6.42	8.41	4.33	5.68
Tandem Disk (reg) 14-18ft	0.16	2.68	0.00	0.00	11.45	2.68	1.85	0.43
Single-axle Truck 2 ton (gas) (self-prop)	0.20	4.32	13.98	2.10	18.75	20.39	3.72	4.05
							39.35	20.57

Developing Sunflower Budgets

Sunflower production in the United States is primarily concentrated in the Great Plains, mainly North Dakota and South Dakota. As shown in table 1, sunflower was grown in 1992 on 7,800 acres in the Southeast with an average yield of 1,136 pounds per acre (USDA, 1995b). The Southeast lacks sunflower varieties specifically developed for the region, and little (if any) research to develop varieties tailored to the Southeast has been identified.² Substantial resources are available for developing enterprise budgets in the study region (Woodruff, et al., 1995; Schneiter, 1997; Myers and Minor, 1993; Raymer, 1998; Raymer, et al., 1988; 1989; 1992; Miller, 1998).

² It is possible that varieties developed for Argentina may be suitable for the Southeastern United States, as the Southeast and the Buenos Aires region of Argentina are considered to have similar climatic characteristics.

Among sunflower production considerations are disease susceptibilities, herbicide limitations, and harvesting. Sunflower is susceptible to *Alternaria* leaf disease and *Sclerotinia* stem rot and, as such, should not be planted more than once every four years (Woodruff, et al., 1995).³ Further, there are no postemergent herbicides labeled for sunflower in Georgia (Woodruff, et al., 1995). Trifluralin, Prowl, and Sonalan are available for use as preplant herbicides incorporated with a cultivator, and cultivation two to three weeks after emergence can be used to control broadleaf weeds. Another consideration is harvest method, as sunflower is harvested with a grain combine using a sunflower head which minimizes the amount of stalks passing through the combine.⁴

To develop sunflower budgets for the study region, it first is assumed that sunflowers would be produced on sandy soils in the study region (Miller, 1998). To determine which ASDs would be appropriate for sunflower production, STATSGO, a soils database, was consulted. An ASD is considered appropriate for sunflower production if a sandy soil is among a particular ASD's four dominant soils.⁵ Regions meeting this criteria are illustrated in figure 5.

³ Note that canola, too, is susceptible to *Sclerotinia* stem rot; thus, neither should be grown separately or in rotation more than once every four years.

⁴ Sunflower may be harvested using a grain head, but harvest losses may be high.

⁵ POLYSYS has the capability of considering as many as four dominant soils in each ASD. These soils are the four soil types which comprise the most land in a particular ASD based on the STATSGO database.

Figure 5. Study region ASDs selected as appropriate for sunflower production.



From this determination, sunflower budgets for Missouri are used as a starting point for the development of budgets for the analysis. The sunflower budgets developed for this analysis assume varieties which are planted as a row crop and require 110 to 120 days to maturity (Miller, 1998). Trifluralin incorporated with two passes of a field cultivator (for a total rate of 0.5 to 1.0 pounds per acre) is used to control grass and some broadleaf weeds (Blamey et al., 1997). Although research by Woodruff (Woodruff, et al., 1995) lists insecticide use in their crop budget (at \$18 per acre), the text states that while sunflower is subject to damage from many insects, such damage occurs only sporadically. An example sunflower budget is presented in table 3.

Table 3. Example of a sunflower enterprise budget.

Commodity	Sunflower Seed, oil type	Tillage	Conventional without Moldboard Plow	Data Year	1996
Previous Crop	Sunflower Seed, oil type	Farm Size	Large	Irrigation	Dry
Region Type	POLYSYS	Region ID	MO-137	Alternate Nutrients	None
Practices	N.A.	N.A.	N.A.		
Category	Name	Units	Quantity	Price/Unit	Amount
Revenue					
Revenue	Sunflower Seed, oil type	LB	1,054.00	0.1	110.67
Subtotal					110.67
Variable Costs					
Seed	Sunflower Seed	LB	3	3.13	9.39
Subtotal					9.39
Fertilizer & Lime	Limestone	LB	660	0.013	8.49
--	N	LB	99	0.405	40.11
--	P2O5	LB	40	0.301	12.04
--	K20	LB	80	0.128	10.27
Subtotal					70.91
Herbicides	Treflan-MTF 4E (Trifluralin)	PT	1	3.68	3.68
Subtotal					3.68
Other	Interest on Operating Capital	AC	1	2.74	2.74
Subtotal					2.74
Machinery	Repairs, Fuel, and Lube	AC	1	29.32	29.32
Subtotal					29.32
Total Variable Expenses					113.3
Returns Above Variable Expenses					-2.63
Machinery Fixed					
Machinery Fixed	Depreciation, Interest, Insurance and Housing	AC	1	54.3	54.3
Returns to Land, Labor, Management, and Risk					-56.93
Labor					
Labor	Machine Operation (includes setup, etc.)	HR	1.95	6.16	12.01
Subtotal					12.01
Returns to Land, Management, and Risk					-68.95

Table 3, Continued. Example of a sunflower enterprise budget.

Operation Schedule													
Date		Machine Name	Tractor Name	Mach. Time	Labor Time	Fertilizer		Chemical			Other Inputs		
Mo.	Day					Name	Lbs	Name	Rate	Unit	AI/ac	Name	Rate
3	15	Chisel Plow GT15ft	Tractor 2wd 100 hp (diesel)	0.083	0.0913								
3	20	Dry Fert Spreader (trailer mtd)	Tractor 2wd 100 hp (diesel)	0.0873	0.096	Limestone	660						
4	5	Tandem Disk (reg) 14-18ft	Tractor 2wd 100 hp (diesel)	0.1611	0.2014								
4	5	Spike-tooth Harrow GT25ft	Multiple Operation	0.1611	0								
4	10	Chem Applicator GE30ft (trailer mtd)	Tractor 2wd 100 hp (diesel)	0.0391	0.043			Treflan-MTF 4E (Trifluralin)	1	PT	0		
4	20	Field Cultivator LT15ft	Tractor 2wd 100 hp (diesel)	0.1471	0.1618								
4	25	Field Cultivator LT15ft	Tractor 2wd 100 hp (diesel)	0.1471	0.1618								
5	5	Dry Fert Spreader (trailer mtd)	Tractor 2wd 100 hp (diesel)	0.0873	0.096	N	33						
5	5	Dry Fert Spreader (trailer mtd)	--	0	0	P2O5	40						
5	5	Dry Fert Spreader (trailer mtd)	--	0	0	K20	80						
5	15	4 Row Planter (regular)	Tractor 2wd 100 hp (diesel)	0.2204	0.2424							Sunflower Seed	3
6	5	Dry Fert Spreader (trailer mtd)	Tractor 2wd 100 hp (diesel)	0.0873	0.096	N	66						
7	1	Row Cultivator LT15ft	Tractor 2wd 100 hp (diesel)	0.2946	0.3241								
9	25	Combine-2wd (self-prop)	Combine-2wd (self-prop)	0.1984	0.2183								
9	25	Single-axle Truck 2 ton (gas) (self-prop)	Harvest Operation	0.1984	0.2183								

Table 3, Continued. Example of a sunflower enterprise budget.

Labor Schedule			
Month	Labor (hrs/acre)	Month	Labor (hrs/acre)
January	0	April	0
February	0.096	May	0
March	0.043	June	0.436
First Quarter	0.139	Second Quarter	0.436
July	0	October	0.628
August	0	November	0
September	0	December	0
Third Quarter	0	Fourth Quarter	0.628
Year Total			1.204

Table 3, Continued. Example of a sunflower enterprise budget.

Machine Name	Machinery Costs							
	Total Hours Per Acre	Repair Cost Per Hour	Fuel Cost Per Hour	Lube Cost Per Hour	Cost Per Hour		Cost Per Acre	
					Fixed	Variable	Fixed	Variable
Combine-2wd (self-prop)	0.198	34.545	6.756	1.013	114.253	42.315	22.669	8.396
4 Row Planter (regular)	0.22	7.515	0	0	23.645	7.515	5.21	1.656
Spike-tooth Harrow GT25ft	0.161	0.629	0	0	6.679	0.629	1.076	0.101
Chem Applicator GE30ft (trailer mtd)	0.039	5.638	0	0	20.131	5.638	0.786	0.22
Dry Fert Spreader (trailer mtd)	0.262	1.883	0	0	6.118	1.883	1.602	0.493
Chisel Plow GT15ft	0.083	4.505	0	0	11.619	4.505	0.964	0.374
Row Cultivator LT15ft	0.295	1.928	0	0	5.041	1.928	1.485	0.568
Tractor 2wd 100 hp (diesel)	1.354	4.246	4.223	0.633	9.481	9.102	12.838	12.325
Field Cultivator LT15ft	0.294	1.339	0	0	4.441	1.339	1.306	0.394
Tandem Disk (reg) 14-18ft	0.161	2.915	0	0	12.438	2.915	2.004	0.47
Single-axle Truck 2 ton (gas) (self-prop)	0.198	5.063	14.545	2.182	21.965	21.79	4.358	4.323
							54.3	29.32

Policy Analysis System (POLYSYS)

POLYSYS is the analytical model used to perform simulations appropriate for the analysis. POLYSYS is composed of national demand (simultaneous block) and regional supply (linear programming) modules of the crop sector, a national livestock supply and demand module, and an agricultural income module. The modeling system includes nine major crops (corn, grain sorghum, oats, barley, wheat, soybeans, cotton, peanuts, and rice), the edible oils and meals sectors, and seven major livestock commodities (beef, pork, poultry, lamb and mutton, turkeys, eggs, and milk). While prices, demand, and other economic variables are estimated at the national level, the supply module allocates production among 305 regions corresponding to ASDs. An overview of POLYSYS is provided in appendix B.

POLYSYS is designed to anchor its analyses to a baseline of projections for all model variables. Thus, POLYSYS estimates are measured as deviations from a baseline, allowing them to be easily interpreted and understood. The benchmark for this study is a ten-year baseline for the agriculture sector developed by the USDA Economic Research Service (ERS). The USDA baseline contains soybean and soybean products but does not contain supply and

demand for cottonseed, peanuts, canola or sunflower. For this analysis, the USDA baseline was modified to include these oilseed commodities. In addition, once the national baseline is established for the simulation period, a POLYSYS baseline simulation is generated to establish regional supply and income parameters under baseline conditions. The POLYSYS national baseline used in this analysis is available in this report in appendix C.

The Soybean Complex in POLYSYS

Currently, only soybean derivative products (oil and meal) are included in the POLYSYS crop derivative products module. The supply of soybean oil and soybean meal is directly calculated from the domestic demand for soybeans for crushing.

As shown in equation 1, the soybean demand for crushing ($SYDCRS^t$) in simulation period t is estimated to be the baseline crush demand ($SYDCRS^b$) adjusted by the demand response due to percentage changes in soybean and corn price over their baseline levels, and the percentage change in the crushing margin for soybeans over its baseline crushing margin, where $SYDPRI$ is the price of soybeans, $CNDPRI$ is the price of corn, $SYCCRM$ is the soybean crushing margin, and ϵ coefficients are elasticities. The crushing demand is further adjusted by a long run adjustment response parameter, I , applied to the difference between the previous period's simulation and baseline soybean demand for crushing. Demand elasticity estimates for soybeans and all other crops in POLYSYS (ϵ coefficients) are presented in table 4.

$$\begin{aligned}
 [1] \quad SYDCRS^t = & SYDCRS^b + e \left[\frac{SYDPRI^t - SYDPRI^b}{SYDPRI^b} \right] \\
 & + e \left[\frac{CNDPRI^t - CNDPRI^b}{CNDPRI^b} \right] \\
 & + e \left[\frac{SYCCRM^t - SYCCRM^b}{SYCDRM^b} \right] \\
 & + I \left[SYDCRS^{t-1} - SYDCRS^{b-1} \right]
 \end{aligned}$$

Table 4. Crop demand module demand elasticities for model crops.

Elasticity Of:	Export Demand	Feed Demand					Crushing Demand			Mill Demand	Ind. Demand	Food Demand
		Own Price	Livstk Index Price	Soy. Meal Price	Livstk Prod'n Index	Corn Price	Own Price	Soybean Crush Margin	Corn Price			
Corn	-0.42	-0.26	0.23	0.05	1.02							
G. Sorg.	-0.50	-0.59	0.66			0.59						
Oats	-0.35	-0.79				0.79						
Barley	-0.50	-1.08				1.08						
Wheat	-0.38	-0.62				0.19					-0.02	
Soybeans	-0.57						-0.27	0.10	0.02			
Cotton	-1.0									-0.05		
Rice	-0.48										-0.26	
Peanuts	-0.40						-1.00					
Sugar Cane	0										-0.05	
Sugar Beets	0										-0.05	
Dry Beans	0										0	

A set of six derivative product demand and price equations are included in the demand system to estimate demand by use, effective supply, price, and a crushing margin. Demand equations relative to soybean products are presented below. Elasticities for soybean derivative product demand are presented in table 5.

Beginning Stocks

Prior to estimation of the crop demand (and crop derivative product demand) system, the crop demand module estimates beginning stocks for a set of soybean products, currently including soybean oil and soybean meal, according to the identity in equation 2. Beginning

Table 5. Demand elasticities for crop derivative products.

Product	Elasticity Of			
	DPDEXP	DPDDOM	DPDDOM	DPDDOM
	With Respect To			
	DPDPRI	DPDPRI	MLIPRI	MLIPDN
Soybean Oil	-0.25	-0.05	-	-
Soybean Meal	-0.61	-0.25	0.19	1.00

stocks for each derivative product in simulation period t ($DPSBEG^t$) are set equal to ending stocks in the previous period ($DPDEND^{t-1}$) through an identity equation:

$$[2] \quad DPSBEG^t = DPDEND^{t-1}$$

Export Demand

Export demand for each derivative product in simulation period t ($DPDEXP^t$) is the baseline estimated export demand for that product ($DPDEXP^b$) adjusted by the demand response due to a percentage change in the price of that product over the baseline price, where the price of the derivative product is $DPDPRI$ and elasticity estimates, e , are provided in table 5, as shown in equation 3:

$$[3] \quad DPDEXP^t = DPDEXP^b \left(1 - e \left(\frac{DPDPRI^t - DPDPRI^b}{DPDPRI^b} \right) \right)$$

Domestic Demand

Domestic demand for each derivative product in simulation period t ($DPDDOM^t$) is the baseline domestic demand adjusted by the demand response due to percentage changes in own price over baseline price, where own price of the derivative product is given by $DPDPRI$. Soybean meal domestic demand is further adjusted by the demand response due to percentage changes in the model livestock index price ($MLIPRI$) and the model livestock index of

production ($MLIPDN$), as soybean meal is used as a component of livestock feed. This is shown in equation 4.

$$[4] \quad DPDDOM^t = DPDDOM^b + e \left[\frac{DPDPRI^t - DPDPRI^b}{DPDPRI^b} + \frac{MLIPRI^t - MLIPRI^b}{MLIPRI^b} + \frac{MLIPDN^t - MLIPDN^b}{MLIPDN^b} \right]$$

Total Utilization

As shown in equation 5, total utilization for each derivative product in simulation period t ($DPDTOT^t$) is the sum of the quantities demanded for export ($DPDEXP^t$), domestic use ($DPDDOM^t$), and other use ($DPDOTH^t$), where *other use* is an exogenously-determined quantity demanded.

$$[5] \quad DPDTOT^t = DPDEXP^t + DPDDOM^t + DPDOTH^t$$

Effective Supply

The effective supply of each derivative product is the sum of production, imports, and beginning (or carryover) stocks, as shown in equation 6. Production is calculated as the baseline level of production ($DPSPDN^b$) plus the product of a conversion factor from whole soybeans to respective oil and meal products ($DPCSOY$) and the change in the crushing demand in simulation period t over the baseline, b , level ($SYDCRS$), as estimated in the model crops portion of the demand module. Imports of each product ($DPSIMP$) are exogenously determined and beginning stocks are given by $DPSBEG^t$ as estimated in equation 2.

$$[6] \quad DPSEFF^t = \left[DPSPDN^b + DPCSOY (SYDCRS^t - SYDCRS^b) \right] + DPSIMP^t + DPSBEG^t$$

Price

Equation 7 presents the equation used to estimate the price of each derivative product. Similar to the estimation of price in the crop demand portion of the demand module, simulated prices in simulation period t ($DPDPRI^t$) in the derivative products portion of the demand system are estimated by adjusting the baseline price ($DPDPRI^b$) by the product of the percentage change in supply and a price flexibility coefficient, where $DPSEFF$ is effective supply of the derivative product, $DPDTOT$ is total demand, and price flexibilities ($DPDPFX$) are presented in table 6.

$$[7] \quad DPDPRI^t = DPDPRI^b + DPDPFX \frac{(DPSEFF^t - DPSEFF^b) - (DPDTOT^t - DPDTOT^b)}{DPSEFF^b}$$

Table 6. Price flexibilities for crop derivative products.

Product	Price Flexibility for Stock-to-Use Ratio of										
	< 0.005	0.005 - 0.0075	0.0075 - 0.01	0.01 - 0.015	0.015 - 0.020	0.020 - 0.05	0.05 - 0.08	0.08 - 0.10	0.10 - 0.12	0.12 - 0.15	> 0.15
Soybean Oil	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.25	-0.75	-0.5	-0.25	-0.0
Soybean Meal	-2.25	-1.9	-1.55	-1.2	-0.85	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5

Crushing Margin

A crushing margin for soybeans in simulation period t ($SYCCRM^t$), with oil and meal derivative products, is estimated as the sum over all products of the price of the product ($SODPRI$ for soybean oil and $SMDPRI$ for soybean meal) multiplied by the conversion factor from soybeans to that derivative product, ($SOCISOY$ for soybean oil and $SMCSOY$ for soybean meal).

meal) and multiplied by a production units conversion factor (ψ) if necessary, as shown in equation 8.

$$[8] \quad SYCCRM^t = SODPRI^t \delta_{SOC} SOY | y_{SO} + SMDPRI^t \delta_{SMC} SOY | y_{SM}$$

Ending Year Inventories

Upon the demand module's estimation of demands and prices for model crops and derivative products, ending year inventory for each model crop in simulation period t ($CRDEND^t$) is calculated as the effective supply for that crop ($CRSEFF^t$, as estimated in the crop supply module) less the total demand for all uses of that crop ($CRDTOT^t$). Similarly, ending inventory for crop derivative products ($DPDEND^t$) is calculated as the effective supply ($DPSEFF^t$, as estimated in the crop demand module) less the total demand for all uses of that product ($CRDTOT^t$), according to equation 9.

$$[9] \quad \begin{aligned} CRDEND^t &= CRSEFF^t - CRDTOT^t \\ DPDEND^t &= DPSEFF^t - DPDTOT^t \end{aligned}$$

Example: Estimating Demands and Prices for Soybeans

Although the crop demand module solves for demands and prices for all model crops and model crop derivative products simultaneously, presentation of the relevant crop demand equations for soybeans may serve as a useful example. Following are the demand system equations relevant for soybeans, with elasticities, long-run adjustment coefficients, and price flexibilities inserted.

Export Demand

Soybean export demand ($SYDEXP^t$) is the baseline export demand adjusted by the product of the soybean export demand elasticity with respect to soybean price and the percentage

change in soybean price over the baseline level ($\%DSYDPRI^t$). There is no long run adjustment made to the baseline price since the soybean adjustment coefficient is zero. Export demands for soybean products are calculated similarly. Export demand equations for soybeans ($SYDEXP^t$), soybean oil ($SODEXP^t$), and soybean meal ($SMDEXP^t$) are presented in equation 10.

$$\begin{aligned}
 SYDEXP^t &= SYDEXP^b \left[1 - 0.57(\% \Delta SYDPRI^t) \right] + \left[0.0 (\Delta SYDEXP^{t-1}) \right] \\
 [10] \quad SODEXP^t &= SODEXP^b \left[1 - 0.25(\% \Delta SODPRI^t) \right] \\
 SMDEXP^t &= SMDEXP^b \left[1 - 0.61(\% \Delta SMDPRI^t) \right]
 \end{aligned}$$

Crushing Demand

As shown in equation 11, crushing demand for soybeans ($SYDCRS^t$) is calculated as the baseline crushing demand adjusted by the impacts of changes in soybean price ($\%DSYDPRI^t$), soybean crushing margin ($\%DSYCCRM^t$), and the price of corn ($\%DCNDPRI^t$). Again, there is no long run adjustment made to the baseline crushing demand since the soybean crushing demand adjustment coefficient is zero.

$$[11] \quad SYDCRS^t = SYDCRS^b \left\{ \begin{array}{l} - 0.27(\% \Delta SYDPRI^t) \\ + 0.10(\% \Delta SYCCRM^t) \\ + 0.02(\% \Delta CNDPRI^t) \end{array} \right\} + \left[0.0 (\Delta SYDCRS^{t-1}) \right]$$

Crushing Margin

The soybean crushing margin ($SYCCRM^t$) is estimated as the price of soybean oil ($SODPRI^t$) multiplied by the conversion factor from soybeans to soybean oil ($SOCISOY$) added to the product of the soybean meal price ($SMDPRI^t$) and the conversion factor from soybeans

to soybean meal (*SMCSOY*), which must be divided by 2000 to convert meal units to oil units. The equation for soybean crushing margin is presented in equation 12.

$$[12] \quad SYCCRM^t = \frac{SODPRI^t | \Delta SOC SOY | + SMDPRI^t | \Delta SMCSOY |}{2000}$$

Domestic Demand (Soybean Products)

An equation is not required to estimate domestic demand for soybeans since domestic demand is identical to the crushing demand for soybeans, as they are not utilized for feed, milling, or industrial uses. Domestic demand for soybean oil (*SODDOM^t*) is calculated as the baseline demand adjusted by the impact of the percentage change in own price (*%DSODPRI^t*). Soybean meal is primarily used as a feed ingredient, so its domestic demand (*SMDDOM^t*) is its baseline level adjusted by the impact of the percentage change in its own price (*%DSMDPRI^t*), the percentage change in the model livestock price index (*%DMLIPRI^t*), and the percentage change in the model livestock production index (*%DMLIPDN^t*). These equations are presented in equation 13.

$$[13] \quad \begin{aligned} SODDOM^t &= SODDOM^b \left[1 - 0.05 (\% \Delta SODPRI^t) \right] \\ SMDDOM^t &= SMDDOM^b \left[-0.25 (\% \Delta SMDPRI^t) + 0.19 (\% \Delta MLIPRI^t) + 1.00 (\% \Delta MLIPDN^t) \right] \end{aligned}$$

Total Utilization

Total utilization of soybeans (*SYDTOT^t*), soybean oil (*SODTOT^t*), and soybean meal (*SMDTOT^t*) are each the sum of demand for utilization as exports, domestic demand, and other demand uses, as shown in equation 14. Note that an equation was not required for estimation of domestic demand for soybeans since domestic demand is identical to the crushing demand for soybeans.

$$\begin{aligned}
[14] \quad & SYDTOT^t = SYDEXP^t + SYDCRS^t + SYDOTH^t \\
& SODTOT^t = SODEXP^t + SODDOM^t + SODOTH^t \\
& SMDTOT^t = SMDEXP^t + SMDDOM^t + SMDOTH^t
\end{aligned}$$

Effective Supply (Soybean Products)

Production of soybean oil and meal is estimated as the baseline production level adjusted by the change in the soybean crushing demand over baseline levels multiplied by the soybean to derivative product conversion factor. The effective supply of soybean oil and meal is the sum of the production level of each product, imports (exogenous), and beginning stocks (previously estimated by the demand module). This is presented in equation 15, where soybean oil variables have a prefix of *SO* and soybean meal variables have a prefix of *SM*; effective supply is given by *SEFF*, conversion from soybeans to the derivative products is given by *CSOY*, demand for crushing is given by *DCRS*, imports are given by *SIMP*, and beginning stocks are given by *SBEG*.

$$\begin{aligned}
[15] \quad & SOSEFF^t = [SOSEFF^b + SOC SOY (\Delta SYDCRS^t)] + SOSIMP^t + SOSBEG^t \\
& SMSEFF^t = [SMSEFF^b + SMC SOY (\Delta SYDCRS^t)] + SMSIMP^t + SMSBEG^t
\end{aligned}$$

Price

Soybean (soybean product) price is calculated as the baseline price adjusted by the price impacts of the change in soybean (soybean product) supply over the baseline level. The price impact is the percentage change in the difference between the supply change and demand change over baseline levels multiplied by the appropriate price flexibility, which is determined by the stocks-to-use ratio. If the soybean stock-to-use ratio is 0.12 for soybeans, 0.09 for soybean oil, and 0.007 for soybean meal, then the corresponding price flexibilities would be -

2.4, -0.75, and -1.90 respectively, and soybean and soybean product prices would be calculated as:

$$\begin{aligned}
 [16] \quad SODPRI^t &= SODPRI^b + 0.09 \frac{\Delta SOSEFF^t - \Delta SODTOT^t}{SOSEFF^b} \\
 SMDPRI^t &= SMDPRI^b + 0.007 \frac{\Delta SMSEFF^t - \Delta SMDTOT^t}{SMSEFF^b},
 \end{aligned}$$

where soybean oil variables have a prefix of *SO* and soybean meal variables have a prefix of *SM*; price is given by *DPRI*, effective supply is given by *SEFF*, and total demand is given by *DTOT*.

Ending Year Inventory

Finally, ending year inventories for soybeans ($SYDEND^t$), soybean oil ($SODEND^t$), and soybean meal ($SMDEND^t$) are calculated as the effective supply less the total utilization in simulation year t , as shown in equation 17:

$$\begin{aligned}
 [17] \quad SYDEND^t &= SYSEFF^t - SYDTOT^t \\
 SODEND^t &= SOSEFF^t - SODTOT^t \\
 SMDEND^t &= SMSEFF^t - SMDTOT^t
 \end{aligned}$$

The use of POLYSYS allows the estimation of changes in supply, production, and price over a ten-year time period. The advantage of using POLYSYS for this analysis is that estimation of supply and price changes in oilseeds occurs amid interactions with the major crops in the Southeast and amid interactions with the livestock sector. Of concern in such an analysis is the interaction between soybean oil demand and new plantings of other crops. This analysis incorporates several crops currently lacking both a significant production base and crushing facilities in the Southeast. New oilseed crop production is influenced heavily by the presence of crushing facilities and, in turn, crushing facility investment is based on a clear demand for the products extracted from these crops. This concern is addressed in the following manner:

- For crops without a production base in the Southeast, production and budget information are used to simulate any changes in acreage and production that may occur under a range of demand levels. This first step assumes crushing facilities are not a constraint.
- By reviewing the results, the level and geographic concentration of production in the Southeast under different price levels can be compared. Conversion of oilseed production to biodiesel can be addressed using ratios which embed conversion losses.

Thus, demand parameters for other oilseed crops with a potential for biodiesel production (e.g., sunflower, rapeseed/canola) will be estimated and introduced into POLYSYS. Once these items are installed in POLYSYS, alternative demand scenarios for vegetable oils for use in biodiesel will be defined and simulated for the entire United States to estimate the price impacts of incremental use on the Southeast.

Analytical Scenarios

Upon establishment of the baseline and aggregation by region, scenarios examining changes in the demand for vegetable oils and resulting demand for oilseed crops are developed and simulated using POLYSYS. The first simulation in each scenario deals primarily with the increase in demand for soybean oil for biodiesel production assuming oilcrop producers (including producers of soybeans, canola, sunflower, and peanuts) continue using current-oil-content seeds. To examine the impact of changes in the oil content of oilseeds, an additional set of simulations examining the effects of higher oil content on oilseed production is devised and simulated. This simulation also estimates the impact of increased demand for soybean oil but assumes producers use higher-oil-content seeds for soybeans, canola, sunflower, and peanuts. A summary of the scenarios and respective simulations used in this study is provided in table 7.

Table 7. Oil demand and oilseed yield scenarios used for simulations.

Scenario	Simulation	Description
1	1a	Demand assumed in 1996 ERS/USDA study
	1b	Scenario 1a plus increased oil yields
2	2a	Twice the demand in scenario 1
	2b	Scenario 2a plus increased oil yields
3	3a	One percent of U.S. middle distillate fuels consumption by biodiesel
	3b	Scenario 3a plus increased oil yields

The analytical scenarios were developed using the 1996 ERS/USDA study conducted by Ranese, Glaser, and Price, which considered a potential demand of up to 100 million gallons of soybean-oil-based biodiesel from three niche markets (Ranese, et al., 1996). The niche markets examined in the study included federal fleets, mining, and marine environments. A blend containing 20% biodiesel (B20) was assumed. Simulations 1a and 1b assume the demand level found in the ERS/USDA study.

In order to evaluate the production possibilities in the SERBEP region, alternative simulations designed for this study create a larger shock than the one implicit in the ERS/USDA study. Thus, simulations 2a and 2b imply twice the demand for oil assumed by Ranese, Glaser, and Price – 200 million gallons of biodiesel or 1.54 billion pounds of soybean oil. Scenarios 3a and 3b assume one percent of total diesel use is replaced by biodiesel. This implies soybean oil demand of 3.85 billion pounds. The three scenarios are designed to achieve their respective targets by the year 2005, with initiation in 1998 and equal shifts in the demand curve for each year.

The “b” series of simulations simply addresses the issue of potential oil yield improvements in oilseed crops beginning in 2002. For example, the oil content of peanuts in a collection of wild germplasm ranged from 46 percent to 63 percent and in cultivars from 44

percent to 56 percent (Knauft, et al., 1987). Any changes in prices resulting from altered seeding practices were not included in the analysis. It also appears feasible to develop oil yield improvements in sunflower, canola, and soybeans (Fick and Miller, 1997; Auld, 1986; Wilson, 1987; KeShaun, 1997; Gresshoff, 1998). Future expected value of oilseed oil and meal are presented in table 8.

Table 8. Present and expected future value of oil and meal in oilseeds.

Oilseed	Present		Future	
	<i>Oil</i>	<i>Meal</i>	<i>Oil</i>	<i>Meal</i>
Canola	39.9%	58.0%	55.0%	42.9%
Peanuts	42.5%	52.1%	55.0%	39.6%
Soybeans	18.4%	70.6%	22.0%	67.0%
Sunflower	42.0%	46.8%	55.0%	33.7%

^a Yield without shells (shelled), which is 75% that with shells.

Sources: Knauft et al., 1987; Fick and Miller, 1997; Auld, 1986; Gresshoff, 1998.

Three hypotheses will be evaluated using the six simulations described. The first assumes that if soybean oil price rises, meal price will decline. Further, if the value of soybean oil per unit of soybeans (bushel) offsets the decrease in value of soybean meal, then the effect for farmers will be increased soybean crushing and thus an increase in soybean price. The second hypothesis assumes that, depending on the prices of soybeans, other crops will be impacted. The final expected result of increased demand for soybean oil states that, since the price of canola and sunflowers are linked to the price of other oils and soybeans, as the price of oil and soybeans increases, canola and sunflower prices should increase as should their plantings. However, increased canola and sunflower production may also drive the price of soybeans and their byproducts down. The expected results remain the same for the “b” set of simulations.

Animal Fats Analysis

Estimating the Supply of Animal Fats

Animal fats are also a potential source of feedstock for biodiesel production, though their supply is determined indirectly by the demand for meat. Research in this area has focused on tallow and greases due to their low prices and changes in domestic consumer preferences for vegetable versus animal fats. Literature on the use of lard in biodiesel production is scant. Tallow-derived fuels, on the other hand, have been the subject of research into their efficacy and effects on diesel engines (University of Idaho, 1994; Lepori, et al., 1992) and their potential cost and supply (Nelson, et al., 1994, Ahouissoussi and Wetzstein, 1995).

Among the limitations of animal fats for use in biodiesel fuels is the nature of their supply. The supply of animal fats is subject to the traditional livestock cycles of herd contraction and expansion. At the same time, the supply of animal fats depends on the slaughter rates of livestock, which are influenced by livestock and feed prices. There is no indication in the scientific literature that prices of animal fats have an influence on livestock slaughter levels. A second limitation is the competing uses for fats (livestock feed, cosmetics, etc), and another is the quantity of feedstock required for production. A typical biodiesel plant requires sufficient feedstock to produce at least 750,000 gallons of biodiesel per year (Burnham, 1992).⁶ The largest portion of U.S. livestock slaughter, however, occurs outside the 13-state SERBEP region.

While national data on lard and tallow production are available, these data are not available at the state or regional level. Thus, the starting point for estimating the potential supply of

animal fats in the SERBEP region (and, by extension, the potential supply of fat-derived biodiesel) is livestock slaughter data from the U.S. Department of Agriculture's National Agricultural Statistics Service (USDA/NASS, various years). These monthly and annual data are available at the state level for cattle, calf, hog, and sheep slaughter, although some data are not reported to avoid disclosure of proprietary information.

Further, working from data for a given year neglects the traditional livestock cycles of herd contraction and expansion.⁷ During 1995 and 1996, for example, the cattle sector as a whole experienced significant herd reduction as tight grain supplies forced feed grain prices up. While the cattle cycle typically runs from eight to ten years, four years of data (1994-97) were obtained for this analysis to capture a significant portion of the most recent cycle, which began its expansion phase in 1991.

While the rendering industry has been processing animal fats from the poultry industry, this has not been considered among the traditional sources of animal fats. This may be due in part to the lack of published statistics, or perhaps because poultry has not previously obtained status as a mature industry. However, fats from poultry do have similar characteristics as tallow and lard, and therefore could be used as inputs in many industrial processes. It is precisely in the poultry sector in which the SERBEP region has a comparative advantage, given that 75% of the national broiler production is located in the region. Although, there are no published statistics on the production of chicken fat, it is approximated in this study by using published poultry production figures and applying live-weight-to-fat yield coefficients. While Benoff, Hudspeth and Lyon (1981) reported a 2.4% yield of animal fat from a pound of live weight

⁶ Burnham suggests that typical European biodiesel plants process 3 to 10 million gallons per year, compared to U.S. biodiesel plants, which typically average 2 million gallons per year, in response to commercial markets.

animal, Smith (1999) indicated that a more likely factor would be 1.7%, taking into account the recent emphasis consumers and the broiler industry (since 1981) have placed on production and consumption of a leaner animal.

Conversion factors are used to estimate the lard and tallow produced by cattle, hogs, and sheep, as well as animal fat from chickens. Table 9 lists and provides sources for the conversion factors used in this study.

Table 9. Conversion factors used in the animal fats analysis.

Conversion Factor	Value	Source
Edible tallow per 1,000 pounds of liveweight cattle	12.9 lbs.	USDA AMS
Inedible tallow per 1,000 pounds of liveweight cattle	45.0 lbs.	USDA AMS
Average lard per slaughtered hog	10.8 lbs.	Southard, 1998
Average fat yield per slaughtered sheep	17.0 %	Franco, 1998
Fat to tallow conversion for sheep	0.75	Duewer, 1998
Chicken fat per pound of live weight of poultry	1.7 %	Smith, 1999

It should be noted that USDA stopped publishing animal-specific fat estimates toward the end of the 1980s. Finally, while animal-specific estimates are available for cattle and hogs, a more generic fat yield provided by the National Renderers Association (Franco, 1998) is used to estimate sheep tallow. Lacking information from the sheep industry regarding tallow yield, the sheep fat-to-tallow conversion factor in table 9 actually is a factor USDA uses for hogs.

Once the potential tallow and lard production is estimated, implicit biodiesel conversion factors for edible and inedible tallow categories from research conducted by Nelson (Nelson, et al., 1994) are used to estimate the supply of biodiesel from the total production of tallows in the 13-state region. The esterification process produces methyl esters (which can be used

⁷ Generally, several years are necessary for herd expansion while herd reduction can occur in the space of a single year.

directly in most diesel engines) and a glycerine by-product which can be sold separately. For this analysis, it is assumed that what remains after esterification is glycerine.

Relating Supply of Animal Fats to the Crop Sector

Due to the dynamic relationship between the crops and livestock sectors (through feed grains), this study uses the POLYSYS model to estimate changes in livestock production – which may affect supply of animal fats for biodiesel feedstock – that result from simulating the scenarios previously described examining expansion of demand for vegetable oils for biodiesel. Following is a description of the equations that POLYSYS uses to estimate livestock production.

Livestock production cycles generally exceed one year, so that current production levels are determined in part by production decisions that were made based on price expectations and other production decision influences in place at an earlier time. A POLYSYS simulation, then, begins by estimating livestock production levels, which are a function of baseline and predetermined (or lagged) prices, production, and other production shifting factors. The livestock module initially estimates national production for each of the seven livestock categories (cattle, hogs, poultry, sheep, turkeys, eggs, and milk) from baseline variables, lagged livestock price variables, lagged feed and input price index variables, and production elasticities. This is shown in equation 18, where percentage change variables are the percentage change in the value in the previous year ($t-1$) over the baseline value in the previous year ($b-1$), the h variables are production elasticities, and the I variable is a long run production adjustment factor.

$$\begin{aligned}
LVSPDN^t = LVSPDN^b * & \\
[18] \quad & \left(\begin{aligned}
& + \mathbf{h}_{LV,LV} \left(\% \Delta LVDPRI^{t-1} \right) + \mathbf{h}_{LV,BF} \left(\% \Delta BFDPRI^{t-1} \right) \\
& + \mathbf{h}_{LV,PK} \left(\% \Delta PKDPRI^{t-1} \right) + \mathbf{h}_{LV,LM} \left(\% \Delta LMDPRI^{t-1} \right) \\
& + \mathbf{h}_{LV,IPIFED} \left(\% \Delta IPIFED^{t-1} \right) + \mathbf{h}_{LV,IPIOTH} \left(\% \Delta IPIOTH^{t-1} \right) \\
& + \mathbf{I}_L \left(\Delta LVSPDN^{t-1} \right)
\end{aligned} \right)
\end{aligned}$$

Production of a livestock commodity in year t ($LVSPDN^t$) is the baseline production level ($LVSPDN^b$) adjusted up or down by the sum of the production responses due to the previous year's percentage change in own price, beef price, pork price, lamb and mutton price, input price index for feed, and input price index for other production inputs, and adjusted for the long-run production response. Production elasticity coefficients for each livestock category are presented in table 10 and the long-run Nerlovian distributed lag production adjustment coefficients are presented in table 11.

Table 10. Direct and cross supply elasticities for model livestock categories.

Production Response of	With Respect to Percentage Change in Lagged					
	Own Price	Beef Price	Pork Price	Lamb-Mutton Price	Feed Price Index	Input Price Index
Beef	0.38	-	-0.04	-0.01	-0.11	0
Pork	0.30	-0.20	-	0	-0.25	0
Lamb-Mutton	0.14	-0.001	-0.005	-	-0.14	0
Broilers	0.31	0	0	0	-0.26	0
Turkeys	0.57	0	0	0	-0.35	0
Eggs	0.20	0	0	0	-0.16	0
Milk	0.15	0.10	0	0	-0.10	0

Table 11. Long run production adjustment coefficients for model livestock categories.

	Beef	Pork	Lamb & Mutton	Broilers	Turkeys	Eggs	Milk
Long-Run Adj. Coefficient (λ_L)	0.536	0.60	0.60	0.75	0.75	0.85	0.60

CHAPTER 3: CROP ANALYSIS RESULTS

The objective of this chapter is to report the changes introduced in POLYSYS to model the supply and demand of new oil seed crops, and also to report the results from processing the scenarios described in the previous chapter. The analysis of the results includes national and SERBEP region analysis.

POLYSYS Expansion

In the crop supply module, activities that represent the production of sunflower and canola for the POLYSYS regions previously identified were introduced in each of the regional linear programming models. These linear programming models allocate land use by ASD through the maximization of expected net returns per acre. Expected net returns are calculated using ABS, following the methodology presented in chapter two.

To overcome the deficit of information to estimate the demand parameters for sunflower and canola, this study estimates a price function for each of these crops. These estimated equation for the price of sunflower is presented in equation 19 and the estimated equation for the price of canola is presented in equation 20.

$$[19] \quad P_{sunflower}^t = -1.7 * P_{Soyoil}^{0.30t-1} * P_{Soymeal}^{0.33t-1} * P_{Soybeans}^{0.75t-1}$$

$$[20] \quad P_{canola}^t = 0.99 * P_{Soyoil}^{0.207t-1} * P_{Soybeans}^{0.408t-1}$$

A key assumption in the analysis is that the meal from canola and sunflower can be expressed in terms equivalent to soybean meal after taking into account the differences in the protein content of each meal source. It is also assumed that the oils from the different oilseeds

are near perfect substitutes, thereby ignoring any specialized uses of these oils, which is consistent with the type of analysis intended in this study.

The above assumption allows POLYSYS to express the total supply for oils and meals as changes in the supply of soybean meal and oil and, therefore, directly impact the stock-to-use ratio of these products and their consequent prices. These relationships are expressed in equations 20 and 21.

$$\begin{aligned}
 [20] \quad \text{Supply}_{meal} &= \text{SoybeanMeal} + \text{CottonseedMeal}_{\text{SoybeanMealEquiv.}} \\
 &+ \text{PeanutMeal}_{\text{SoybeanMealEquiv.}} + \text{SunflowerMeal}_{\text{SoybeanMealEquiv.}} \\
 &+ \text{CanolaMeal}_{\text{SoybeanMealEquiv.}}
 \end{aligned}$$

$$\begin{aligned}
 [21] \quad \text{Supply}_{oil} &= \text{SoybeanOil} + \text{CottonseedOil} + \text{PeanutOil} + \\
 &\text{SunflowerOil} + \text{CanolaOil}
 \end{aligned}$$

Because the price of soybeans is linked to the price of meal and oil, it will be affected by changes in the prices of both of these by-products. At the same time, given the equations above, the prices of canola and sunflower will also change as the prices for soybeans, soybean meal, and soybean oil change. In the case of cotton and peanuts, the other two oilcrops considered in this study, it is assumed that their prices are not directly linked to the meal and oil markets, but to the lint and peanut/peanut butter markets. Moreover given the peanut quota system, changes in the production of peanuts in the SERBEP region are unlikely.

Analysis of Results

To interpret these results, one must bear in mind the logic underlying the interaction among soybeans, soybean oil and meal, and other crops – especially other oilseed crops. When demand for soybean increases, signaling an increase in the price of soybean oil, greater supplies of soybean meal are also created. Since the domestic market cannot be expected to absorb the extra quantities of soybean meal, alternative markets are sought, but ultimately its

price decreases. If the increased value of soybean oil per unit of soybeans offsets the decrease in value of soybean meal then the outcome for farmers will be increased crushing margins and increased prices. The opposite occurs if the decreased value of soybean meal is greater than increased value of soybean oil.

Depending on the relative magnitude of the change in the price of soybeans, other crops will also be affected. If more farmers opt to plant higher-priced soybeans, then the amount of alternative crops planted, such as corn, will decrease, driving its per-unit price up. The production and price of canola and sunflower are also linked to the price of soybeans and soybean oil. As the price of oil and soybeans increases, canola and sunflower prices should increase as should their plantings. However, increased sunflower and canola plantings could drive the price of soybeans, soybean oil, and soybean meal down. Conversely, increased soybean oil production at marketable prices could discourage the production of both sunflower and canola because their prices under such a situation would not warrant their production. Cotton, for the most part, is excluded from this interaction because of the high value of the fiber it produces. Peanuts are not affected by an increase in soybean oil production for biodiesel purposes because they are grown almost exclusively under quota.

Output data from POLYSYS simulations are presented in appendix D. Tables 12, 13, 14, 15, and 16 provide an overview of the results of the three scenarios. Table 12 presents biodiesel demand in pounds for each scenario in each simulation year. Table 13 provides the ending stock levels for soybean oil, the major source of vegetable oil and driving element of the price change. Table 14 presents the baseline and simulated average market prices for soybean oil and meal for the six simulations and 10 years included in the analysis. Baseline and scenario prices for the major crops (corn, grain sorghum, oats, barley, wheat, soybeans, cotton,

rice, sunflower, and canola) during 2007 are shown in table 15, and table 16 provides baseline and scenario planted acreage information for the major crops for each of the 10 simulation years. Following this is a more detailed discussion of the effect of increased demand for soybean oil for biodiesel purposes on the model crops under each of the six simulations.

Table 12. Biodiesel demand in each scenario by year (million pounds).

Year	Scenario 1	Scenario 2	Scenario 3
1998	96	192	480
1999	192	385	960
2000	288	577	1440
2001	384	770	1922
2002	480	962	2400
2003	576	1155	2882
2004	672	1347	3362
2005	770	1540	3850
2006	770	1540	3850
2007	770	1540	3850

Table 13. Soybean oil ending stock levels (million pounds).

Year	Baseline	Scenario 1		Scenario 2		Scenario 3	
		1a	1b	2a	2b	3a	3b
1998	1,775	1,721	1,721	1,668	1,668	1,507	1,507
1999	2,010	1,873	1,873	1,735	1,735	1,519	1,519
2000	2,085	1,848	1,848	1,702	1,702	1,223	1,223
2001	2,000	1,771	1,771	1,493	1,493	873	873
2002	1,900	1,565	1,662	1,229	1,379	469	607
2003	1,870	1,431	1,565	1,092	1,198	490	658
2004	1,895	1,409	1,556	975	1,089	392	556
2005	1,900	1,346	1,499	872	1,049	193	416
2006	1,940	1,340	1,512	875	1,064	171	373
2007	1,960	1,346	1,522	828	1,078	196	422

Table 14. Baseline and simulated per-unit average market prices by simulation for soybean oil and meal by year.

Oil							
Year	Baseline	Scenario 1		Scenario 2		Scenario 3	
		1a	1b	2a	2b	3a	3b
1998	0.248	0.250	0.250	0.251	0.251	0.256	0.256
1999	0.245	0.249	0.249	0.253	0.253	0.260	0.260
2000	0.243	0.250	0.250	0.255	0.255	0.270	0.270
2001	0.243	0.250	0.250	0.258	0.258	0.283	0.283
2002	0.250	0.260	0.257	0.271	0.267	0.302	0.297
2003	0.258	0.272	0.268	0.285	0.280	0.337	0.327
2004	0.263	0.279	0.274	0.295	0.291	0.350	0.340
2005	0.265	0.283	0.278	0.303	0.297	0.363	0.350
2006	0.268	0.287	0.282	0.308	0.301	0.369	0.357
2007	0.270	0.290	0.284	0.308	0.302	0.370	0.357

Meal							
Year	Baseline	Scenario 1		Scenario 2		Scenario 3	
		1a	1b	2a	2b	3a	3b
1998	182.50	182.50	182.50	182.50	182.50	182.50	182.50
1999	182.50	182.50	182.50	182.50	182.50	175.70	175.70
2000	198.00	198.00	198.00	196.80	196.80	192.70	192.70
2001	211.50	207.50	207.50	209.20	209.20	202.10	202.10
2002	216.50	216.40	208.90	212.90	201.50	200.00	191.40
2003	222.50	221.70	214.50	213.10	210.40	202.50	192.70
2004	230.50	224.40	219.30	220.90	216.90	207.50	197.10
2005	233.00	227.40	221.70	222.50	214.10	207.20	193.80
2006	234.00	228.90	221.40	222.20	215.00	208.00	198.40
2007	236.50	231.10	223.90	224.30	216.60	207.20	196.50

Table 15. Baseline and scenario per-unit prices for major crops during 2007.

Crop	Baseline	Scenario 1		Scenario 2		Scenario 3	
		1a	1b	2a	2b	3a	3b
Corn	3.10	3.11	3.19	3.12	3.18	3.17	3.22
Grain Sorghum	2.90	2.92	2.99	2.92	2.99	2.96	3.01
Oats	1.85	1.86	1.88	1.86	1.88	1.87	1.89
Barley	2.80	2.81	2.87	2.82	2.86	2.84	2.88
Wheat	4.45	4.45	4.46	4.45	4.47	4.47	4.47
Soybeans	7.25	7.29	7.24	7.28	7.27	7.32	7.27
Cotton	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Rice	12.13	12.14	12.14	12.14	12.14	12.13	12.13
Sunflower	13.07	13.40	13.27	13.68	13.58	14.63	14.39
Canola	12.02	12.22	12.14	12.40	12.33	13.00	12.85

Table 16. Baseline and scenario planted acreage information by simulation for major crops by year (million acres).

Crop	Baseline	Scenario 1		Scenario 2		Scenario 3	
		1a	1b	2a	2b	3a	3b
Corn	84.50	84.30	83.30	84.10	83.30	83.20	82.00
Grain Soghum	11.20	11.20	11.20	11.20	11.20	11.20	11.20
Oats	4.70	4.70	4.70	4.70	4.70	4.70	4.70
Barley	7.10	7.10	7.10	7.10	7.10	7.10	7.10
Wheat	76.00	76.10	76.10	76.10	76.20	76.10	76.20
Soybeans	69.50	69.60	70.60	69.80	70.60	70.70	71.80
Cotton	14.00	14.00	14.00	14.00	14.00	13.90	14.00
Rice	3.20	3.20	3.20	3.20	3.20	3.20	3.20
Sunflower	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canola	0.00	0.00	0.00	0.00	0.00	0.10	0.10

As seen in table 13, given the high level of stocks in the baseline situation, the initial impact of the increase in the demand for vegetable oils would more likely imply a reduction in the level of soybean oil stocks, as well as higher prices for this product. Only when the level stocks have been sufficiently depleted will the higher demand translate into a significant increase in the production and crushing of soybeans, and consequently the supply of soybean oil. It is difficult to assess how low the stocks of soybean oil could fall before disrupting the marketing system, given that the market has traditionally been driven by meal use. It is possible that either the price change of soybean oil is underestimated at low levels of stocks, or that the change in soybean acreage that results from an increase in the price of soybean oil is being underestimated.

Scenario 1: Biodiesel use as in 1996 ERS/USDA study; 770 million pounds by 2005.

The ERS/USDA study sets the possible amount of soybean oil that could be used for biodiesel purposes at 770 million pounds by 2005. Performing this simulation resulted in a 0.5 percent increase in soybean oil production and a one percent production increase for soybean

meal over USDA baseline levels in 2007.¹ The simulated production changes provided by Raneses, Glaser, and Price estimated that both soybean oil and soybean meal production would increase between 0.3 and 1.6 percent by 2000. The price of soybean oil is seen to rise 7 percent (\$0.02) in 2007 over the USDA baseline level while the price of soybean meal falls 2.3 percent (\$5.40). The ERS/USDA study predicted an increase in soybean oil price per pound from 2.8 to 14.1 percent (between \$0.006 and \$0.031 per pound) by 2000 and the per-unit price of meal to decline between 0.7 and 3.3 percent. The changes in oil and meal prices result in a 0.6 percent increase in soybean crush (an increase of between 0.3 and 1.6 percent by 2000 in the ERS/USDA study) and a 0.5 percent (\$0.04) increase in per bushel price (estimated to increase between 0.4 and 2.0 percent by 2000 in the ERS/USDA simulation).

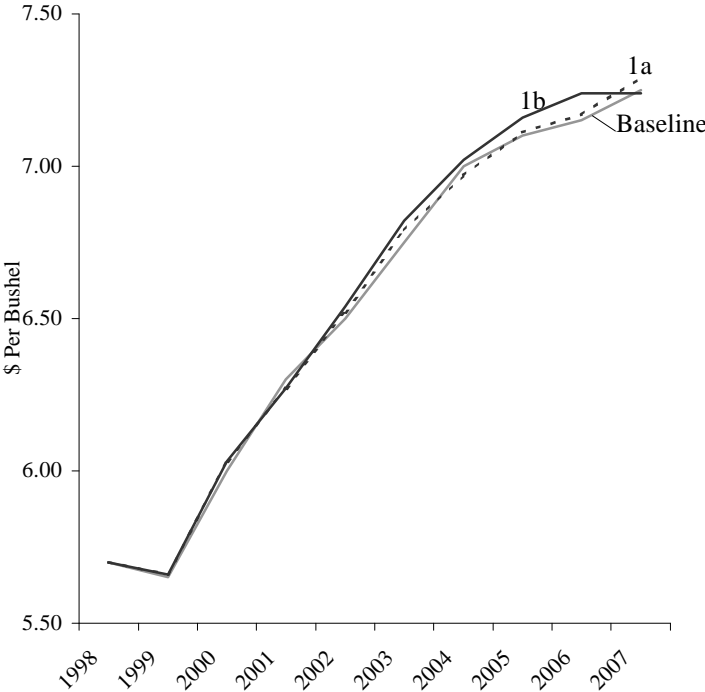
Half of the prices of non-oil crops included in the simulation (corn, grain sorghum, oats, barley, wheat, rice, sugarcane, sugarbeets, and dry beans) were not affected in 2007 by increased soybean oil demand for biodiesel. The price of corn, oats, barley, and rice increased one cent in 2007 over the USDA baseline projection, and the price of grain sorghum declined \$0.02. The prices of the other non-oil crops were not affected. In this simulation prices for both sunflower and canola were not high enough to warrant their production for the entire simulation period for sunflower and after 2002 for canola. Changes in cotton included a 100,000-acre dip in planted and harvested acreage and a 0.67 percent decrease in production in 2004. Cotton production also declined 0.056 percent in 1998, but its planted acreage and price remained unchanged from the baseline.

Results from the introduction of higher-oil-quantity seeds for oilcrops in simulation 1b varied somewhat from those in simulation 1a. Soybean oil production with higher-oil-quantity

¹ It is important to note that the ERS/USDA study simulated soybean oil demand for biodiesel purposes between 1996 and 2000, a five-year period. This study simulates demand from 1998 to 2007, a ten-year

seeds in 2007 was 1.4 percent higher than the USDA baseline projection and oil price gained 5 percent (\$0.014). The production of soybean meal rose 2.2 percent in 2007 over the USDA baseline, but its price decreased 5.6 percent (\$12.60). This interaction caused the per-bushel price of soybeans to drop one cent over the baseline in 2007 and \$0.05 over the soybean price in scenario 1a. Soybean prices from the baseline and scenarios 1a and 1b are shown in graph 1.

Graph 1. Soybean price: baseline and simulations 1a and 1b.



While prices under this scenario still did not justify sunflower production, canola is seen to be planted from 1998 until 2002, as was the case in simulation 1a. Changes in cotton also remained the same as in simulation 1a. Many non-oil crops were also affected by the introduction of higher-oil-producing seed. Beginning in 2001 the price of corn, grain sorghum,

period.

oats, and barley began to deviate from the USDA baseline; by 2007 corn and grain sorghum had gained \$0.09, oats \$0.03, and barley \$0.07 over the baseline. Wheat and rice deviated from the baseline beginning in 2000 (both with a one cent gain), and by 2007 both still remained at an increase of one cent.

Scenario 2: Biodiesel use twice that of 1996 ERS/USDA study; 1,540 million pounds.

In simulations 2a and 2b, the use of soybean oil for biodiesel purposes was set at twice the amount of the ERS/USDA study, or 1,540 million pounds. As a result, soybean oil production increased 1.1 percent, and the per-unit price of oil gained \$0.038 (12 percent) in 2007 over the USDA baseline. The production of soybean meal increased 2.2 percent while its price decreased \$12.20 (5.4 percent). The combination of these factors resulted in a 0.5 percent gain for soybean production in 2007, a 0.78 percent increase in crush, and a \$0.03 (0.4 percent) gain in per-bushel soybean price over the baseline.

Canola is seen to enter production for the first five years of the simulation, but after 2002 the price did not justify its further production. Sunflower production remained at zero for the entire 10 years. Again, changes in cotton included a 100,000-acre decline in planted and harvested acreage and a 0.67 percent decrease in production in 2004 as well as a dip in production by 0.06 percent in 1998. However, in this simulation, cotton production in 2002 fell 0.05 percent as well. Corn, grain sorghum, and barley each showed a \$0.02 gain over their baseline prices in 2007. Oats and rice both increased \$0.01. Wheat, sugar, sugarcane, sugarbeets, and dry bean prices were not affected by the simulation.

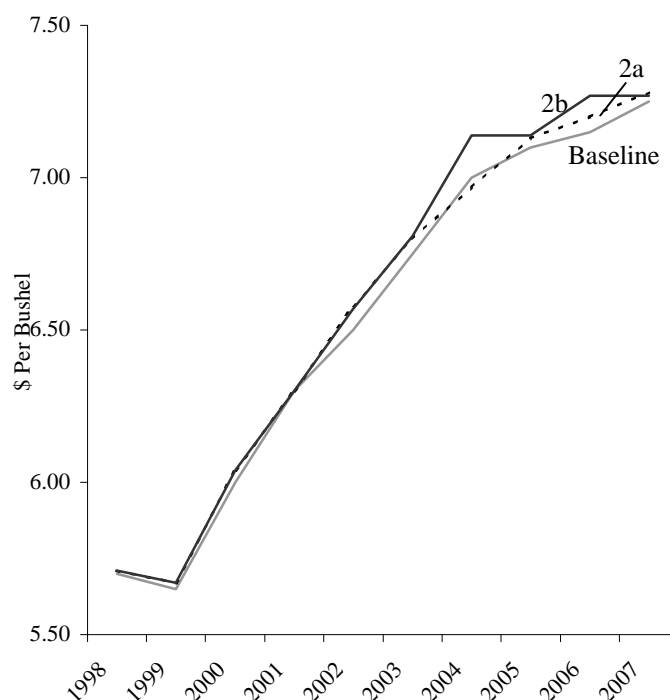
The conditions for the production of alternative oilseeds under simulation 2b are similar to those in simulation 2a. Canola was produced through 2002, but after this year its price no longer justified its production. Sunflower production was never warranted by the simulated

price. Changes in cotton included those seen in the simulation 2a plus a 0.15 percent decrease in cotton production in 2006.

Non-oil crops experienced higher price increases over the baseline in 2007 with the introduction of higher-oil-yielding seed. The per-unit price of corn increased \$0.08, grain sorghum price gained \$0.09, the price of oats rose \$0.03, barley \$0.06, wheat \$0.02, and the price of rice increased \$0.01. Only corn and wheat maintained fewer acres in 2007 than in the baseline – corn acreage decreased 1.2 million and wheat lost 100,000 acres.

Adding the use of higher-oil-yielding seed to simulation 2b increased the production of soybean oil 2.2 percent and its price 10.6 percent (\$0.032) in 2007 above the baseline. Soybean meal production increased 3.58 percent while its per-unit price fell 9.19 percent (\$19.90) in 2007. Due to the relationship between the value of oil and that of meal in this simulation the per-bushel price of soybeans increased one cent less over the baseline in 2007 than the same price in simulation 2a (\$0.03 increase in simulation 2a; \$0.02 increase in simulation 2b). The relationship among the soybean baseline price and the simulated prices from simulations 2a and 2b is shown in graph 2.

Graph 2. Soybean price: baseline and simulations 2a and 2b.



Scenario 3: Biodiesel use 1 percent of middle distillate fuels; 3,850 million pounds by 2005.

In this scenario the demand for soybean oil for biodiesel production was increased to 1 percent of all demand for middle distillate fuels, equaling 3,850 million pounds. This resulted in a steady increase in soybean oil price throughout the simulation period, culminating in a 27 percent per-pound gain (\$0.10) in 2007 over the baseline in simulation 3a. Soybean oil production was also increased by 2.6 percent, and ending stock was lower by 1,034.5 percent in 2007. Soybean meal production was also increased over the USDA baseline by 5.1 percent in 2007 while its price declined steadily over the simulation period, ending with a 14.1 percent decrease over the baseline in 2007 (-\$29.3). Increased demand for soybean oil for biodiesel production led to a 1.7 percent increase in soybean harvested acres, a 2.4 percent gain in

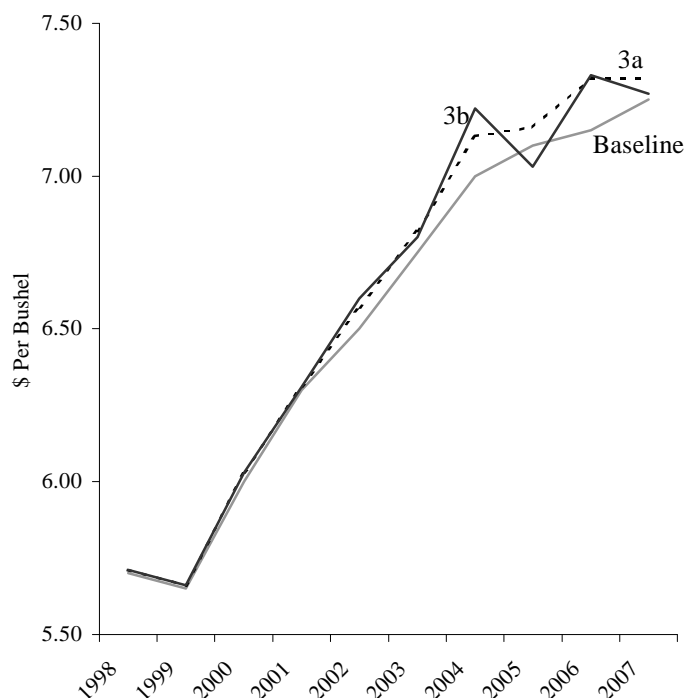
soybean crush, and a \$0.07 increase in per-bushel soybean price in 2007 over the USDA baseline.

The effects on the price of other non-oil crops (corn, oats, grain sorghum, barley, wheat, and rice) ranged from \$0.07 for corn to no effect for rice. Corn harvested acreage also lost 1.6 percent and corn production fell 1.6 percent in 2007 over USDA baseline projections. Wheat production remained below baseline levels between 1998 and 2006 (except during 2000) but gained one million acres over the baseline in 2007. Sugar, sugarcane, sugarbeets, and dry beans remained unchanged.

While the simulated price justified no sunflower production, canola remained in production throughout the entire simulation period and gained \$0.98 per unit in 2007 over the baseline. Cotton harvested acreage and production fell slightly below baseline projections beginning in 2004 and remained so throughout the rest of the simulation. Cotton production also remained 0.06 percent below baseline projections in 1998, but its price was unchanged throughout the entire simulation period.

With the introduction of higher-oil-producing seed in simulation 3b, both the production of soybean oil and meal increased, but the effect on per-unit soybean price was less than with current-oil-quantity seed (\$0.02 gain over the baseline with higher-oil-yielding seed; \$0.07 increase over baseline with current-oil-yielding seed). This resulted from the value of oil and meal under the scenario, which can be explained as follows: Although soybean oil production rose 4.5 percent and oil price increased 24.4 percent (\$0.087) in 2007 over the baseline, this was not enough to greatly offset the effect of the 6.9 percent gain in soybean meal production and the 20.4 percent (\$40.00) decrease in soybean meal price. This interaction is shown in graph 3.

Graph 3. Soybean price: baseline and simulations 3a and 3b.



Prices of several non-oil crops were affected under simulation 3b. The per-unit price of both corn and sorghum were deviated the greatest from the USDA baseline in 2007, showing a gain of \$0.12 for corn and \$0.11 for sorghum. The price of barley rose \$0.08, barely \$0.04, and wheat \$0.02 above the baseline price in 2007. Corn experienced by far the largest drop in harvested acreage: 3.16 percent below baseline acreage in 2007.

Again, the simulated price of sunflower across the entire period did not warrant their production even with a price gain of \$1.32 over the baseline in 2007. Canola prices were high enough throughout the 10-year period to justify small amounts of their production, but in 2007 the per-unit price of canola was \$0.15 less than that in scenario 3a, probably an effect of more soybean oil production during the higher-oil-yielding seed simulation period. Planted and harvested acreage for cotton declined 100,000 acres in both 2004 and 2006. Cotton production

decreased below the baseline levels for five of the 10 simulation years (1998 and 2004–07), but its price remained constant throughout.

Effects on the SERBEP Region

The purpose of this section is to analyze the effects of increased soybean oil production for biodiesel purposes on the planted and harvested acres of specific model crops in the SERBEP region. The scenarios correspond to those already described and for which a national analysis has been presented. Crops focused upon in this portion of the study include soybeans, sunflower, canola, cotton, corn, and wheat. Furthermore, the analysis also estimates the acreage ratios of these crops in the SERBEP region to the overall national average. An overview of the results is presented in table 17, and a discussion of significant changes follows.

Table 17. Results of scenarios 1, 2, and 3 in the SERBEP region.

Scenario 1: Biodiesel use as in '96 ERS/USDA study; 770 million pounds by 2005							
1a	Planted Acres	Soybeans	Sunflower	Canola	Cotton	Corn	Wheat
	planted ac. baseline	17,764,346	0	0	7,059,888	8,976,408	6,605,063
	% chg from baseline 2007	-0.01%	0	22,216	0	0	-0.204%
	baseline SERBEP ac. as a % of national ac.	25.56%	0	--	50.43%	10.62%	8.69%
	% of national ac. after simulation	25.52%	0	--	50.43%	10.65%	8.66%
	Harvested Acres						
	harvested ac. baseline	17,281,808	0	0	7,013,403	8,134,923	5,686,989
	% chg from baseline 2007	-0.012%	0	22,216	0	0	-0.16%
	baseline SERBEP ac. as a % of national ac.	25.27%	0	--	53.95%	10.39%	8.49%
	% of national ac. after simulation	25.23%	0	--	53.95%	10.42%	8.46%
1b	Planted Acres	Soybeans	Sunflower	Canola	Cotton	Corn	Wheat
	planted ac. baseline	17,764,346	0	0	7,059,888	8,976,408	6,605,063
	% chg from baseline 2007	-0.01%	0	22,216	0	0	-0.20%
	baseline SERBEP ac. as a % of national ac.	25.56%	0	--	50.43%	10.62%	8.69%
	% of national ac. after simulation	25.16%	0	--	50.43%	10.78%	8.66%
	Harvested Acres						
	harvested ac. baseline	17,281,808	0	0	7,013,403	8,134,923	5,686,989
	% chg from baseline 2007	-0.01%	0	22,216	0	0	-0.16%
	baseline SERBEP ac. as a % of national ac.	25.27%	0	--	53.95%	10.39%	8.49%
	% of national ac. after simulation	24.86%	0	--	53.95%	10.55%	8.46%
Scenario 2: Biodiesel use twice that of '96 ERS/USDA study; 1,540 million pounds by 2005							
2a	Planted Acres	Soybeans	Sunflower	Canola	Cotton	Corn	Wheat
	planted ac. baseline	17,764,346	0	0	7,059,888	8,976,408	6,605,063
	% chg from baseline 2007	-0.01%	0	23,125	0	-0.02%	-0.20%
	baseline SERBEP ac. as a % of national ac.	25.56%	0	--	50.43%	10.62%	8.69%
	% of national ac. after simulation	25.45%	0	--	50.43%	10.67%	8.66%
	Harvested Acres						
	harvested ac. baseline	17,281,808	0	0	7,013,403	8,134,923	5,686,989
	% chg from baseline 2007	-0.01%	0	23,125	0	-0.02%	-0.16%
	baseline SERBEP ac. as a % of national ac.	25.27%	0	--	53.95%	10.39%	8.49%
	% of national ac. after simulation	25.15%	0	--	53.95%	10.44%	8.46%
2b	Planted Acres	Soybeans	Sunflower	Canola	Cotton	Corn	Wheat
	planted ac. baseline	17,764,346	0	0	7,059,888	8,976,408	6,605,063
	% chg from baseline 2007	-0.01%	0	23,125	0	0	-0.09%
	baseline SERBEP ac. as a % of national ac.	25.56%	0	--	50.43%	10.62%	8.69%
	% of national ac. after simulation	25.16%	0	--	50.43%	10.78%	8.66%
	Harvested Acres						
	harvested ac. baseline	17,281,808	0	0	7,013,403	8,134,923	5,686,989
	% chg from baseline 2007	-0.01%	0	23,125	0	0	-0.07%
	baseline SERBEP ac. as a % of national ac.	25.27%	0	--	53.95%	10.39%	8.49%
	% of national ac. after simulation	24.86%	0	--	53.95%	10.55%	8.47%
Scenario 3: Biodiesel use 1 percent of middle distillate fuels; 3,850 million pounds by 2005							
3a	Planted Acres	Soybeans	Sunflower	Canola	Cotton	Corn	Wheat
	planted ac. baseline	17,764,346	0	0	7,059,888	8,976,408	6,605,063
	% chg from baseline 2007	-0.07%	0	111,727	-0.74%	-0.16%	-0.25%
	baseline SERBEP ac. as a % of national ac.	25.56%	0	--	50.43%	10.62%	8.69%
	% of national ac. after simulation	25.11%	0	--	50.41%	10.77%	8.66%
	Harvested Acres						
	harvested ac. baseline	17,281,808	0	0	7,013,403	8,134,923	5,686,989
	% chg from baseline 2007	-0.06%	0	111,727	-0.74%	-0.147%	-0.22%
	baseline SERBEP ac. as a % of national ac.	25.27%	0	--	53.95%	10.389%	8.49%
	% of national ac. after simulation	24.81%	0	--	53.97%	10.536%	8.47%
3b	Planted Acres	Soybeans	Sunflower	Canola	Cotton	Corn	Wheat
	planted ac. baseline	17,764,346	0	0	7,059,888	8,976,408	6,605,063
	% chg from baseline 2007	0.22%	0	111,727	-0.67%	-0.00820839	-0.00241123
	baseline SERBEP ac. as a % of national ac.	25.56%	0	--	50.43%	10.62%	8.69%
	% of national ac. after simulation	24.80%	0	--	50.09%	10.86%	8.65%
	Harvested Acres						
	harvested ac. baseline	17,281,808	0	0	7,013,403	8,134,923	5,686,989
	% chg from baseline 2007	0.2%	0	111,727	-0.67%	-0.74%	-0.21%
	baseline SERBEP ac. as a % of national ac.	25.3%	0	--	53.95%	10.39%	8.49%
	% of national ac. after simulation	24.5%	0	--	53.59%	10.64%	8.46%

Under scenario 1, in which biodiesel use is set nationally at 770 million pounds by 2007, the only significant changes in simulation 1a occurred in planted and harvested acreage for wheat and canola. Wheat planted acreage declined 0.20 percent from the baseline in 2007; wheat harvested acreage fell 0.16 percent. The decline in planted and harvested acreage to wheat caused the percent of national wheat acres in the SERBEP region to decrease from the baseline level of 8.69 percent to 8.66 percent. Canola planted and harvested acreage both increased from the baseline value of zero to 22,216 acres. However, since only acreage of 100,000 or more were displayed in the national simulation output, the percent of national canola acreage in the SERBEP region could not be calculated. The introduction of higher-oil-quantity seed in simulation 1b did not significantly deviate from the results of simulation 1a.

With double the use of biodiesel to 1,540 million pounds in scenario 2, baseline deviations were observed in 2007 for wheat, canola, and corn in simulation 2a. Increased biodiesel production of wheat caused planted acreage to decline 0.20 percent and harvested acres to decrease 0.16 percent, the same effect seen in simulations 1a and 1b. The percent of national planted and harvested wheat acres in the SERBEP region remained unchanged as well. Canola planted and harvested acreage increased to 23,130 (about 900 more acres than in simulations 1a and 1b). Corn lost 0.03 percent of its planted acres in 2007, but the percent of corn planted in the SERBEP region (10.67 percent) remained greater than the baseline (10.62 percent) because of the 400,000-acre dip in planted acres to corn nationwide. Corn harvested acres also decreased 0.02 percent from the baseline, but the percent of harvested acres in the SERBEP region (10.44 percent) also remained higher than the baseline (10.39 percent) because of a large national decline. The introduction of higher-oil-quantity seed in simulation 2b did not significantly change the results seen in simulation 2a.

Scenario 3 introduced biodiesel use as one percent of all middle distillate fuels, totaling 3,850 pounds by 2007. In the SERBEP region, this induced changes on the planted and harvested acres of wheat, canola, corn, and cotton in simulation 3a. Wheat planted acreage dropped 0.25 percent below the baseline in 2007, and the percent of national wheat planted acreage in the SERBEP region fell from the baseline level of 8.69 percent to 8.66 percent. Harvested acres for wheat declined 0.22 percent while the percent of national harvested acreage in the SERBEP region decreased from the baseline percentage of 8.49 percent to 8.47 percent. Canola planted and harvested acreage jumped by 88.6 thousand acres from simulations 2a and 2b to 111,730 acres in simulation 3a. Corn planted acres declined 0.16 percent from the baseline in 2007; corn harvested acreage followed this trend decreasing 0.15 percent from the baseline. The percentage of national planted and harvested acres in corn remained higher than their baseline values, however, due to the national dip in corn acreage.

The first changes to cotton acreage in the SERBEP region were seen in simulation 3a. Planted acreage declined 0.75 percent over the baseline, but did not significantly affect national cotton planted acreage. Harvested acreage for cotton also decreased from the baseline by 0.74 percent in 2007. This decline was not great enough, however, to bring the percent of national cotton harvested acres in the SERBEP region down from the baseline value of 53.95 percent. Rather, a 100,000-acre loss in national harvested acres for cotton allowed the percent of harvested cotton acres in the SERBEP region to increase to 53.97 percent of the national average.

Planted and harvested acres for the six model crops in the SERBEP region were affected by the introduction of higher-oil-quantity seed in simulation 3b, except for sunflower. Soybean planted and harvested acres increased 0.216 and 0.222 percent in 2007, respectively, but the

percent of the national average for both remained below their baseline values because of the large increase in national acreage. The percentage of national planted acreage for soybeans declined from the baseline of 25.6 percent to 24.8 percent, and that of harvested acreage decreased from 25.3 to 24.5 percent.

Wheat planted acres declined in simulation 3b more than any other, 0.241 percent below the baseline. Harvested acreage for wheat decreased by 0.214 percent. This did not greatly affect the percentage of national wheat acreage in the SERBEP region, however. Planted and harvested acreage in canola remained unchanged from simulation 3a. Corn planted acres lost 0.82 percent in 2007 from the baseline, and harvested acres decreased 0.74 percent. While acreage did decline, however, the percentage of national planted and harvested acreage for corn in the SERBEP region remained above baseline values because of the large national decline in corn acreage. The change in cotton acreage in simulation 3b was not as great as that in simulation 3a. Planted acreage fell 0.67 percent from the baseline; harvested acreage declined 0.68 percent from the baseline. The change in the percentage of national cotton acreage planted in the SERBEP region was more significant than in simulation 3a. Planted cotton acreage in the SERBEP region decreased from the baseline value of 50.43 percent to 50.09 percent of the national average while harvested acreage declined from 53.95 percent to 53.59 percent of the national average.

In summary, the overall production of vegetable oil crops in the SERBEP region does not significantly benefit from the increase in the price of vegetable oils that results from a greater demand for biodiesel. However, the increase in the national availability of oil crops would tend to depress the prices of animal fats, and therefore indirectly increase the potential for the SERBEP region to support the operation of biodiesel facilities using primarily animal fats.

In terms of income impacts, table 18 summarizes the changes in realized net farm income for each of the six scenarios considered in this study. Realized net farm income does not include the value of the changes in stocks, as net farm income does. The results show that the overall increase in demand of vegetable oils for biodiesel purposes and the introduction of higher-oil-content seed varieties result overall in an increase in realized net farm income that ranges from \$100 million to \$600 million. The change in realized net farm income presented is after considering the higher prices in the crops sector, and the resulting lower income in the livestock sector as a consequence of higher feed costs.

Table 18. Realized net farm income by 2007 (billion dollars).

Scenario	Simulation Description	Realized Net Farm Income
Baseline	USDA Baseline	\$58.2
1	Demand assumed in 1996 ERS/USDA study	\$58.3
	Scenario 1a plus increased oil yields	\$58.6
2	Twice the demand in scenario 1	\$58.4
	Scenario 2a plus increased oil yields	\$58.7
3	One percent of U.S. middle distillate fuels consumption by biodiesel	\$58.8
	Scenario 3a plus increased oil yields	\$58.8

CHAPTER 4: ANIMAL FATS ANALYSIS RESULTS

Livestock Slaughter in the Study Region

The annual cattle, calf, hog, and sheep slaughter data for the 13-state study region are presented in tables 19 and 20. Quite a bit of variation occurred among the four years of data obtained for this analysis, primarily due to drought-related liquidation during 1995 and 1996, and a sharp increase in feed grain prices during 1996 and, to a lesser extent, in 1997 (USDA, 1998a). These events occurred during the low point of the cattle cycle and resulted in increased liquidation of cattle herds during those years of the study period. For hogs, high corn prices in 1996 coupled with increased export demand resulted in reduced herds (USDA, 1997a).

Reviewing these data underscores how most cattle, hog, and sheep slaughter occurs outside the study region. In 1997, the SERBEP region was responsible for 21.6 percent of total U.S. hog slaughter but only 2 percent of the total U.S. cattle slaughter, 2.3 percent of calf slaughter, and 1.0 percent of sheep slaughter. Half of the region's hog slaughter (10.1 percent of U.S. slaughter) occurred in North Carolina, while half of the study region's cattle slaughter occurs in Alabama and North Carolina.

Data for poultry production for the same period is presented in table 21. These data show that at the same time that overall production has steadily increased, the participation of the SERBEP region has also increased from 73 to 75% of the national production of broilers. The focus on broilers in this analysis is due to the importance of these animals in overall livestock

production in the region, and also due to the quality of the figures on other components of this industry.

Table 19. Total livestock slaughter of cattle, calves, hogs, and sheep and lambs in the SERBEP region, 1994–97 (in thousands of head).

State	Cattle				Calves			
	1994	1995	1996	1997	1994	1995	1996	1997
Alabama	11	156	225	209			0.4	
Arkansas	28	30	35	31			1.6	1.0
Florida								
Georgia							0.7	4.2
Kentucky	63	67	66	54				1.3
Louisiana	27	27	32	30	25.3	27.8	34.6	24.1
Mississippi								2.2
Missouri	155	179	184	110	1.9	2.0	2.3	2.1
North Carolina	151	157	202	188	1.5	1.5	0.5	0.0
South Carolina								
Tennessee				62				
Virginia	22	20	31	26			1.4	1.6
West Virginia	16	17	20	17				
Total Region	474	653	794	725	29	31	42	37
Total U.S.	34,197	35,639	36,583	36,318	1,268	1,430	1,768	1,575

State	Hogs				Sheep & Lambs			
	1994	1995	1996	1997	1994	1995	1996	1997
Alabama	130	122	114	107			0.2	
Arkansas	228	249	216	188			0.6	0.5
Florida	91	113	126	126	1.1	0.7	0.4	0.5
Georgia				310	1.4		2.1	2.4
Kentucky	2,912	3,118	2,547	2,195	11.1	10.4	10.7	10.0
Louisiana	56	50	45	39	4.3	3.8	3.5	3.0
Mississippi								
Missouri			3,318	3,529				
North Carolina	6,592	7,598	8,846	9,274	2.3	2.5	2.4	2.2
South Carolina								
Tennessee								
Virginia	4,470	4,658	4,296	4,121	25.0	21.5	22.8	18.6
West Virginia	18	16	14	10				
Total Region	14,498	15,923	19,521	19,899	45	39	43	37
Total U.S.	95,696	96,325	92,394	91,960	4,938	4,560	4,184	3,907

Notes: These data exclude animals slaughtered on farms. States with no data were not printed to avoid disclosing proprietary data.

Sources: USDA 1995a, 1996, 1997b, 1998b.

Table 20. Total liveweight slaughter of cattle, calves, hogs, and sheep and lambs, 1994–97 (1,000 pounds).

State	Cattle				Calves			
	1994	1995	1996	1997	1994	1995	1996	1997
Alabama	9,202	162,730	229,594	221,760			137	
Arkansas	27,849	28,255	31,432	28,762			584	394
Florida								
Georgia							268	589
Kentucky	66,780	69,946	64,566	53,765				539
Louisiana	21,848	21,230	24,612	23,532	11,488	12,725	15,901	11,086
Mississippi								905
Missouri	168,439	197,083	199,060	121,345	711	754	819	741
North Carolina	155,692	159,843	206,295	194,229	476	526	193	
South Carolina								
Tennessee				59,534				
Virginia	20,592	19,084	28,550	24,628			442	446
West Virginia	15,230	15,720	17,420	14,180				
Total Region	485,632	673,891	801,529	741,735	12,675	14,005	18,344	14,700
Total U.S.	40,624,237	42,172,204	42,763,030	42,604,995	486,114	532,081	605,830	532,459

State	Hogs				Sheep & Lambs			
	1994	1995	1996	1997	1994	1995	1996	1997
Alabama	52,516	50,826	47,076	43,115			16	0
Arkansas	84,802	102,111	90,415	83,007			73	59
Florida	17,180	23,216	26,837	25,885	95	61	34	53
Georgia				82,098	136		178	245
Kentucky	755,077	794,026	648,017	566,046	1,395	1,265	1,383	1,397
Louisiana	11,864	10,888	9,598	8,210	389	352	318	270
Mississippi								
Missouri			834,810	897,034				
North Carolina	1,648,008	1,932,536	2,187,479	2,301,204	196	209	202	186
South Carolina								
Tennessee								
Virginia	1,121,952	1,165,227	1,074,137	1,016,236	2,693	2,337	2,405	1,928
West Virginia	6,370	5,681	4,892	3,229				
Total Region	3,697,769	4,084,511	4,923,261	5,026,064	4,904	4,224	4,609	4,138
Total U.S.	24,430,314	24,624,974	23,431,309	23,533,896	616,579	571,646	534,212	520,342

Notes: These data exclude animals slaughtered on farms. States with no data were not printed to avoid disclosing proprietary information.

Sources: USDA 1995a, 1996, 1997b, 1998b.

Table 21. Broiler production by state, 1994–97 (1,000 pounds).

	1994	1995	1996	1997
Alabama	4,184,200	4,230,000	4,191,800	4,349,800
Arkansas	4,853,700	4,982,900	5,659,500	5,590,100
Florida	570,600	615,100	591,300	595,800
Georgia	4,723,500	5,136,000	5,654,600	5,914,000
Kentucky	237,300	258,000	331,100	497,700
Louisiana	na	na	na	na
Mississippi	2,711,700	2,962,400	3,109,100	3,313,400
Missouri	658,300	800,500	1,059,100	1,075,000
North Carolina	3,217,500	3,417,500	3,541,700	3,657,500
South Carolina	588,800	680,400	786,300	829,900
Tennessee	548,700	572,000	603,000	623,700
Virginia	1,187,700	1,196,500	1,243,700	1,219,200
West Virginia	384,400	391,200	394,700	381,400
Total Region	23,866,400	25,242,500	27,165,900	28,047,500
Total USA	32,528,500	34,222,000	36,479,100	37,540,750

Source: USDA/NASS, 1999.

It should be noted that the data presented in tables 19 and 20 suffer from limitations. These data exclude animals slaughtered on farms, which is a minor source of inedible tallow, and the state-level data do not include data where an individual slaughter operation's proprietary information may be revealed. Thus, these data most likely underestimate somewhat the amount of animal fats that are produced in the SERBEP region.

Given the equations and parameters presented, any changes in the production of livestock have to be induced by changes in the index of feed prices, all else assumed constant. As will be described later in this report, the major price changes occur in soybeans and corn. The largest increases in soybean prices are in scenarios 3a and 1a, in both cases the increases are less than one percent. In the case of corn, the price increases are the largest in scenarios 3b and 1b, where the increases are between 4 and 3 percent respectively. In summary, the index of feed prices, which does not directly include the price of soybean meal, does not experience any increases larger than 1.5 percent.

When considering the price of soybean meal, which experiences a significant reduction of up to 17 percent in the more aggressive scenario, it could be reasonable to see a significant impact on the production of livestock. In relative terms, the largest users of soybean meal in the livestock sector are broilers, turkeys, and egg production; cattle and hogs, the largest source of animal fats, are marginal users of soybean meal.

A common feed formulation used by USDA for feedlots cost considers 45 bushels of corn, 330 pounds of hay, and 20 pounds of soybean meal. Under the assumption that hay prices remain constant, and introducing the price changes corresponding to scenario 3b – that is an increase in the prices of corn of 12 cents/bu and a reduction in the price of soybean meal of 40 dollars per ton (2,000 lbs.) – the feedlot costs actually increases by almost 5 dollars per unit feed. Hence, in the case of livestock the reduction in the price of soybean meal is not likely to override the impact of the increase in the corn price, and therefore will not increase the production level of cattle. A similar result could be reproduced for the case of hogs, considering that the participation of soybean meal in the overall ration is less than 20 percent.

Livestock production does not experience a significant change in any of the scenarios considered. While in all cases, there is a slight drop in production, it is less than a third of a percent in even the most dramatic case. Consequently, there are no significant changes in the production of animal fats. Even after the increases in the price of vegetable oils as simulated, at most there could be a shift toward the substitution of vegetable oils for animal fats.

The above would likely result in some increase in the price of animal fats, but will not affect the overall supply of animal fats, primarily because the supply of animal fats is driven by slaughter levels, which are insensitive to changes in the price of animal fats. Perhaps in a situation which could dramatically alter the price of animal fats, it could be possible to

hypothesize that the price of animal fats could have an impact on livestock slaughter levels, but it does not seem likely at the levels considered in this analysis.

Tallow and Lard Production

Tables 22 and 23 present the estimates of tallow and lard produced in the study region. The edible tallow estimates are for cattle, calves, and sheep, while the inedible tallow represents that initially collected at slaughter time from cattle and calves. As would be expected from the inter-year variation in slaughter, both tallow and lard production vary over the four-year study period. Edible tallow in 1996 is nearly double the 7.1 million pounds produced two years earlier. On average over 1994-97, 91.7 percent of the edible tallow produced in the SERBEP region is produced from cattle slaughter. For inedible tallow, 1995-97 production ranges between 35.2 percent and 60.8 percent above the 1994 level of 22.4 million pounds. Lard produced in the study region grows steadily over time, from 156.6 million pounds in 1994 to 214.9 million pounds in 1997.

Table 22. Estimated edible tallow production from cattle and sheep, and inedible tallow from cattle, 1994–97 (1,000 pounds).

State	Edible Tallow				Inedible Tallow from Cattle			
	1994	1995	1996	1997	1994	1995	1996	1997
Alabama	118.7	2,099.2	2,965.6	2,860.7	414.1	7,322.9	10,337.9	9,979.2
Arkansas	359.3	364.5	422.3	383.6	1,253.2	1,271.5	1,440.7	1,312.0
Florida	12.1	7.8	4.3	6.8				
Georgia	17.3		26.2	38.8			12.1	26.5
Kentucky	1,039.3	1,063.6	1,009.2	878.6	3,005.1	3,147.6	2,905.5	2,443.7
Louisiana	479.6	482.9	563.2	481.0	1,500.1	1,528.0	1,823.1	1,557.8
Mississippi				11.7				40.7
Missouri	2,182.0	2,552.1	2,578.4	1,574.9	7,611.8	8,902.7	8,994.6	5,493.9
North Carolina	2,039.6	2,095.4	2,689.5	2,529.3	7,027.6	7,216.6	9,292.0	8,740.3
South Carolina								
Tennessee				768.0				2,679.0
Virginia	609.0	544.2	680.6	569.3	926.6	858.8	1,304.6	1,128.3
West Virginia	196.5	202.8	224.7	182.9	685.4	707.4	783.9	638.1
Total Region	7,053.4	9,412.4	11,164.0	10,285.6	22,423.8	30,955.3	36,894.3	34,039.6

Table 23. Estimated lard production, 1994–97 (1,000 pounds).

State	1994	1995	1996	1997
Alabama	1,400.8	1,312.2	1,225.8	1,156.7
Arkansas	2,464.6	2,693.5	2,336.0	2,030.4
Florida	980.6	1,220.4	1,359.7	1,365.1
Georgia	-	-	-	3,343.7
Kentucky	31,452.8	33,676.6	27,509.8	23,703.8
Louisiana	605.9	538.9	480.6	421.2
Mississippi	-	-	-	-
Missouri	-	-	35,835.5	38,111.0
North Carolina	71,197.9	82,054.1	95,535.7	100,158.1
South Carolina	-	-	-	-
Tennessee	-	-	-	-
Virginia	48,277.1	50,301.0	46,393.6	44,510.0
West Virginia	193.3	171.7	153.4	109.1
Total Region	156,573	171,968	210,830	214,909

As previously discussed, these estimates exclude inedible tallow from the farm slaughter of animals. While these estimates do include internal fats (e.g., fats from the kidney and stomach lining), they do not include waste fat returned from retail meat and food service operations. Meat packers/processors trim a certain portion of animal fat as they break an animal down into primal and subprimal cuts; depending on the customer, additional trimming as close as 1/8 inch may occur. This fat typically is returned to the original processor or shipped to a rendering facility for conversion to fat products (Dockerty, 1998).

Animal Fats from Broilers

The estimates for animal fat production from broilers are presented in table 24. As discussed earlier, these estimates come from applying the yield conversion factor from pounds of live weight animals to the production of fat. The figures show the availability of this source

of animal fat, and again the concentration in the SERBEP region, in particular the concentration in the states of Georgia, Arkansas, and Alabama.

Table 24. Estimated production of chicken fat by state and total, 1994–97 (1,000 pounds).

	1994	1995	1996	1997
Alabama	71,131	71,910	71,261	73,947
Arkansas	82,513	84,709	96,212	95,032
Florida	9,700	10,457	10,052	10,129
Georgia	80,300	87,312	96,128	100,538
Kentucky	4,034	4,386	5,629	8,461
Louisiana	-	-	-	-
Mississippi	46,099	50,361	52,855	56,328
Missouri	11,191	13,609	18,005	18,275
North Carolina	54,698	58,098	60,209	62,178
South Carolina	10,010	11,567	13,367	14,108
Tennessee	9,328	9,724	10,251	10,603
Virginia	20,191	20,341	21,143	20,726
West Virginia	6,535	6,650	6,710	6,484
Total Region	405,729	429,123	461,820	476,808
Total USA	552,985	581,774	620,145	638,193

Biodiesel Production Potential

The animal fats portion of the overall project is charged with estimating the potential supply of animal fats which could be available for conversion to biodiesel in the study region. One key question is the availability of feed stock, namely animal fat, in the region that could be used for biodiesel production. Table 25 shows the total feed stock available in the region and the relative importance of each of the sources as of 1997. The total availability is over 730 million pounds of animal fats, most of which is supplied by the poultry industry (65%). Further note that almost 40% of the total supply available is concentrated in Georgia, North Carolina, and South Carolina.

Table 25. Total potential feedstock for biodiesel processing from all animal sources, 1997 (1,000 pounds).

	Edible Tallow	Inedible Tallow	Lard	Chicken Fat	Total Animal Fat
Alabama	2,861	9,979	1,157	73,947	87,943
Arkansas	384	1,312	2,030	95,032	98,758
Florida	7	-	1,365	10,129	11,501
Georgia	39	27	3,344	100,538	103,947
Kentucky	879	2,444	23,704	8,461	35,487
Louisiana	481	1,558	421	-	2,460
Mississippi	12	41	-	56,328	56,380
Missouri	1,575	5,494	38,111	18,275	63,455
North Carolina	2,529	8,740	100,158	62,178	173,605
South Carolina	-	-	-	14,108	14,108
Tennessee	768	2,679	-	10,603	14,050
Virginia	569	1,128	44,510	20,726	66,934
West Virginia	183	638	109	6,484	7,414
Total Region	10,286	34,039	214,909	476,808	736,042

For comparison purposes, the amount of biodiesel which could be produced from the tallow estimates presented earlier, along with the amount of glycerine by-product remaining after conversion, are presented in table 26. Table 26 shows the average biodiesel production potential of 7.7 million gallons for the entire study region over the four-year study period. Total production potential for the region ranges from 5.6 million gallons in 1994 to a high of 9.1 million gallons in 1996. The states with the greatest production potential appear to be North Carolina, Missouri, and Alabama. These three states each average more than 1 million gallons of biodiesel potential from tallow during 1994–97.

Table 26. Estimated tallow-derived biodiesel and glycerine production potential in the study region, 1994–97.

State	Biodiesel From Tallow					Glycerine By-Product From Tallow			
	1994	1995	1996	1997	Average	1994	1995	1996	1997
	<i>(1,000 Gallons)</i>					<i>(1,000 Pounds)</i>			
Alabama	101.2	1,790.4	2,527.8	2,439.9	1,714.8	432	7,632	10,776	10,400
Arkansas	306.4	310.9	353.5	321.8	323.1	1,306	1,325	1,510	1,374
Florida	-	-	-	-	-	-	-	-	-
Georgia	-	-	-	-	-	-	-	-	-
Kentucky	757.8	790.5	733.2	620.6	725.5	3,287	3,421	3,181	2,702
Louisiana	373.2	379.4	451.0	385.3	397.2	1,607	1,631	1,935	1,653
Mississippi	-	-	-	-	-	-	-	-	-
Missouri	1,861.0	2,176.7	2,199.1	1,343.2	1,895.0	7,933	9,278	9,374	5,726
North Carolina	1,721.4	1,767.9	2,275.2	2,140.0	1,976.1	7,346	7,544	9,706	9,130
South Carolina	-	-	-	-	-	-	-	-	-
Tennessee	-	-	-	655.0	163.8	-	-	-	2,792
Virginia	271.1	248.6	358.7	307.7	296.5	1,265	1,154	1,627	1,390
West Virginia	167.6	173.0	191.7	156.0	172.0	714	737	817	665
Total Region	5,559.8	7,637.2	9,090.2	8,369.5	7,664.2	23,888.0	32,722.7	38,925.5	35,831.1

However, given that the focus is on livestock activity in which the SERBEP region has a comparative advantage – poultry – the picture changes dramatically. Given the projections for broiler production contained in the baseline used in this study (appendix C), the production of broilers and consequently the supply of animal fat from chickens would increase by more than 38% by the year 2007 as shown in Table 27. Every thing else held constant, this growth would imply an additional 143 million pounds of animal fat production in the SERBEP region, of which 53 million pounds of animal fat a year would be produced in the North Carolina, South Carolina, Georgia sub-region alone. Using the conversion factor of 5.3 pounds of tallow per gallon of biodiesel, the additional animal fat generated by poultry could imply a potential of more than 10 million gallons of biodiesel; which could easily support a biodiesel facility of the scale suggested by Burnham (1992). A similar conclusion can be reached for the sub-region Alabama, Mississippi and Arkansas. In summary, enough production of animal fat could be regionally concentrated within the SERBEP region to support several biodiesel facilities.

Table 27. Estimated potential biodiesel production from chicken fat based on February 1998 USDA baseline projections for 2007.

	Poultry Production 2007	Poultry Production 1998	Change in Poultry Production	Chicken Fat Equivalent	Biodiesel Equivalent
	<i>Million Pounds</i>			<i>Million Gallons</i>	
Alabama	4,658	3,355	1,303	22	4
Arkansas	5,986	4,311	1,675	28	5
Florida	638	460	178	3	1
Georgia	6,332	4,561	1,771	30	6
Kentucky	533	384	149	3	0
Louisiana	-	-	-	-	-
Mississippi	3,538	2,555	983	17	3
Missouri	1,151	829	322	5	1
North Carolina	3,916	2,821	1,095	19	4
South Carolina	889	640	249	4	1
Tennessee	668	481	187	3	1
Virginia	1,305	940	365	6	1
West Virginia	408	294	114	2	0
Total Region	30,032	21,631	8,401	143	27
Total USA	40,197	28,953	11,244	191	36

The actual potential, however, will depend on the growth of the industries which currently use animal fats as inputs. Also, a significant increase in the national availability of vegetable oils and fats would contribute to the decrease of the price of animal fats, and perhaps to the extent that biodiesel use could be a significant competitor in the market for animal fats.

Table 19 shows the average biodiesel production potential of 7.7 million gallons for the entire study region over the four-year study period. Total production potential for the region ranges from 5.6 million gallons in 1994 to a high of 9.1 million gallons in 1996. The states with the greatest production potential appear to be North Carolina, Missouri, and Alabama. These three states each average more than 1 million gallons of biodiesel potential from tallow during 1994–97.

CHAPTER 5: CONCLUSIONS

The Use of Vegetable Oils for Biodiesel in the Southeast

As presented in chapter 3, an increase in the use of vegetable oils for biodiesel would imply an increase in the price of vegetable oils. The increase in oil demand would initially be absorbed by the level of inventories available to industry, and slowly would translate into higher prices for oil and soybeans, and, due to additional crushing, would result in lower prices for soybean meal.

The increase in biodiesel use of vegetable oil results in larger plantings for soybeans at the national level. Soybean planting in the SERBEP region did not register a significant increase. By the same token, neither of two new oil crops introduced in the region, sunflower and canola, show any significant planted acreage. Increased plantings for canola reached 300,000 acres by the year 2007 in the scenario 3, in which the demand for biodiesel was the largest. However, compared to total plantings, canola acreage in the SERBEP region is minimal.

The highest increase in soybeans price was \$0.17, which is higher than the price increase reported in the work of Raneses, et al., but that price increase was not sustained. In simulation 3a the price differential from the baseline situation was \$0.07 cents per bushel. To a large extent, the small increase in the price of soybeans is due to the drop in the price of meal. Considering the limited storage capacity for soybean meal, any significant increase in its availability would result in a significant drop in its price, with the consequent impact on the price of soybeans.

The introduction of higher-oil-quantity seed, while affecting the path of price changes, did not have a significant impact in the overall results of the study. The small changes in the plantings of oil crops in the study region did not justify looking at the issue of planting location or installed capacity.

The study does not look at elements of the vegetable meals other than the protein content, which could have caused an overestimation in the decline in the price of the meal. A similar argument can be made with the assumption about the near perfect substitution of the vegetable oils, which could cause the increase in the vegetable oil prices to be underestimated.

Another important limitation of the study relates to the baseline situation, which is characterized by relatively high prices for most commodities. An analysis of a wide variety of price scenarios could have resulted in higher acreage planted to canola and sunflower, as well as higher price impacts for soybeans and other crops.

The Use of Animal Fats for Biodiesel in the Southeast

Based on the figures in tables 25 and 27 which address the total animal fat produced in the SERBEP region and the potential growth of the poultry industry, the SERBEP region has the potential to support biodiesel production. Given the capacity required to viably operate a biodiesel plant, plants might be located in subregions including North Carolina, Georgia, and South Carolina, as well as in a subregion defined by Alabama, Mississippi and Arkansas. Based on this analysis, no one state in the SERBEP region could produce enough animal fat biodiesel to satisfy the capacity of such a plant, unless it also could process plant-based oils.

Considering only the potential availability of animal fats for conversion to biodiesel, this analysis indicates that the Southeast has at least some potential to produce biodiesel from animal fats in limited areas. That potential, however, is limited by the supply stream of animal

fats for conversion and the current uses. By far, the study region's primary source of animal fat is the poultry industry, followed by tallow resulting from the slaughtering of cattle. The availability of tallow from cattle is subject to the vagaries of the cattle cycle.

This analysis most likely somewhat underestimates the production potential for tallow-derived biodiesel for reasons noted earlier. Also, these estimates are only as good as the animal-to-fat product and tallow-to-biodiesel conversion factors from which they are derived. As process changes occur in biodiesel production, these estimates should be revisited. If the trend toward leaner meat products continues, it also can be expected that average tallow and lard yields, too, will decline over time.

Finally, this analysis intentionally overlooks some basic economic questions which would be associated with the production of biodiesel in the study region. The use of animal fats in biodiesel production would require biodiesel plants to compete with other animal fats consumers. Such competition can be expected to raise the price of animal fats, affecting the economics of animal fats-derived biodiesel production. Also, increased production of glycerine also can be expected to reduce market prices for glycerine; again, the price received for glycerine would affect a biodiesel producer's profit margin. A more complete analysis would assess the viability of tallow-derived biodiesel production given competition for feedstock.

The relationship between the prices of vegetable and animal fats is not directly addressed in this study. However, it would be fair to assume that given the inflexibility of the supply of animal fats with respect to the price of fat, the animal fat market offers relatively small opportunities to attenuate any price swings in the vegetable oils. At the same time, it is hypothesized that an increase in the supply of vegetable oils – from, for example, the use of

high-oil-content seed varieties – could help lower the price of animal fats, through increasing the total availability of oils and fats. As prices of animal fats decline, they would become more attractive for use in biodiesel production. In summary, the SERBEP region has potential to contribute to the growth of the biodiesel industry as the volume of animal fat from the poultry sector increases and as the total U.S. supply of vegetable oils increases.

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