TABLE 16.1. A comparison of studies on the estimated delivered cost of corn stover to ethanol plants[1]

AUTHOR	Year Published	DOLLARS PER DRY TON			
		Low Estimate	High Estimate	Low Estimate	High Estimate
		$, in year published		$, adjusted to 2015	
Gallagher [23]	2003	15	32	29	61
Petrolia [55]	2008[2]	40	-[3]	67	-
Lazarus [40]	2008	50	-	63	-
Brechbill and Tyner [8]	2008	37	49	46	60
Eidman et al. [17]	2009	74	87	99	116
Larson et al. [37]	2008	35	80	44	100

[1] These studies contain different cost components.
[2] Published in 2008 but submitted in 2006
[3] "-" indicates that data is not available.

TABLE 16.2. continued

SCENARIO	NET PRESENT Value Costs ($/acre)	ANNUALIZED NET PRESENT VALUE Cost ($/acre)	Yield (dry ton/acre)	Cost/Dry Ton ($/dry ton)
10 Year Planning Horizon				
Baseline	1,900	309	5.73	54
Replanting	1,942	316	5.63	56
Storage and Transportation				
25 Bale Single-Row Stack	3,127	509	5.10	100
72 Bale 3-2-1 Stack	2,831	461	5.10	90
BCAP Planting[4]				
25 Bale Single-Row Stack	2,888	470	5.10	92
72 Bale 3-2-1 Stack	2,593	422	5.10	83
BCAP Planting and Harvest[4, 5]				
25 Bale Single-Row Stack	2,079	338	5.10	66
72 Bale 3-2-1 Stack	1,783	290	5.10	57

[1] Costs of production without replanting, storage, and transportation costs and BCAP subsidies.
[2] Assumes 20 percent probability of replanting the stand after the initial planting [24].
[3] Assumes switchgrass was planted four years before the biorefinery is operational in year four. Thus, biomass produced in years one, two and three was assumed to be delivered in years four and five, respectively. Feedstock harvested in years four through 10 was assumed to be stored an average of 0.5 years before delivery. Biomass in years one, two and three was assumed to be stored an average of 3.5 years, 2.5 years and 1.5 years, respectively. Biomass yields were adjusted for storage dry-matter losses using 5 percent for bales stored for up to six months and 14 percent for bales stored between six months and 1.5 years [36]. Annualized storage costs of $14.64 and $8.79 per dry ton going into storage were used for the single-row and 3-2-1 stacks. Transportation to the biorefinery assumed 2 percent dry-matter losses and trucking costs of $11.95 per dry ton [38].
[4] BCAP planting incentive payment of 75 percent of initial establishment costs.
[5] BCAP harvest incentive payment of $45 per dry ton for biomass sold in years four and five.

TABLE 16.4. Switchgrass establishment materials costs per acre

Cost Item	Description	Units	Quantity	Price	Cost
Seed	Pure live seed	Pound	8[1]	$20[2]	$160
Fertilizer					
	P_2O_5	Pound	40[1]	$0.52[3]	$20.80
	K_2O	Pound	80[1]	$0.44[3]	$35.20
Weed control					
Fall burn down	Glyphosate	Quart	1[1]	$8.76[3]	$8.76
Spring burn down	Glyphosate	Quart	1.5[1]	$8.76[3]	$13.14
Post-emerge	Broadleaf herbicide	Pint	2[1]	$2.50[1]	$5
Post-emerge	Grass herbicide	Acre	1[1]	$8[1]	$8
Post-emerge	Grass herbicide	Acre	1[1]	$8[1]	$8
Total materials cost—seed, fertilizer and chemicals ($ per acre)					**$258.90**

[1] From [24]
[2] From [45]
[3] From [42]

TABLE 16.5. Switchgrass establishment machinery costs per acre

Cost Item	Sprayer	Drill	Rotary mower	Tractor	Total
	$ per acre				
Diesel fuel[1]				$12.39	$12.39
Lubrication[2]				$1.86	$1.86
Repair and maintenance[3]	$0.69	$5.65	$1.37	$5.30	$13
Operating costs	$0.69	$5.65	$1.37	$19.55	$27.25
Capital recovery[4]	$0.74	$5.99	$0.99	$7.74	$15.47
Taxes, insurance and housing[5]	$0.19	$1.92	$0.44	$2.82	$5.37
Ownership costs	$0.93	$7.91	$1.44	$10.56	$20.84
Total cost	**$1.62**	**$13.56**	**$2.81**	**$30.11**	**$48.09**

[1] A fuel price of $2.35 per gallon [42], a fuel consumption rate of 6.57 gallons per hour for a 150 HP tractor [4], and the machine time per acre for each equipment operation [24] were used to calculate fuel costs.
[2] Lubrication costs were estimated using 15 percent of diesel fuel costs [4].
[3] Repair and maintenance costs were estimated using the formula and coefficients for each equipment type from the ASABE Standards [4].
[4] Depreciation and interest on equipment were calculated using the capital recovery method [3], a real interest rate of 3 percent [3], and the remaining (salvage) value formula and coefficients for each equipment type from the ASABE Standards [4].
[5] Taxes, insurance and housing annual expenses were calculated as 2 percent of the purchase price of equipment [4].

TABLE 16.6. Switchgrass establishment cost summary

Cost Item	Amount	
	$ per acre	
Total materials cost—seed, fertilizer, chemicals		$258.90
Seed	$160	
Fertilizer	$56	
Chemicals	$36.02	
Total machinery costs		$48.09
Operating costs	$27.25	
Ownership costs	$20.84	
Labor cost at $9.75 per hour[1]		$6.83
Operating capital—six months at 6 percent[1]	$286.10[2]	$8.58
Total cost of establishment		**$322.40**

[1] From [42]
[2] Operating capital is the total materials cost plus the total machinery operating cost.

TABLE 16.7. Switchgrass annual maintenance operations schedule [24]

Month	Operation	Equipment	Machine hours	Labor hours
May	Herbicide application[1]	Tractor and sprayer, 60-foot boom	0.03	0.0375
	Herbicide application[1]	Tractor and sprayer, 60-foot boom	0.03	0.0375
	Spread fertilizer	Tractor	0.07	0.0875

[1] Herbicide applications only occur in year two if needed.

TABLE 16.8. Switchgrass annual maintenance materials costs

Cost Item	Description	Units	Quantity	Price	Cost
Fertilizer					
	N	Pound	6[1]	$0.48[2]	$28.80
	P_2O_5	Pound	40[1]	$0.52[2]	$20.80
	K_2O	Pound	80[1]	$0.44[2]	$35.20
Weed control					
Post-emerge	Grass herbicide	Acre	1	$8[1]	$8
Post-emerge	Grass herbicide	Acre	1	$8[1]	$8
Total materials costs ($ per acre)					**$100.80**

[1] Quantities are University of Tennessee (UT) Extension's recommended fertilization rates for switchgrass. UT Extension does not recommend P2O5 and K2O on medium- and high-test soils [24].
[2] From [42].

TABLE 16.9. Switchgrass annual maintenance machinery costs

Cost Item	Sprayer	Tractor	Total
	$ per acre		
Diesel fuel[1]		$2.88	$2.88
Lubrication[2]		$0.43	$0.43
Repair and maintenance[3]	$0.27	$1.23	$1.50
Operating costs	**$0.27**	**$4.54**	**$4.81**
Capital recovery[4]	$0.29	$1.80	$2.09
Taxes, insurance and housing[5]	$0.08	$0.65	$0.73
Ownership costs	**$0.37**	**$2.45**	**$2.82**
Total cost	**$0.65**	**$6.99**	**$7.64**

[1] A fuel price of $2.35 per gallon [42], a fuel consumption rate of 6.57 gallons per hour for a 150 HP tractor [4], and the machine time per acre for each equipment operation [24] were used to calculate fuel diesel costs.
[2] Lubrication costs were estimated using 15 percent of diesel fuel costs [4].
[3] Repair and maintenance costs were estimated using the formula and coefficients for each equipment type from the ASABE Standards [4].
[4] Depreciation and interest on equipment were calculated using the capital recovery method [3], a real interest rate of 3 percent [3], and the remaining (salvage) value formula and coefficients for each equipment type from the ASABE Standards [4].
[5] Taxes, insurance and housing annual expenses were calculated as 2 percent of the purchase price of equipment [4].

TABLE 16.10. Switchgrass annual maintenance cost summary

Item	Amount	
	$ per acre	
Total materials cost—fertilizer, chemicals		$100.80
Fertilizer	$84.80	
Chemicals[1]	$16	
Total machinery cost		$7.64
Operating costs	$4.81	
Ownership costs	$2.82	
Labor cost at $9.75 per hour[2]		$1.58
Operating capital—six months at 6 percent[2]	$105.61[3]	$3.17
Total annual cost of maintenance		**$113.19**

[1] Chemical cost occurs only in the second year.
[2] From [42]
[3] Includes material cost plus operating costs

TABLE 16.11. Switchgrass harvest, hauling and storage operations schedule

Month	Operation	Equipment	Machine time/rate	Labor Hours
November–February	Mow (hours per acre)	Mower	0.38[1]	0.48[1]
	Rake (hours per acre)	Rake	0.25[1]	0.31[1]
	Bale (tons per acre)	Large round baler	5.5[2]	
	Haul to stack (dry tons per hour)	Front end loader	8[2]	
	Haul pallets and tarp (hours per 20 pallets)	Pickup	0.5[3]	1
	Affix tarp to stack (hours per 72-bale stack)			0.5
	Affix tarp to stack (hours per 25-bale stack)			0.25

[1] From [24]

[2] Tractor and labor time to haul 8 dry tons of bales per hour (2 bales per trip) to the edge of the field to the stack [45] was increased by an extra 10 percent to account for additional tractor and operator time to place the pallets as the stack is being built.

[3] Assumes 0.5 hours of operating and ownership costs for a pickup truck to haul a load of 20 pallets to the site of the stack and one hour of labor time to drive the pickup and load and unload pallets.

TABLE 16.12. Switchgrass harvest, hauling and storage materials costs

Item	Description	Units	Quantity	Price	Cost
Twine	Twine per dry ton	Bale	1	$2.92[1]	$2.92
				Total	**$2.92**
Single-row stack	Pallet	Pallet	25	$6. 50[2]	$162.50
25 bales	1,000 square foot tarp	Tarp	1	$115[3]	$115
	Tie-down kit	Kit	1	$60[3]	$60
				Total	**$337.50**
3×2×1 stack	Pallet	Pallet	36	$6.50[2]	$234
72 bales	1,620 square foot tarp	Tarp	1	$25[4]	$251
	Tie-down kit	Kit	1	$68[5]	$68
				Total	**$553**

[1] From [24]

[2] Cost per 40-inch-by-48-inch pallet is the average from a survey of providers by the authors.

[3] Slip Ons/Bale Bonnet Company, Cynthiana, Ohio: http://roundbalecovers.com/info.htm.

[4] Assumes 22.5 square feet of reinforced plastic tarp per 5-foot-by-4-foot bale in a 3-2-1 pyramid stack housing 72 bales [26]. Reinforced plastic tarp cost of $0.16 per square foot was the average from a survey of providers by the authors.

[5] Average cost from a survey of providers by the authors.

TABLE 16.13. Switchgrass annual operating, ownership and labor expenses for harvest assuming a five-year planning horizon[1]

Stand Year	Fuel and Lubrication	Twine and Repairs	Capital Recovery	Taxes Insurance and Housing	Labor	Operating Interest	Total
	$ per acre						
1	22.15	26.56	23.07	2.43	15.20	1.46	90.86
2	36.46	50.35	40.34	4.28	25.03	2.60	159.07
3	40.46	57	45.16	4.80	27.77	2.92	178.12
4	43.19	61.54	48.45	5.15	29.65	3.14	191.13
5	48.54	70.41	54.90	5.84	33.32	3.57	216.57

[1] Annual expenses for mowing, raking, baling and handling of biomass before being placed into storage.

TABLE 16.14. Switchgrass annual operating, ownership and labor expenses for harvest assuming a 10-year planning horizon[1]

Stand Year	Fuel and Lubrication	Twine and Repairs	Capital Recovery	Taxes Insurance and Housing	Labor	Operating Interest	Total
	$ per acre						
1	22.83	27.56	23.97	2.53	15.67	1.51	94.08
2	34.01	46	37.53	3.99	23.34	2.40	147.27
3	45.06	64.22	50.92	5.44	30.93	3.28	199.84
4	46.79	67.08	53.02	5.66	32.12	3.42	208.08
5	54.34	79.54	62.18	6.65	37.30	4.02	244.02
6	48.72	70.27	55.37	5.92	33.44	3.57	217.29
7	57.31	84.44	65.78	7.04	39.34	4.25	258.17
8	53.75	78.57	61.47	6.57	36.90	3.97	241.23
9	55.84	82.02	64	6.85	38.33	4.14	251.18
10	57.17	84.21	65.61	7.02	39.24	4.24	257.50

[1] Annual expenses for mowing, raking, baling and handling of biomass before being placed into storage.