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Economic Assessment of Alternative Kentucky Bluegrass Seed Production Systems

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ABSTRACT

Kentucky bluegrass (*Poa pratensis* L.) seed is an economically important crop in northern Idaho and eastern Washington that is also valued for its use in controlling erosion on the hills and slopes that are prevalent in this area. However, smoke created from the burning of bluegrass residue following seed harvest has given rise to opposition from local interest groups. Washington has banned residue burning completely. In Idaho, residue burning is still allowed, but the timing and amount of acreage burned at one time are controlled.

Non-thermal residue removal techniques include combinations of mechanical operations such as baling, harrowing, and/or mowing to reduce straw accumulation. Since the ban on burning in Washington, growers have implemented these non-thermal residue management techniques. The viability of non-thermal bluegrass seed production has come into question, however, because the economically productive stand life purportedly is reduced.

To compare non-thermal, reduced burn, and traditional, full-load burn bluegrass residue management systems, replicated plots were established north of Worley, Idaho, in 2001. This analysis examines the operating and ownership costs associated with each of four production systems and assesses the net returns using yields from 4 years of the experiment.

Based on plot data, the bale-then-burn treatment is the most profitable with a net present value (NPV) of $351 per acre, including the amortized cost of establishment, followed closely by the full-load burn treatment with a per-acre NPV of $349. The NPVs for the mechanical and system treatments were $139 and $140, respectively. Both the mechanical and system treatments were hindered by lower yields and higher costs.

NOTE: This publication is the third in a series evaluating the effects of residue management on bluegrass production, growth, and seed production. Please refer to other UI College of Agricultural and Life Sciences publications for the impacts of residue management on bluegrass seed production (BUL 843) and for an overview of Kentucky bluegrass production (BUL 842). Both are available online at info.ag.uidaho.edu. Also find resources at the UI bluegrass website, www.ag.uidaho.edu/bluegrass.

INTRODUCTION

Kentucky bluegrass (*Poa pratensis* L.) is an economically important crop in the Pacific Northwest (PNW). In 2002, approximately 152,000 acres of Kentucky bluegrass seed were produced in the PNW, accounting for over 90 percent of total U.S. production. Northern Idaho and eastern Washington have historically produced up to 80 percent of the nation's bluegrass seed (Mahler and Ensign, 1989).

Kentucky bluegrass is a perennial plant that is typically planted in late April to early May or in late-fall. Dryland bluegrass seed production in northern Idaho requires 1 year for crop establishment with no harvest occurring during that year. Customary harvesting practices for bluegrass seed in northern Idaho include swathing in late June to early July and curing the grass in windrows until seed moisture is low enough for safe storage. Grass is then combine harvested to extract the seed. Following harvest, field residue is burned in mid-August to mid-September.

Burning as a management tool has a long history. Native Americans burned grass residue to increase plant productivity (Hardison, 1976). In 1944, the United States Forest Service discovered that burning resulted in increased seed production of native pasture grasses in Georgia, and agricultural burning was initiated (Hardison, 1976). Field burning practices were adopted around 1950 in the PNW to control diseases in ryegrass and tall fescue (Holman and Thill, 2005).

Burning bluegrass residue removes residue from the plant crown and promotes fall tiller development and increased seed production the following year. The timing of field burning is important because a sufficient fall regrowth period is required for seed development (i.e., floral induction) and to reduce disease and weed incidence (Holman and Thill, 2005).

Increased residential growth in northern Idaho and eastern Washington has intensified conflict over smoke created from burning bluegrass residue. Some citizens are concerned about the public health impacts and air quality issues associated with burning. Legislation in Washington banned residue burning and required growers to use non-thermal residue removal methods as of 1998. In 2003, the Idaho Legislature empowered the Idaho State Department of Agriculture (ISDA) to manage field burning as long as "no other economically viable alternative exists" (Idaho Legislature House, 2003). To burn straw residue, farmers must register their acreage and apply for a burning permit from the ISDA. Smoke management coordinators from the ISDA and Idaho Department of Environmental Quality (DEQ) and representatives from the Nez Perce and Coeur d'Alene tribes monitor and authorize residue burns.

To examine alternative bluegrass residue management systems, replications of long-term, large-scale, on-farm trials were established north of Worley, Idaho, in 2001. On-farm trials were used to reflect typical grower field conditions and to properly assess treatment effectiveness on residue levels and impacts on grass seed production. The first stage was the establishment of the experiment and assessment of the first 4 years of production. The second stage is a 3-year continuation of the experiment to assess the impact of alternative production methods on stand life and associated seed yields.

OBJECTIVES

The objectives of this analysis are to determine the operating and ownership costs associated with thermal and non-thermal production systems and to assess their net returns using yield data from the first 4 years of the experiment.

METHODS

Treatments

In an experiment near Worley, Idaho, modifications to traditional residue burn management methods were evaluated to determine if burning could be reduced or eliminated while maintaining seed production. The four treatments studied were: (1) traditional full-load burn, (2) bale-then-burn, (3) mechanical, and (4) system, or combined treatment.

The traditional full-load burn treatment involves burning all straw residue as soon as possible after each harvest to eliminate crop residue and enhance seed production for the next year. Burning is a low-cost residue removal technique, but air quality can be adversely affected because of smoke and particulate matter emissions from the burned straw residue.

The bale-then-burn treatment consists of raking and baling the residue after harvest, removing the bales from the field, and then burning the remaining residue. The advantage of the bale-then-burn treatment is that seed production is stimulated while particulate emissions can be reduced because of a reduction in the fuel load. Also, baled straw residue has potential market value. Depending upon weather conditions, smoke emissions from the reduced fuel load can remain closer to the ground before dissipating, thus causing particulate matter to interfere more with human activity (Johnston and Schaaf, 2003). Other disadvantages of the bale-then-burn treatment include higher machinery and labor costs associated with the raking, baling, and hauling of grass bales.

The mechanical treatment involves raking and baling the residue following each harvest, removing the bales from the field, then mowing and harrowing the remaining residue to fragment the residue for faster decomposition in order to enhance sunlight access to the plant crown. No burning takes place, thus no smoke is created with this treatment. Higher machinery and labor costs are associated with this treatment than the bale-then-burn treatment because of the additional mowing and harrowing operations.

The system treatment involves alternating the previously described three treatments, starting with mechanical in year 1, bale-then-burn in year 2, traditional full-load burn in year 3, and repeating the sequence during years 4 through 6 of production. The advantage of the system treatment is that burning remains a tool in residue management but occurs less frequently than in the full-load burn treatment, therefore reducing overall smoke emissions. Disadvantages of the system treatment are higher machinery and labor requirements than the full-load burn treatment.

Plot establishment and management

'Alene' Kentucky bluegrass was established in 2001, and plots were established following the first seed harvest in 2002. Each plot was 60 to 70 feet wide by 300 feet long and replicated four times.

Grass stands in all plots were swathed at maturity and seed was harvested 2 to 4 weeks later. Both operations were performed using a commercial-size swather and combine. Grass in each plot was harvested separately and dumped into a semitrailer. Seed from each plot was weighed using truck scales to determine the uncleaned seed yield for each plot.

A 5-gallon sample of seed from each plot was collected from the combine during harvest, cleaned, and the percentage clean seed yield for each plot was calculated.

Mechanical residue removal operations were preformed after harvest, during late summer to early fall, using grower equipment. Thermal residue removal plots were burned during early to late August, while the mechanical residue removal plots were protected from fire.

The grass stand was fertilized in the fall (mid-October to early November). In 2002, 2003, and 2004 ammonium nitrate fertilizer was used. In 2005 urea was used because ammonium nitrate fertilizer was no longer available.

Costs

The Crop Enterprise Budget Worksheet (CEBW) software program (Patterson et al., 2003) was used to develop costs and returns estimates for each year and treatment of bluegrass seed production. Production costs were categorized into two groups: operating and ownership (Kay et al., 2004). Operating, or variable, costs are expenses directly associated with the production of the bluegrass seed. These costs tend to fluctuate with the level of activity or production. Seed, fertilizer, herbicides, fuel, lubricants, and repairs are all examples of operating costs. Ownership, or fixed, costs are those costs incurred from owning machinery, equipment, buildings, etc. Depreciation, interest, housing, taxes, and insurance are examples of ownership costs.

Bluegrass production costs assumed in this analysis are typical of practices in northern Idaho. The bluegrass seed production cost accounting year is assumed to extend from after harvest through the next year's harvest.

Operating interest for 8 months was assessed on operating expenses to account for the cost of operating loans and/or to account for the opportunity cost of the owner funding these expenses until the crop is sold. The operating interest rate was 7 percent.

Labor to operate machinery was valued at $12 per hour, and non-machine labor was valued at $7 per hour (Patterson and Smathers, 2004). Non-machine labor was included to account for supplemental harvest labor.

Fertilizer and herbicide costs are identical under each residue management treatment, but vary by year of seed production. In 2002, Express (tribenuron methyl at 0.012 pounds active ingredient (ai) per acre (0.25 ounces per acre), and 2,4-D amine, at 0.48 pound acid equivalent (ae) per acre (0.5 quarts per acre), were applied. Herbicide rates for 2003 were 0.17 pound ae per acre (5.5 ounces per acre) of Banvel (dicamba), 0.023 pound ai per acre (0.5 ounces per acre) of Beacon (primisulfuron), and 1.5 pints of crop oil concentrate. Rates for 2004 were 0.023 pound ai per acre (0.5 ounce per acre) of Beacon, 1 quart per acre of methylated seed oil, and 0.56 pound ai per acre (18 ounces per acre) of Direx (diuron). In 2005, 0.4 pound ai per acre of Sinbar (terbacil) were applied.

Approximately 110 pounds per acre of nitrogen were applied on the 2002, first-year crop, and 150 pounds per acre were applied on subsequent crops. An average on-farm price of $0.13 per pound of 26-5-5-5 was used to price fertilizer.

A charge of $7 per acre was allocated to each year of bluegrass production to account for incidental pesticide or fungicide spray costs. A fungicide application (total cost of $42 per acre) is anticipated for at least 1 production year during the expected stand life of bluegrass.

Harvest costs of $15 per cwt include bags, tags, seed cleaning, etc. Harvest costs varied each year by treatment depending on seed yields. Custom rates for hauling and stacking bales to the edge of the field are $2 per ton for loading and $6 per ton for stacking. Residue burning costs are $2 per acre for a burn permit from the state of Idaho.[1] Other variable burning costs are $4 per acre and include labor and fuel. On-farm diesel was charged at $1.57 per gallon and off-farm gasoline was $2.01 per gallon.

The *Machinery Cost Analysis* software program (MachCost) (Smathers et al., 2002) was used to develop ownership and operating costs for all machinery and equipment used in each treatment. An opportunity interest cost was assessed on the average investment value to account for the funds dedicated to owning the machinery and equipment. Straight-line depreciation was used to allocate the investment value over the useful life of the machinery and equipment. Machinery and equipment insurance costs were 0.45 percent of annual investment value for the combines and 0.27 percent for all other machinery and equipment. Property tax was not assessed on machinery and equipment because it is nonexistent in Idaho. Housing costs for machinery and equipment were assessed based upon coefficients in MachCost. Coefficients and parameters within the program used in calculating machinery costs are consistent with the American Society of Agricultural Engineers (ASAE) standards.

Ownership costs were allocated to the bluegrass enterprise based on the relative proportion of hours the equipment is used as a percentage of all use. A 2,000-acre farm with an oat, spring wheat, legume, winter wheat, and bluegrass rotation was assumed for this study. The crop rotation includes 1 year of oats, 1 year of spring wheat, 1 year of legumes, 1 year of winter wheat, and 7 years of bluegrass. A typical year would, thus, have 182 acres planted to oats, 182 acres planted to spring wheat, 182 acres planted to winter wheat, 182 acres planted to legumes, and 1,274 acres planted to bluegrass. Approximately 182 acres of the 1,274 acres planted to bluegrass would be newly established acres, with no production occurring in the establishment year.

Machinery and equipment, except for a used combine harvester and two used trucks, were valued at new prices (table 1). The useful life for most machinery and equipment ranges from 10 to 15 years. The assumed remaining life is 4 years for the used pickup and 10 years for the used combine and 2-ton truck. The purchase price, useful life, and salvage values for all machinery and equipment used in this study are indicated in table 1.

The machinery and other equipment used for each treatment are shown in table 2, along with total capital investment. The full-load burn treatment requires the least capital investment at $658,000. The bale-then-burn treatment capital investment rises to $750,000 because of the addition of a rake and baler. The mechanical and system treatments require the highest capital investment ($777,500) because of the rake, baler, mower, and harrow required for straw residue management.

[1] Tribal lands are assessed an additional $1 per acre permit fee for burning.

TABLE 1. Machinery and Equipment Parameters Used to Allocate Ownership Costs.

	Purchase price	Years to trade	Salvage value
Swather	$65,000	10	$22,500
Combine new	$240,000	15	$50,000
Combine used	$45,000	10	$17,500
Rake	$12,000	10	$2,150
Baler	$80,000	10	$20,000
Mower	$25,000	10	$10,000
Harrow	$2,500	15	$250
Tractor 255hp	$115,000	15	$22,500
Tractor 255hp	$115,000	15	$22,500
2-ton truck used	$30,000	10	$10,000
3/4-ton pickup new	$38,000	10	$14,500
3/4-ton pickup used	$10,000	4	$2,000

Annual hours of machinery and equipment use for each treatment are shown in Table 3. Swather and combine annual use is equal for all treatments as well as annual miles for the truck and pick-ups. Annual use for each tractor is least under the full-load burn treatment at 253 hours, followed by the system treatment at 251, the bale-then-burn treatment at 370, and the mechanical treatment at 432 hours. Even though the mechanical and system treatments require the same machinery and implements, annual use of the rake, baler, mower and harrow is less under the system treatment because one-third of the bluegrass acreage is burned each year without baling.

An umbrella liability insurance policy was charged at $0.40 per acre along with a pollution insurance policy at $0.05 per acre. Field crop fire insurance was assessed at $0.30 per $100 value; or $1.20 per acre assuming a crop value of $400 per acre.

Land rent was assumed to be share-cropped, with one-quarter of the unclean seed distributed to the

TABLE 2. Machinery and Equipment Used in the Full-Load Burn, Bale-then-Burn, Mechanical, and System Treatments and Total Capital Investment Required for Each Treatment.

	Full-load burn	Bale-then-burn	Mechanical	System
Swather	+	+	+	+
Combine new	+	+	+	+
Combine used	+	+	+	+
Rake	-	+	+	+
Baler	-	+	+	+
Mower	-	-	+	+
Harrow	-	-	+	+
Tractor 255hp	+	+	+	+
Tractor 255hp	+	+	+	+
2-ton truck used	+	+	+	+
3/4-ton pickup new	+	+	+	+
3/4-ton pickup used	+	+	+	+
Total capital investment	$658,000	$750,000	$777,500	$777,500

Note: "+" implies equipment is used in the treatment and "-" implies equipment is not used in the treatment.

TABLE 3. Annual Equipment and Machinery Use Under the Full-Load Burn, Bale-then-Burn, Mechanical, and System Treatments.

	Full-load burn	Bale-then-burn	Mechanical	System
	------------	{ *hours* }	------------	
Swather	175	175	175	175
Combine new	200	200	200	200
Combine used	122	122	122	122
Rake	0	63	63	42
Baler	0	75	75	50
Mower	0	0	87	59
Harrow	0	0	40	27
Tractor 255hp	253	370	432	351
Tractor 255hp	253	370	432	351
	------------	{ *miles* }	------------	
2-ton truck used	5,000	5,000	5,000	5,000
3/4-ton pickup new	20,000	20,000	20,000	20,000
3/4-ton pickup used	10,000	10,000	10,000	10,000

landlord. The landlord does not assume any cost of production.

Bluegrass stand establishment costs are uniform for all four treatments and are based on published University of Idaho crop budgets (Smathers, 2003), with modifications to represent current management practices for fertilizer and herbicide use, custom application, and land rent. The total cost for the establishment is $188 per acre. This cost is amortized to a yearly investment value of $36 assuming a 6-year bluegrass stand life and a 4 percent discount rate.

Revenues

Revenues generated during bluegrass production years were based on a 5-year average price of $0.75 per pound of seed (NASS) and a representative value of $25 per ton for baled straw residue. Growers reported that straw prices ranged from $0 to $42 per ton depending on straw quality and the market for the straw. Growers with an established market who were able to bale the residue immediately after harvest, with some dew on the straw, received upwards of $42 per ton. Growers without a market received little or no value from their baled residue. Where no market exists for baled straw residue, bales are typically left to rot near the edges of the field.

Yields were obtained from the residue management treatments in Worley, Idaho. Seed yield for the first year of production following the establishment year (2002) averaged 610 pounds per acre. Because the experimental plots were established and managed together during the first year of seed production, the whole-field yield average of 610 pounds per acre was assumed for all treatments in 2002.

Yields through 2005, i.e., the first 4 years of the study, are summarized in table 4. Yields for the full-load burn and bale-then-burn treatments were statistically higher than for the mechanical treatment only in 2004 ($P = 0.05$). Seed yields for the full-load burn and bale-then-burn treatments were similar in 2003, at 970 and 983 pounds per acre, respectively, while in 2004 the full-load burn treatment had a lower seed yield than the bale-then-burn treatment, 540 and 584 pounds per acre, respectively. Lower seed yield for the full-load burn treatment in 2004 was due to a weed infestation in one of the four replications. Omitting the weed-infested replication would result in a yield of 606 pounds per acre for the full-load burn treatment. Seed yield for the full-load burn treatment in 2005 was higher (776 pounds per acre) than for the bale-then-burn treatment (745 pounds per acre).

Residue is assumed to yield 1.5 tons per acre for the bale-then-burn treatment. This averages to 1 ton of residue per bluegrass acre for the system treatment because only two-thirds of the acreage is baled each year, with the residue on the other third of the acreage being burned.

The NPV of net returns to management and risk over the four production periods was determined using a 4 percent discount rate under the assumption that bluegrass stand establishment costs are amortized over a 6-year stand life.

TABLE 4. Kentucky Bluegrass Seed Yield from Full-Load Burn, Bale-then-Burn, Mechanical, and System Treatments in Worley, Idaho, 2002-2005.

	Clean seed yield (pound/acre)			
	2002[1]	**2003**	**2004**	**2005**
Full-load burn	610	970 a	540 a	776 a
Bale-then-burn	610	983 a	584 a	745 a
Mechanical	610	881 a	314 b	657 a
System[2]	610	795 a	571 a	671 a

Note: Values within a column with the same letter (a or b) are not significantly different ($P \le 0.05$).

[1] 2002 is the first seed yield prior to plot establishment.

[2] System treatments: 2003 yields follow mechanical treatment in fall 2002; 2004 yields follow bale-then-burn treatment in fall 2003; 2005 yields follow the full-load burn treatment in fall 2004.

RESULTS

Costs

Typical operating and ownership costs per acre for bluegrass seed production, by treatment, are summarized in table 5. Detailed cost and return statements for each treatment are shown in the appendix. Some operating costs vary between treatments, while other costs are constant across year and treatment. Total operating costs are $202, $227, $225, and $224 per acre for the full-load burn, bale-then-burn, mechanical, and system treatments, respectively. Operating costs that differ among treatments are burning, harvest, labor, fuel, lube, repair, and operating interest. Operating costs that remain constant among treatments are fertilizer, insurance, herbicide, and incidental pesticide or fungicide applications.

Variability in harvest costs is explained by variability in seed yield and whether the residue is baled. The bale-then-burn and mechanical treatments have a $12 per acre cost for custom stacking and hauling 1.5 tons of straw per acre to the edge of the field. The system treatment has an $8 per acre cost for custom stacking and hauling an average of 1 ton of straw per acre, while the full-load burn treatment has no harvest cost for baled straw residue.

Operating interest varies with operating costs, which change with seed yield. As seed yield increases, variable harvest costs increase, and, consequently, operating interest increases. Operating interest was highest in 2003 for all treatments because yields, and thus harvest costs, were highest.

Ownership and operating costs for machinery and equipment, as developed in MachCost, are summarized in table 5 and presented by operation for each treatment in the appendix (table A6). Machinery costs vary across treatments but are identical year-to-year within the same treatment. Total per-acre operating and ownership costs for machinery and equipment are $71 for the full-load burn, $99 for the bale-then-burn, $109 for the mechanical, and $116 for the system treatment. Machinery operating costs vary by treatment depending upon the total capital investment and the total annual hours of use. Higher annual use on machinery results in lower ownership costs per acre. Conversely, the more hours of use per year, the higher the repair costs each year.[2] Because of the inefficient utilization of machinery and equipment, the system treatment has the highest ownership and operating costs.

Costs per acre for operations (e.g., baling) powered by a tractor vary with total annual use of the equipment and machinery. Operation costs are $28 and $13 per acre for combining with the new and used combines, respectively, and $10 per acre for swathing. Operation costs per acre range from $9 to $10 among treatments for mowing, $5 to $6 for raking, and $22 to $27 for baling. The costs of harrowing average $3 per acre.

TABLE 5. Typical Operating and Ownership Costs per Acre for Kentucky Bluegrass Seed Production for the Full-Load Burn, Bale-then Burn, Mechanical, and System Treatments.

	Full-load burn	Bale-then-burn	Mechanical	System[1]
	----------------	{ $/acre }	----------------	
OPERATING COSTS				
Fertilizer	$62	$62	$62	$62
Burn	$6	$6	$0	$4
Harvest	$69	$83	$83	$78
Herbicide	$12	$12	$12	$12
Incidental pesticide or fungicide	$7	$7	$7	$7
Labor	$18	$21	$22	$22
Fuel, lube, and repair	$19	$26	$29	$28
Operating interest at 7%	$9	$10	$10	$10
Total operating costs	$202	$227	$225	$224
OWNERSHIP COSTS				
Depreciation and interest	$33	$50	$54	$62
Machinery housing and insurance	$3	$4	$5	$5
Liability insurance	$1	$1	$1	$1
Total ownership costs	$37	$55	$60	$68
TOTAL COSTS	$239	$282	$285	$292

[1] Under the system treatment we assume one-third of the acreage is full-load burn, one-third is bale-then-burn, and one-third is mechanical treatment. Two-thirds of the acreage would therefore we burned each year.

[2] Depreciation and investment interest are spread evenly over the useful life (as measured in years) of the machine (or equipment) and then are placed on a per-hour basis by determining the total number of hours the machine (or equipment) will be used per year. These ownership costs are then allocated to the various operations (such as baling) on a per-acre basis by determining the number of hours it takes for the machine to cover 1 acre of the operation. Thus, the more total acres the machine (or equipment) is used on during a year, the lower the ownership costs per acre. Conversely, repair costs increase proportionally with hours of use and will increase on a per-acre basis as the hours of machinery use increase per year. A change in farming practices that significantly change hours of annual use will likely change the number of years of useful life.

Net returns

Net returns to management and risk for each treatment are presented, by year, in table 6. The $188 required for the establishment of the bluegrass stand, while an expenditure in 2001, was amortized over an assumed 6-year stand life at a discount rate of 4 percent, with $36 being allocated to each year.

Yearly net returns are quite variable due to the variability in seed yield. The price of bluegrass seed was assumed constant in order not to confound treatment results. The highest returns were obtained under the bale-then-burn and full-load burn treatments in 2003 with net returns to management and risk of $200 and $195 per acre, respectively. The lowest return was witnessed with the mechanical treatment in 2004 at -$107. This return mainly was due to a low seed yield of 314 pounds. All treatments provided a positive net return for the first four years of production with the exception of the mechanical and system treatments (-$107 and -$12, respectively) in 2004. Each treatment netted its lowest return during 2004.

Overall, for the 4 years examined and including the associated amortized cost of establishment, the bale-then-burn treatment is the most profitable with a NPV of $351 per acre, followed closely by the full-load burn treatment at $349. The mechanical and system treatments yielded a NPV of $139 and $140, respectively. Both treatments were hindered by lower yields and higher costs. If the 2004 weed-infested full-load burn replication is omitted, the 2004 net return for the full-load burn treatment is $69, and the NPV is $375, making the full-load burn treatment the most profitable treatment.

As noted, this analysis accounts only for the first 4 years of the productive stand life, whereas the establishment costs were amortized over an assumed 6-year productive life. For the per-acre 6-year NPV of each treatment to be $0 (i.e., the yield required in the final 2 years of the assumed 6-year stand life for all treatments to achieve the same profit) when discounted to 2001 at a seed price of $0.75 per pound, seed yields for both 2006 and 2007 would have to be 182 pounds for the full-load burn, 178 pounds for the bale-then-burn, 392 pounds for the mechanical, and 425 pounds per acre for the system treatment.

TABLE 6. Net Returns to Management and Risk, and Net Present Value Over the Four-Year Trial Period for the Full-Load Burn, Bale-then-Burn, Mechanical, and System Treatments.

Year	Full-load burn	Bale-then-burn	Mechanical	System
	{ $/acre }			
2002	$70	$64	$60	$41
2003	$200	$195	$146	$89
2004	$3[1]	$33	-$107	-$12
2005	$111	$95	$48	$35
Net present value[2]	$349	$351	$139	$140

Note: Net returns include an amortized annual establishment cost of $36 per acre to account for a $188 per-acre establishment cost amortized at 4 percent over an assumed 6-year stand life.

[1] Excluding the weed-infested replication for the full-load burn treatment results in a net return of $69 in 2004 and a net present value of $375.

[2] Annual net returns are discounted to 2001 to obtain the net present value.

TABLE 7. Net Present Value of the First 4 Years of Seed Yield, by Treatment, Assuming Establishment Costs are Amortized Over a 4-to 8-year Expected Stand Life.

Stand life	Full-load burn	Bale-then-burn	Mechanical	System
	{ $/acre }			
4 Years	$291	$294	$81	$83
5 Years	$326	$328	$116	$117
6 Years	$349	$351	$139	$140
7 Years	$365	$368	$155	$157
8 Years	$378	$380	$168	$169

Note: Amortized establishment costs are $52, $42, $36, $31, and $28 for stand lives of 4 through 8 years, respectively.

Stand-Life sensitivity

Net present values of the first 4 years of seed yield for each treatment are compared in table 7 with the establishment cost amortized over varying years of plant stand life. This analysis assumes the same net return for each system as was obtained from 2002 through 2005, with the exception that the establishment costs are spread over different productive stand lives. As the $188 establishment cost is amortized over a longer productive stand life the profitability of each system increases.

All systems yield a positive NPV over the 4 years examined when plant stand life ranges from 4 to 8 years. If, as most farmers have witnessed, the non-burn treatment stands must be reestablished after 3 to 4 years of production, while stands where residue has been burned last for 6 to 8 years, a wide disparity in returns to management and risk may exist.

Yield and Price Sensitivity

Sensitivity analyses with respect to seed yield and price, by treatment, are presented in Tables 8 through 11. The net returns per acre are based on the 2005 cost and return budgets and include an amortized cost ($36 per acre) for the establishment year. While the magnitude of net returns between treatments mirrors the 2005 net returns presented in table 7, these tables provide an estimate of break-even values for each yield and price. For example, at a bluegrass seed price of $0.50 per pound, all treatments, except system, require between a 900 and 1,000 pound seed yield to break even. The system treatment requires a seed yield of over 1,000 pounds per acre. At any price for seed evaluated, the full-load burn requires the least seed production to break even because of the lower cost structure.

None of the treatments is profitable when seed yields are below 200 pounds per acre when seed prices are within the price range examined. The full-load burn and bale-then-burn treatments are profitable at 500 pounds of seed per acre when the price is above $0.79 per pound and at 600 pounds of seed per acre when the price is above $0.70 per pound. The mechanical treatment is profitable at seed yields of 500 pounds of seed per acre when the price is above $0.81 per pound. The system treatment is profitable at seed yields of 500 pounds per acre when the price is $0.87 per pound. At any yield evaluated, the full-load burn requires the lowest price to break even.

TABLE 8. Net Returns ($/acre) with Varying Seed Yield and Price for the Full-load Burn Treatment.

	Yield (pound/acre)									
Price ($/pound)	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**
0.50	-186	-160	-133	-107	-81	-55	-28	-2	24	50
0.60	-171	-137	-103	-70	-36	-2	32	65	99	133
0.70	-156	-115	-73	-32	9	50	92	133	174	215
0.80	-141	-92	-43	5	54	103	152	200	249	298
0.90	-126	-70	-13	43	99	155	212	268	324	380
1.00	-111	-47	17	80	144	208	272	335	399	463
1.10	-96	-25	47	118	189	260	332	403	474	545
1.20	-81	-2	77	155	234	313	392	470	549	628
1.30	-66	20	107	193	279	365	452	538	624	710
1.40	-51	43	137	230	324	418	512	605	699	793
1.50	-36	65	167	268	369	470	572	673	774	875

Note: Assumes a 6-year stand life with annual costs of $238, harvest costs of $0.15 per pound of seed, and a 25% share rent.

TABLE 9. Net Returns ($/acre) with Varying Seed Yield and Price for the Bale-then-Burn Treatment.

	Yield (pound/acre)									
Price ($/pound)	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**
0.50	-188	-162	-136	-110	-83	-57	-31	-5	22	48
0.60	-173	-140	-106	-72	-38	-5	29	63	97	130
0.70	-158	-117	-76	-35	7	48	89	130	172	213
0.80	-143	-95	-46	3	52	100	149	198	247	295
0.90	-128	-72	-16	40	97	153	209	265	322	378
1.00	-113	-50	14	78	142	205	269	333	397	460
1.10	-98	-27	44	115	187	258	329	400	472	543
1.20	-83	-5	74	153	232	310	389	468	547	625
1.30	-68	18	104	190	277	363	449	535	622	708
1.40	-53	40	134	228	322	415	509	603	697	790
1.50	-38	63	164	265	367	468	569	670	772	873

Note: Assumes a 6-year stand life with annual costs of $278, harvest costs of $0.15 per pound of seed, and a 25% share rent.

TABLE 10. Net Returns ($/acre) with Varying Seed Yield and Price for the Mechanical Treatment.

	Yield (pound/acre)									
Price ($/pound)	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**
0.50	-195	-169	-142	-116	-90	-64	-37	-11	15	41
0.60	-180	-146	-112	-79	-45	-11	23	56	90	124
0.70	-165	-124	-82	-41	0	41	83	124	165	206
0.80	-150	-101	-52	-4	45	94	143	191	240	289
0.90	-135	-79	-22	34	90	146	203	259	315	371
1.00	-120	-56	8	71	135	199	263	326	390	454
1.10	-105	-34	38	109	180	251	323	394	465	536
1.20	-90	-11	68	146	225	304	383	461	540	619
1.30	-75	11	98	184	270	356	443	529	615	701
1.40	-60	34	128	221	315	409	503	596	690	784
1.50	-45	56	158	259	360	461	563	664	765	866

Note: Assumes a 6-year stand life with annual costs of $285, harvest costs of $0.15 per pound of seed, and a 25% share rent.

TABLE 11. Net Returns ($/acre) with Varying Seed Yield and Price for the System Treatment.

	Yield (pound/acre)									
Price ($/pound)	200	300	400	500	600	700	800	900	1000	1100
0.50	-214	-188	-162	-136	-109	-83	-57	-31	-4	22
0.60	-199	-166	-132	-98	-64	-31	3	37	71	104
0.70	-184	-143	-102	-61	-19	22	63	104	146	187
0.80	-169	-121	-72	-23	26	74	123	172	221	269
0.90	-154	-98	-42	14	71	127	183	239	296	352
1.00	-139	-76	-12	52	116	179	243	307	371	434
1.10	-124	-53	18	89	161	232	303	374	446	517
1.20	-109	-31	48	127	206	284	363	442	521	599
1.30	-94	-8	78	164	251	337	423	509	596	682
1.40	-79	14	108	202	296	389	483	577	671	764
1.50	-64	37	138	239	341	442	543	644	746	847

Note: Assumes a 6-year stand life with annual costs of $292, harvest costs of $0.15 per pound of seed,and a 25% share rent.

CONCLUSIONS

Alternative bluegrass residue treatments were analyzed in an on-farm experiment in Worley, Idaho. The treatments studied were full-load burn, bale-then-burn, mechanical, and system, or combined, treatments. This analysis developed costs and returns estimates and reports the economic feasibility of each treatment for the first four years of the Worley experiment.

Yearly net returns were quite variable due to the variability in seed yield. The highest yearly returns were obtained under the full-load burn and bale-then-burn treatments, with net returns to management and risk of $200 and $195 per acre, respectively. The lowest return, -$107, was observed in the mechanical treatment due to low seed yield and higher ownership costs. All treatments provided a positive net return each year of production except the mechanical and system treatments in 2004.

For the 4 years examined, the bale-then-burn and full-load burn treatments were the most profitable with NPV's of $351 and $349, respectively, including the amortized cost of establishment. The NPV for the mechanical and system treatments were $139 and $140, respectively.

While the bale-then-burn and full-load burn treatments performed equally well from an economic viewpoint, several issues should be noted. First, the assumption was made that baled residue could be sold for $25 per ton. If a market for baled residue cannot be developed or maintained, the profitability of the bale-then-burn system declines because of the reduced revenue from straw sales. If straw can be sold for more, the effort and time of baling and selling the straw may be worthwhile.

Second, if the 2004 weed-infested full-load burn replication is ignored (because it was a random event unassociated with the treatment), the full-load burn outperforms the bale-then-burn treatment.

Third, if the burn season is excessively dry, a full-load burn can damage the bluegrass stand, while the bale-then-burn fire will not be as hot and will cause little or no damage to the stand. Conversely, if the burn season is wet and the bluegrass stand is too green, the extra residue from the full-load burn treatment will provide a better burn.

Lastly, the reduced fuel load from the bale-then-burn system may cause smoke to remain closer to the ground before dissipation, thus causing particulate matter to interfere more with human activity (Johnston and Schaaf, 2003).

Machinery ownership costs were higher in the mechanical and system treatments than in the full-load burn treatment because of the additional rake, baler, mower, and harrow operations. Ownership costs were highest in the system treatment because machinery was underutilized. Equipment sharing is becoming more typical in eastern Washington and northern Idaho to assure machinery is utilized efficiently and economically. If growers are willing and able to share machinery and equipment without hindering timely production practices, the system treatment would be a more attractive bluegrass residue management technique than portrayed in this report. For this study, equipment was assumed to be producer-owned and not shared between growers.

Operating costs in this study were not as much of a distinguishing profitability characteristic among treatments as they may eventually prove to be. Fertilizer and herbicide rates were held constant, within years, for each treatment. Preliminary observations indicate that herbicide and fertilizer inputs may be greater in production systems where residue is mechanically removed and not burned than in systems where residue is burned. Fuel, lube, repairs, harvest costs, and operating interest did vary between treatments because of variation in yield.

Sensitivity analysis with respect to seed yield and price showed that none of the treatments was profitable when seed yields were below 200 pounds per acre and prices were under $1.50 per pound. The full-load burn and bale-then-burn treatments were profitable at 500 pounds per acre when the price was above $0.79 per pound, and at 600 pounds per acre when the price was above $0.70 per pound. The mechanical treatment was profitable at seed yields of 500 pounds per acre when the price was above $0.81 per pound. The system treatment was profitable at seed yields of 500 pounds per acre when the price was above $0.87 per pound.

Bluegrass seed yields are quite variable from year to year depending on environmental conditions and year of stand life. Therefore, care should be taken when interpreting the results of this study. A case in point is the lower seed yield obtained in the 2004 full-load burn treatment due to a weed infestation in one of the four replications. If the weed-infested replication were not included in the yield average, the full-load burn would have been more profitable.

Bluegrass seed production in northern Idaho requires an expensive establishment year, with no income derived the year of establishment. As shown is this study, stand life is an important factor when deciding among bluegrass residue management alternatives. While this study examined bluegrass production for only the first 4 years of the study, a 6-year stand life was assumed, with the establishment costs amortized over that stand life. If non-thermal production techniques reduce stand life, yearly returns will be reduced as establishment costs are amortized over fewer years. Conversely, treatments that extend stand life beyond 6 years will have increased yearly returns.

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TABLE A1. Costs and Returns Estimate for the Establishment of Kentucky Bluegrass.

Item	Quantity per acre	Units	$/unit	$/acre
VALUE OF PRODUCTION				
Gross returns				$0.00
OPERATING COSTS				
Fertilizer				**$14.50**
Custom fertilizer spreader	1.00	acre	$5.50	$5.50
16-20-0-14.5	75.00	pound	$0.12	$9.00
Seed				**$9.63**
Grass seed	5.50	pound	$1.75	$9.63
Herbicide				**$31.65**
Buctril Advanced (2.5 lb)	1.00	quart	$17.55	$17.55
Express	0.25	ounce	$21.20	$5.30
Non-ionic surfactant (NIS)	0.10	quart	$4.88	$0.49
Roundup Ultra Max RT	24.00	ounce	$0.32	$7.68
Ammonium Sulfate (AMS)	0.14	quart	$4.50	$0.63
Labor				**$29.89**
Labor (machine)	2.46	hours	$12.15	$29.89
Labor (non-machine)	0.00	hours	$7.20	$0.00
Fuel, lube, and repair				**$22.64**
Fuel				$15.79
Lube				$1.82
Repairs				$5.03
Operating interest				**$5.05**
Operating interest at 7%				$5.05
Total operating costs				**$113.36**
Net returns above operating costs				**($113.36)**
OWNERSHIP COSTS				
Depreciation & interest				$69.71
Machinery and equipment housing and insurace				$4.00
Insurance				$0.45
Total ownership costs				**$74.16**
TOTAL COSTS				**$187.52**
NET RETURNS				**($187.52)**

TABLE A2. Typical Costs and Returns Estimate for the Full-Load Burn Treatment at Worley, Idaho, Using Seed Yield from the 2001-02 Bluegrass Seed Production Year.

Item	Quantity per acre	Units	$/unit	$/acre
VALUE OF PRODUCTION				
Seed yield, farmer share	458.00	pound	$0.75	$343.50
Seed yield, landowner share	152.00	pound	$0.00	$0.00
Gross returns				**$343.50**
OPERATING COSTS				
Burn				**$6.00**
Burning permit	1.00	acre	$2.00	$2.00
Burning variable costs	1.00	acre	$4.00	$4.00
Herbicide				**$12.40**
Express	0.25	ounce	$21.20	$5.30
2,4-D amine	0.50	quart	$3.70	$1.85
Custom spray	1.00	acre	$5.25	$5.25
Fertilizer				**$60.75**
Custom fertilizer spreader	1.00	acre	$5.50	$5.50
26-5-5-5	425.00	pound	$0.13	$55.25
Miscellaneous				**$8.20**
Field crop fire insurance				$1.20
Incidental pesticide				$7.00
Harvest				**$68.70**
Bags, tags, cleaning, etc.	4.58	cwt	$15.00	$68.70
Labor				**$17.49**
Labor (machine)				$15.69
Labor (non-machine)	0.25	hour	$7.20	$1.80
Fuel, lube, and repair				**$19.02**
Fuel and lube				$8.20
Repairs				$10.82
Operating interest				**$8.99**
Operating interest @ 7%				$8.99
Total operating costs				**$201.55**
Operating cost per pound	458.00	pound		**$0.44**
Net returns above operating costs				**$141.95**

TABLE A2. Typical Costs and Returns Estimate for the Full-Load Burn Treatment at Worley, Idaho, Using Seed Yield from the 2001-02 Bluegrass Seed Production Year *(continued)*.

Item	Quantity per acre	Units	$/unit	$/acre
OWNERSHIP COSTS				
Depreciation and interest				$33.27
Machinery and equipment housing and insurance				$2.95
Insurance				$0.45
Amortized establishment costs				$35.77
Total ownership costs				**$72.44**
Ownership costs per pound	458.00	pound		**$0.16**
TOTAL COSTS				**$273.99**
TOTAL COSTS PER POUND	458.00	pound		**$0.60**
NET RETURNS				**$69.51**

TABLE A3. Typical Costs and Returns Estimate for the Bale-then-Burn Treatment at Worley, Idaho, Using Seed Yield from the 2001-02 Bluegrass Seed Production Year.

Item	Quantity per acre	Units	$/unit	$/acre
VALUE OF PRODUCTION				
Seed yield, farmer share	458.00	pound	$0.75	$343.50
Straw sales	1.50	ton	$25.00	$37.50
Seed yield, landowner share	152.00			
Gross returns				**$381.00**
OPERATING COSTS				
Burn				**$6.00**
Burning permit	1.00	acre	$2.00	$2.00
Burning variable costs	1.00	acre	$4.00	$4.00
Herbicide				**$12.40**
Express	0.25	ounce	$21.20	$5.30
2,4-D Amine	0.50	quart	$3.70	$1.85
Custom spray	1.00	acre	$5.25	$5.25
Fertilizer				**$60.75**
Custom fertilizer spreader	1.00	acre	$5.50	$5.50
26-5-5-5	425.00	pound	$0.13	$55.25
Miscellaneous				**$8.20**
Field crop fire insurance				$1.20
Incidental pesticide				$7.00
Harvest				**$83.21**
Twine	1.50	ton	$1.67	$2.51
Bags, tags, cleaning, etc.	4.58	cwt	$15.00	$68.70
Custom stack and haul	1.50	ton	$8.00	$12.00
Labor				**$20.62**
Labor (machine)				$18.82
Labor (non-machine)	0.25	hour	$7.20	$1.80
Fuel, lube, and repair				**$25.71**
Fuel and lube				$12.44
Repairs				$13.27
Operating interest				**$10.12**
Operating interest @ 7%				$10.12
Total operating costs				**$227.01**
Operating cost per pound	458.00	pound		**$0.50**
Net returns above operating costs				**$153.99**

TABLE A3. Typical Costs and Returns Estimate for the Bale-then-Burn Treatment at Worley, Idaho, Using Seed Yield from the 2001-02 Bluegrass Seed Production Year *(continued)*.

Item	Quantity per acre	Units	$/unit	$/acre
OWNERSHIP COSTS				
Depreciation and interest				$50.07
Machinery and equipment housing and insurance				$4.12
Insurance				$0.45
Amortized establishment costs				$35.77
Total ownership costs				**$90.41**
Ownership cost per pound	458.00	pound		**$0.20**
TOTAL COSTS				**$317.42**
TOTAL COSTS PER POUND	458.00	pound		**$0.69**
NET RETURNS				**$63.58**

TABLE A4. Typical Costs and Returns Estimate for the Mechanical Treatment at Worley, Idaho, Using Seed Yield from the 2001-02 Bluegrass Seed Production Year.

Item	Quantity per acre	Units	$/unit	$/acre
VALUE OF PRODUCTION				
Seed yield, farmer share	458.00	pound	$0.75	$343.50
Straw sales	1.50	ton	$25.00	$37.50
Seed yield, landowner share	152.00	pound		
Gross Returns				**$381.00**
OPERATING COSTS				
Herbicide				**$12.40**
Express	0.25	ounce	$21.20	$5.30
2,4-D amine	0.50	quart	$3.70	$1.85
Custom spray	1.00	pound	$5.25	$5.25
Fertilizer				**$60.75**
Custom fertilizer spreader	1.00	acre	$5.50	$5.50
26-5-5-5	425.00	pound	$0.13	$55.25
Miscellaneous				**$8.20**
Field crop fire insurance				$1.20
Incidental pesticide				$7.00
Harvest				**$83.21**
Twine	1.50	ton	$1.67	$2.51
Bags, tags, cleaning, etc.	4.58	cwt	$15.00	$68.70
Custom stack and haul	1.50	ton	$8.00	$12.00
Labor				**$22.29**
Labor (machine)				$20.49
Labor (non-machine)	0.25	hour	$7.20	$1.80
Fuel, lube, and repair costs				**$29.05**
Fuel-diesel				$12.49
Lube				$2.20
Repairs				$14.36
Operating interest				**$10.08**
Operating interest @ 7%				$10.08
Total operating costs				**$225.98**
Operating cost per pound	458.00	pound		**$0.49**
Net returns above operating costs				**$155.02**

TABLE A4. Typical Costs and Returns Estimate for the Mechanical Treatment at Worley, Idaho, Using Seed Yield from the 2001-02 Bluegrass Seed Production Year *(continued)*.

Item	Quantity per acre	Units	$/unit	$/acre
OWNERSHIP COSTS				
Depreciation and interest				$54.40
Machinery and equipment housing and insurance				$4.61
Insurance				$0.40
Amortized establishment costs				$35.77
Total ownership costs				**$95.18**
Ownership costs per pound	458.00	pound		**$0.21**
TOTAL COSTS				**$321.16**
TOTAL COSTS PER POUND	458.00	pound		**$0.70**
NET RETURNS				**$59.84**

TABLE A5. Typical Costs and Returns Estimate for the System Treatment at Worley, Idaho, Using Seed Yield from the 2001-02 Seed Production Year.

Item	Quantity per acre	Units	$/unit	$/acre
VALUE OF PRODUCTION				
Seed yield, farmer share	458.00	pound	$0.75	$343.50
Straw sales	1.00	ton	$25.00	$25.00
Seed yield, landowner share	152.00			
Gross returns				**$368.50**
OPERATING COSTS				
Burn				**$4.01**
Burning permit	0.67	acre	$2.00	$1.33
Burning variable costs	0.67	acre	$4.00	$2.68
Herbicide				**$12.40**
Express	0.25	ounce	$21.20	$5.30
2,4-D amine	0.50	quart	$3.70	$1.85
Custom spray	1.00	acre	$5.25	$5.25
Fertilizer				**$60.75**
Custom fertilizer spreader	1.00	acre	$5.50	$5.50
26-5-5-5	425.00	pound	$0.13	$55.25
Miscellaneous				**$8.20**
Field crop fire insurance				$1.20
Incidental pesticide				$7.00
Harvest				**$78.37**
Twine	1.00	ton	$1.67	$1.67
Bags, tags, cleaning, etc.	4.58	cwt	$15.00	$68.70
Custom stack and haul	1.00	ton	$8.00	$8.00
Labor				**$22.29**
Labor (machine)				$20.49
Labor (non-machine)	0.25	hour	$7.20	$1.80
Fuel, lube, and repair				**$28.13**
Fuel-diesel				$12.49
Lube				$2.20
Repairs				$13.44
Operating interest				**$9.99**
Operating interest @ 7%				$9.99
Total operating costs				**$224.14**
Operating costs per pound	458.00	pound		**$0.49**
Net returns above operating costs				**$144.36**

TABLE A5. Typical Costs and Returns Estimate for the System Treatment at Worley, Idaho, Using Seed Yield from the 2001-02 Seed Production Year *(continued)*.

Item	Quantity per acre	Units	$/unit	$/acre
OWNERSHIP COSTS				
Depreciation and interest				$62.24
Machinery and equipment housing and insurance				$5.32
Insurance				$0.45
Amortized establishment costs				$35.77
Total ownership costs				**$103.78**
Ownership costs per pound	458.00	pound		**$0.23**
TOTAL COSTS				**$327.92**
TOTAL COSTS PER POUND	458.00	pound		**$0.72**
NET RETURNS				**$40.58**

Note: Under the system treatment we assume one-third of the acreage is full-load burn, one-third is bale-then-burn, and one-third is mechanical treatment. Two-thirds of the acreage would therefore we burned each year.

TABLE A6. Machinery Operating and Ownership Costs for all Kentucky Bluegrass Seed Production Systems.

	Ownership costs ($/acre)			Operating costs ($/acre)			
	Depreciation	Interest	THI[1]	Repairs	Labor	Fuel/Lube	Total ($/acre)
FULL-LOAD BURN							
Swather	3.34	2.41	0.47	0.94	2.00	1.20	10.36
Combine new	9.95	7.98	1.08	5.05	2.29	1.99	28.34
Combine used	2.36	2.82	0.38	2.93	2.29	1.99	12.77
Truck	1.00	0.70	0.25	1.00	1.82	0.75	5.52
Pickup new	1.18	0.92	0.63	0.30	4.86	1.51	9.40
Pickup used	0.40	0.21	0.14	0.60	2.43	0.76	4.54
Total							**70.93**
BALE-THEN-BURN							
Swather	3.34	2.41	0.47	0.94	2.00	1.20	10.36
Combine new	9.95	7.98	1.08	5.05	2.29	1.99	28.34
Combine used	2.36	2.82	0.38	2.93	2.29	1.99	12.77
Rake[2]	1.86	1.20	0.08	0.21	0.84	1.13	5.32
Baler[2]	8.72	5.02	1.09	2.24	2.29	3.11	22.47
Truck	1.00	0.70	0.25	1.00	1.82	0.75	5.52
Pickup new	1.18	0.92	0.63	0.30	4.86	1.51	9.40
Pickup used	0.40	0.21	0.14	0.60	2.43	0.76	4.54
Total							**98.72**
MECHANICAL							
Swather	3.34	2.41	0.47	0.94	2.00	1.20	10.36
Combine new	9.95	7.98	1.08	5.05	2.29	1.99	28.34
Combine used	2.36	2.82	0.38	2.93	2.29	1.99	12.77
Rake[2]	1.64	1.12	0.07	0.23	0.84	1.13	5.03
Baler[2]	7.79	4.99	1.14	2.27	2.29	3.11	21.59
Mower[2]	2.50	2.00	0.42	0.94	1.16	1.56	8.58
Harrow[2]	0.62	0.47	0.03	0.10	0.51	0.69	2.42
Truck	1.00	0.70	0.25	1.00	1.82	0.75	5.52
Pickup new	1.18	0.92	0.63	0.30	4.86	1.51	9.40
Pickup used	0.40	0.21	0.14	0.60	2.43	0.76	4.54
Total							**108.55**
SYSTEM							
Swather	3.34	2.41	0.47	0.94	2.00	1.20	10.36
Combine new	9.95	7.98	1.08	5.05	2.29	1.99	28.34
Combine used	2.36	2.82	0.38	2.93	2.29	1.99	12.77
Rake[2]	2.23	1.50	0.09	0.18	0.84	1.13	5.97
Baler[2]	10.95	6.93	1.65	1.70	2.29	3.11	26.63
Mower[2]	3.37	2.70	0.59	0.66	1.16	1.56	10.04
Harrow[2]	0.74	0.55	0.04	0.08	0.51	0.69	2.61
Truck	1.00	0.70	0.25	1.00	1.82	0.75	5.52
Pickup new	1.18	0.92	0.63	0.30	4.86	1.51	9.40
Pickup used	0.40	0.21	0.14	0.60	2.43	0.76	4.54
Total							**116.18**

[1] THI = Taxes, housing, and insurance on machinery and equipment. The currently is no Idaho property tax on farm machinery and equipment.

[2] Tractor and implement costs are combined.

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