**TITLE:** Integrated Residue Management Systems for Sustained Seed Yield of Kentucky Bluegrass Without Burning - Phase I and II

**OBJECTIVES:** Design and test economically sustainable Kentucky bluegrass management systems that minimize or eliminate the need for open-field burning of residues, thereby substantially improving regional air, soil, and water quality.
1. Develop non-thermal or reduced thermal systems that optimize straw decomposition and maintain or increase Kentucky bluegrass seed yield.
2. Compare nutrient cycling efficiency and soil quality factors in burned, reduced thermal, and non-thermal Kentucky bluegrass systems.
3. Investigate the aboveground insect pest and predator relationships in bluegrass systems.
4. Examine the economic efficiency of each bluegrass production system including the associated production, price and financial risk.
5. Evaluate public and producer responses to the smoke management plan implemented by the state of Idaho, Nez Perce Tribe, and Coeur d'Alene Tribe to reduce public health impacts and evaluate socioeconomic costs associated with current open-burning practices.
6. Disseminate information to growers, fieldmen, extension educators, and scientific audiences.

**INVESTIGATORS:**
**Principal Investigators:** D. Thill, J. Johnson-Maynard, J. McCaffrey, L. VanTassell, J.D. Wulfhorst , J. Holman, College of Agric. and Life Sci. (CALS), Univ Idaho (UI), Moscow.
**Cooperators:** ***Growers:*** P. Williams, Potlatch, ID; C. Ramsey, Rockford, WA; ***Industry Rep.:*** L. Lampert, Dye Seed Co.; S. Bateman, Jacklin Seed Div.; D. Tellesson, Seeds Inc.; ***EPA:*** D. Cole; ***Coeur d' Alene Tribe:*** B. George; ***Nez Perce Tribe:*** J. Simpson; ***Idaho DEQ:*** D. Redline; **UI E*xtension:*** K. Hart, and D. Clark; ***UI CALS:*** B. Shafii

**ABSTRACT:** In 2006, bluegrass density was 24-76% less inside the windrow area compared to outside the windrow in the Kootenai Co. experiment. Residue in the windrow had a greater effect on bluegrass density in the mechanical treatments than in the burn treatments. Ventenata density was 54-90% lower outside than inside the windrow area. Bluegrass seed yield was 430% higher in the burn treatments than the mechanical treatments. During the entire 3-year study period, burning removed significantly more standing biomass (33 to 100% more) compared to mechanical methods. For the 4 years examined in the Kootenai Co. experiment, and including the associated amortized cost of establishment, the bale-then-burn treatment was the most profitable with a net present value (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. Full load burn and bale-burn treatments removed 77-80% of the residue compared to 34% with the mechanical removal treatment in the Latah Co. experiment in 2006. Full load burn yielded 377% more seed than the mechanical treatment.

**JUSTIFICATION:** Grass seed growers in northern ID usually burn bluegrass residues, while growers in eastern WA use non-thermal residue removal methods. Mandatory regulations restrict burning of grass fields in Idaho. Effective and economical non-thermal and reduced thermal practices must be developed and tested before additional restrictions are imposed, otherwise the viability of this economically and environmentally sound industry will be threatened severely.

Residue management systems must be developed and tested in long-term, large-scale, on-farm trials that represent typical grower field conditions to properly assess treatment effectiveness on residue levels and impacts on grass seed production. This includes appropriate agronomic, ecological, environmental, economic and sociological studies and analyses.

**PROGRESS:** *General (Thill and Reed)* Experiments are located in Kootenai and Latah Co**.** Plots are managed using agronomic practices typical to the area and production operations are performed using field scale equipment. Weather data are collected from permanent weather stations located at each site.
*Kootenai Co. Site*: Post harvest straw was raked, baled, and removed from the bale/burn, and mechanical plots on August 23, 2005. Plots were burned Sept 8 and the overall burn was good. All plots were treated with 0.8 lb ai/A of terbacil to control ventenata. Mechanical plots were harrowed on Oct 30 and mowed on Nov 1. On Nov 6, urea fertilizer was applied to all plots at 148 lbs N/A. Visual observation in April 2006 indicated that ventenata control in the mechanical treatments was poor. Due to crop lodging in June 2005, swathing and harvest of bluegrass was difficult. Large amounts of residue remained on the surface of the mechanical treatments following residue removal treatments in fall 2005. The residue present in the mechanical treatment lowered the effectiveness of weed control, especially in the areas where the windrows were present. Mechanical residue removal plots were treated with 0.0356 lb ai/A of primsulfuron for ventenata control on May 1, 2006. Panicle samples were taken from two 0.25 $m^2$ areas of each plot to determine bluegrass and ventenata density within and outside of the previous harvest windrow areas. Plots were swathed on July 3 and harvested on Aug 3, 2006. Residue in the bale treatments was raked on Aug 20 and baled on Sept 12. Plots were burned on Sept 12. Bluegrass density was 24-76% less inside the windrow area compared to outside the windrow (Table 1). Residue in the windrow had a greater effect on bluegrass density in the mechanical treatments than in the burn treatments. Ventenata density was 54-90% lower outside than inside the windrow area. Bluegrass seed yield was 430% higher in the burn treatments than the mechanical treatments.

*Table 1. 2006 bluegrass and ventenata panicle density and bluegrass seed yield in Kootenai Co.*

| | Bluegrass density | | Ventenata density | | |
|---|---|---|---|---|---|
| Residue treatment | Inside windrow | Outside windrow | Inside windrow | Outside windrow | Bluegrass seed yield |
| | ----------------------------no./0.25 $m^2$ | | | ---------------------------- | lb/A |
| Full load burn | 234 a | 309 a | 202 a | 69 a | 576 a |
| Bale/burn | 165 b | 260 a | 168 ab | 17 a | 458 a |
| Mechanical | 51 c | 199 a | 28 c | 13 a | 138 b |
| System[1] | 38 c | 156 a | 40 bc | 7 a | 102 b |

[1] The system treatment was mechanical residue removal (bale/mow/harrow) in 2005.

*Latah Co. Site*. Residue removal treatments were applied post-harvest in fall 2005. Mechanical and bale/burn plots were raked and baled on July 31. Full load burn and bale/burn plots were burned on Aug 9. Graze and bale/graze plots were grazed from Aug 15 to Sept 3. Mechanical plots were mowed on Sept 26. Plots to be harvested in 2006 were fertilized with 110 lb N, 40 lb P, 32 lb K, and 32 lb S/A on Oct 24. Soil samples taken in March 2006 indicated a lack of plant available nitrogen so urea fertilizer was applied to all plots at 27 lb N/A on March 16. Fallow plots were treated with 0.44 lb ai/A of glufosinate on May 5 or mowed on May 31, 2006. Plots were swathed on July 4 and harvested on July 27, 2006. Full load burn and bale and burn treatments removed 77-80% of the residue compared to 61-62% with graze treatments and 34% with the mechanical removal treatment (Table 2). Full load burn and bale and graze treatments yielded 369% more seed than the mechanical treatment. Visual observation of bluegrass panicles in the plots chemically or mechanically suppressed in 2005 indicated that yield was extremely poor and these plots were not harvested.

*Table 2. 2005 residue removal and 2006 seed yield in Latah Co.*

| Residue treatment | Residue removed | Seed yield |
|---|---|---|
| | % | lb/A |
| Full load burn | 80 a | 181 a |
| Bale/burn | 77 a | 105 c |
| Graze | 61 b | 121 bc |
| Bale/graze | 62 b | 173 ab |
| Mechanical | 34 c | 48 d |

*Objective 1 and 2(Johnson-Maynard)* Residue levels within each treatment were measured early spring, pre-swath, post harvest and following residue management practices during each year of this study. Samples from 2006 are currently being analyzed so 2005 data (not included in last years report) will be discussed in this report. Residue from both a short and tall variety were taken following 2006 harvest. The residue was oven-dried at 60˚C for 48 hours and 4-g portions were weighed into 2-mm mesh bags. The bags will be placed in the field following fall fertilization and collected over time to determine the rate of decomposition of each variety.

Burning removed 97% of the standing biomass in FLB and 96% in BB while baling and mowing removed only 4% of the standing biomass in BMH and 39% in SYST (BMH) in 2005 (Table 3). System (BMH) treatments were raked in 2005 prior to baling, whereas the BMH and BB treatments were not. Thus, raking in SYST (BMH) treatments explains the difference in residue removal compared to BMH treatments. The other treatments that required baling were not raked because residue could be placed in windrows by altering the harvesting equipment, thus eliminating an additional field operation of raking. During the entire 3-year study period, burning removed significantly more standing biomass (33 to 100% more) compared to mechanical methods.

In 2005, FLB and SYST (BMH) treatments removed 59% and 21% of the non-standing residue, respectively, while BB removed only 6%. Non-standing residue appeared to increase 124% in the BMH treatment in 2005. The rake and baler implements did not pick up the entire residue spread across the field in 2005, leaving residue along the pathway of the windrows. A greater amount of non-standing residue would have been collected in samples on or near these windrows causing a high degree of variability in the data. Non-standing residue decreased in the BMH treatment in the first two years of the study as well as in the SYST(BMH) treatment in 2005 (Table 3), indicating that the apparent increase measured in 2005 is likely a sampling effect due to the highly non-uniform distribution of residue across the field.

In the 2004 to 2005 season (Figure 1), each plot was fertilized with 166 kg N $ha^{-1}$ in the fall of 2004. Plant N uptake ranged from 97 kg N $ha^{-1}$ in FLB to 110 kg N $ha^{-1}$ in BMH treatments. Burning and baling with burning removed 27 kg N $ha^{-1}$ in FLB, 34 kg N $ha^{-1}$ in

SYST (FLB) and 34 kg N ha$^{-1}$ in BB treatments. Baling in BMH treatments removed an average of 43 kg N ha$^{-1}$. The residue in windrows that was removed by baling was not fully measured and therefore, measurements taken in bale only plots represent a portion of the amount of residue and N removed from the field. Thus, the amount of residue removed through baling is greater than the amount reported for this year. Nitrogen values are similar to other years and suggest that plant uptake is similar or even higher in BMH as opposed to FLB, although less seed is produced in BMH treatments.

Table 3. Percent residue removal from fall treatment application to summer seed harvest. Residue in 2002 was combined (standing and non-standing). Significant differences (P>0.05) in the percent of residue removed and yield are indicated by unlike letters. Positive values indicate a gain in residue (due to variability within the plots). NA= not available

| | | % Residue Removal | | | |
|---|---|---|---|---|---|
| Year<br>fall-summer | Treatment | Stand. | Non-stand. | Comb. | Yield |
| | | % | | | kg ha$^{-1}$ |
| 2002-2003 | FLB | NA | NA | 96$^{a}$ | 1088$^{a}$ |
| 2002-2003 | BB | NA | NA | 95$^{a}$ | 1102$^{a}$ |
| 2002-2003 | BMH | NA | NA | 83$^{b}$ | 987$^{a}$ |
| 2002-2003 | Syst (BMH) | NA | NA | 86$^{b}$ | 891$^{a}$ |
| 2003-2004 | FLB | 100$^{a}$ | 71$^{a}$ | 78$^{a}$ | 605$^{a}$ |
| 2003-2004 | BB | 100$^{a}$ | 56$^{ab}$ | 71$^{a}$ | 655$^{a}$ |
| 2003-2004 | BMH | 2$^{b}$ | 47$^{b}$ | 35$^{b}$ | 353$^{b}$ |
| 2003-2004 | Syst (BB) | 100$^{a}$ | 59$^{ab}$ | 69$^{a}$ | 640$^{a}$ |
| 2004-2005 | FLB | 83$^{a}$ | 41$^{a}$ | 59$^{a}$ | 870$^{a}$ |
| 2004-2005 | BB | 76$^{a}$ | 56$^{a}$ | 62$^{a}$ | 835$^{a}$ |
| 2004-2005 | BMH | 43$^{b}$ | 60$^{a}$ | 56$^{a}$ | 736$^{a}$ |
| 2004-2005 | Syst (FLB) | 80$^{a}$ | 33$^{a}$ | 53$^{a}$ | 752$^{a}$ |
| 2005-2006 | FLB | 97$^{a}$ | 59$^{a}$ | 65$^{a}$ | 576$^{a}$ |
| 2005-2006 | BB | 96$^{a}$ | 6$^{a}$ | 49$^{a}$ | 458$^{a}$ |
| 2005-2006 | BMH | 4$^{c}$ | +124$^{b}$ | +79$^{b}$ | 138$^{b}$ |
| 2005-2006 | Syst (BMH) | 39$^{b}$ | 21$^{a}$ | 26$^{a}$ | 102$^{b}$ |

*Objective 3: (McCaffrey)* This year's activity has focused on sampling arthropods from the Chris Ramsey site on May 12, June 16, July 17, and August 18. Further sampling will be conducted soon and again late October. Many of the pitfall samples collected this year have been processed, but many are left to process. Large numbers of individual spring tails slow the process. Finally, analyses of samples from 2003-2005 have been conducted for spring tail and predaceous carabid beetle populations for three year period. In short, few significant differences were found among treatments for both the spring tail and carabid populations. This probably is a result of several groups being lumped under one taxonomic classification. Further analyses will

focus on both functional groupings and individual genera where possible. This is easier for the beetles because more is known about their biologies and feeding behaviors. The feeding habits of spring tails are less known other than some are detritivores and others are fungivores. In either case they are functionally important as far as nutrient cycling is concerned. The only significant differences in insect numbers were found among dates and this could be due to insect biology or immediate responses to treatments as reflected in before and after sampling. However, the fact that there were no differences among treatments for either group of organisms is not totally unexpected in that the carabid beetles can fly and walk to disperse and the spring tails can move passively with wind or as “hitchhikers” on equipment, animals and other means. Finally, the lack of differences is potentially positive in that the carabids are available to feed on pests and the spring tails are available for breakdown organic matter in thermal and nonthermal environments. Further analyses relating to before and after treatments will be assessed more directly and further collaboration with Dr. Jodi-Johnson Maynard may yield more information of impact of spring tails nutrient cycling and we will conduct further analyses of the population data to assess the potential role of carabid beetle predators on spring tail populations. Finally, one group of predators that we have not fully characterized are the spiders. The predators feed on a number of insects that are potential causal agents of silver top including grass bugs, leafhoppers, thrips, and various caterpillars. Emphasis this next year will be on assessing the species composition and population dynamics of this important group of predators.

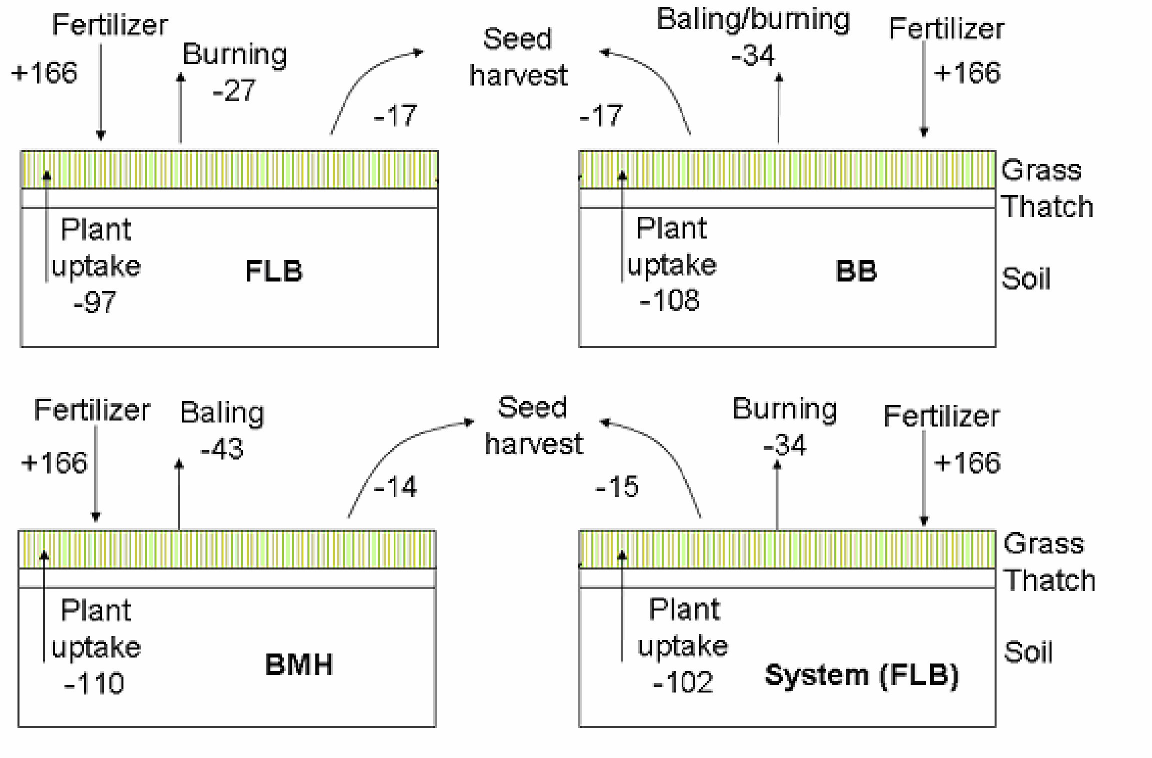


Figure 1. Major N fluxes in kg N ha$^{-1}$ from the four management systems in Kootenai Co. from 2004 to 2005. Note that plant uptake estimates include N that is lost or returned to the soil through burning and baling and N lost through seed harvest. N returned to the soil through decomposition was not detectable due to field residue scatter and burn variability. NA=not available.

*Objective 4: (Van Tassell) Economic Results of Thermal vs. Non-Thermal Treatments:* Cost and return estimates were developed for each year and treatment of bluegrass seed production in the experimental trails. Ownership costs were allocated to the bluegrass enterprise based on the relative proportion of hours the equipment was used on a 2,000 acre farm with an oat, spring wheat, legume, winter wheat, and bluegrass rotation. Land rent was assumed to be share-cropped with one-quarter of the unclean seed distributed to the landlord. The landlord did not assume any cost of production. The total cost for the bluegrass stand establishment ($188 per acre) was amortized to a yearly investment value of $36 assuming a 6-year bluegrass stand life and a 4% discount rate. Revenues were based on a 5-year bluegrass seed average price of $0.75/pound and a representative value of $25/ton for baled straw residue. Residue was assumed to yield 1.5 tons/acre.

The full-load burn treatment required the least capital investment at $658,000. The bale-then-burn treatment capital investment rose to $750,000 because of the addition of a rake and baler. The mechanical and system treatments required the highest capital investment ($777,500) because of the rake, baler, mower, and harrow required for straw residue management. Typical yearly operating costs were $202, $227, $225 and $224 per acre for the full-load burn, bale-then-burn, mechanical, and system treatments, respectively. Operating costs that varied between treatments were burning, harvest, labor, fuel, lube, repair, and operating interest. Operating costs that remained constant between treatments were fertilizer, insurance, herbicide, and incidental pesticide or fungicide applications.

The highest returns (Table 4) 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. All treatments provided a positive net return for the first 4 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.

For the 4 years examined, and including the associated amortized cost of establishment, the bale-then-burn treatment was the most profitable with a net present value (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.

Net present values of the first 4 years of seed yield for each treatment also were compared with the establishment cost amortized over varying years of plant stand life (Table 5). The analysis assumed the same net return for each system as was obtained from 2002 through 2005, with the exception being that the establishment costs were assumed to be spread over different productive stand lives. As the $188 establishment cost was amortized over a longer productive stand life the profitability of each system increased. All systems yielded a positive NPV over the four production years examined when plant stand life ranged from 4 to 8 years.

*Economic Results of Suppression Treatments:* A stochastic simulation model was developed using cost and return estimates of the bluegrass seed production methods examined (mechanical, chemical suppression, and hay suppression) along with necessary rotation crops (spring and winter wheat). Prices of bluegrass seed, hay, and wheat were modeled using harmonic regression techniques to capture the inherent price cycles. On-farm bluegrass seed yields (mechanical treatment) were modeled using a log-linear function and suppression yields were represented by empirical distributions conditional on mechanical treatment yields. Weibull distributions were used to model spring and fall wheat yields. The simulation model was used to report the economic feasibility of each treatment for the expected stand life. Because of unequal treatment lives, annual annuities from the NPV's of the net returns to land, management and risk were developed.

Table 4. Net returns to management and risk, and net present value (NPV) over the 4-year trial period for the full-load burn, bale-then-burn, mechanical, and system treatments.*

| | Full-Load Burn | Bale-then-Burn | Mechanical | System |
|---|---|---|---|---|
| | ($/acre) | | | |
| 2002, Production Year 1 | $70 | $64 | $60 | $41 |
| 2003, Production Year 2 | $200 | $195 | $146 | $89 |
| 2004, Production Year 3 | $3 | $33 | -$107 | -$12 |
| 2005, Production Year 4 | $111 | $95 | $48 | $35 |
| NPV** | $349 | $351 | $139 | $140 |

[*] 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 six-year stand life.

[**] Annual net returns are discounted to 2001 using a 4% discount rate to obtain the NPV.

Table 5. Net present value of the first 4 years of seed yield, by treatment, assuming 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-year | $291 | $294 | $81 | $83 |
| 5-year | $326 | $328 | $116 | $117 |
| 6-year | $349 | $351 | $139 | $140 |
| 7-year | $365 | $368 | $155 | $157 |
| 8-year | $378 | $380 | $168 | $169 |

[*] Amortized establishment costs are $52, $42, $36, $31, and $28 for an assumed stand life of 4 through 8 years, respectively.

Though mean net returns from all treatments were negative, the highest net returns per acre were realized from the mechanical treatment (-$11.41), followed by the chemical suppression treatment (-$22.30). The annual returns per acre for the mechanical and hay suppression treatments were fairly close at -$28.03 and -$31.59 due to an assumed 15% seed yield reduction from the chemical suppression seed yields. This occurred because of limited stand density thinning by these latter treatments. The REM treatment also dominated all suppression treatments when compared by second degree stochastic dominance (SSD). The REM treatment would have dominated the others by first degree stochastic dominance if not for the higher probability of extremely negative returns obtained from iterations when seed yields were low and stand establishments failed. Chemical suppression was preferred by all levels of risk aversion over the mechanical and hay suppression treatments as determined by first degree stochastic dominance (FSD), while mechanical suppression was likewise preferred to hay suppression.

The sensitivity of the suppression yield assumptions was tested by varying suppression yield distributions. Given the cost of suppression and the absence of seed production during the suppression fallow year, suppression techniques are not profitable unless yields can be increased by 25 to 50 percent over those assumed in the base conditions.

*Objective 5: (Wulfhorst)* Additional data were analyzed from the general public and producer surveys conducted in earlier project phases. Within the general public survey, individuals who stated they would like to reduce or eliminate bluegrass burning were asked a follow up question regarding how quickly they would like to see new regulations put into place. The largest percentage of respondents (44%) suggested that new restrictions be phased in within one to two years. The remaining individuals were divided between enforcing new regulations immediately (30%) and phasing in new regulations over a longer period of three to five years (26%). When the results were examined separately for those individuals supporting a total ban versus those individuals supporting increased restrictions, those favoring a total ban were more in favor of imposing restrictions immediately. Those individuals that favored increased restrictions on burning without banning it entirely suggested phasing in any new restrictions over a period of 1-2 years (Fig. 2). The results from these questions appear to indicate that while most people do not want any changes in the current regulations, those individuals who want the most restrictions on burning also want to see those restrictions in place the quickest.

Previous data analyses reveal that many within the general public feel the farmers ought to be responsible to pay the costs of no-burn alternatives. However, this tendency is explained in part by analyzing the relationship between the respondents' relation to farming with alternative compensation sources. Comparison analyses between producer and public responses were conducted using an index of degree of farming background and relationship. Below, Figure 3 illustrates, the public perception is explained in part by analyzing the relationship between the respondents' relation to farming with alternative compensation sources. While those with higher levels of a farming background or relation to farming vary across private, state, and federal payment options, those with no farming background tend to strongly prefer the farmers bear these potential costs.

*Objective 6: (Thill and Reed)* The extension program is a critical link between the bluegrass team, the region's grass seed industry, and the general public. The extension program has disseminated information through numerous local, regional, and national presentations, the bluegrass list server, information database, and website, mass media publications and interviews, extension publications, individual contacts, and field tours. Information has been disseminated to college and elementary students through guest lectures, activity workbooks, and field tours. Information needs and preferred method of information delivery were obtained from ID and WA producers, and that information was used to help prioritize research and extension objectives. The extension program has helped develop research projects that can be practically implemented by practitioners, speed the process of disseminating information and the rate of producers adopting new information, and foster a cooperative atmosphere between research scientists and the grass seed industry.

**INTERACTION:** No other scientists in the PNW are conducting related GSCSSA research.

Figure 2. Preferred timeline of general public for new restrictions.

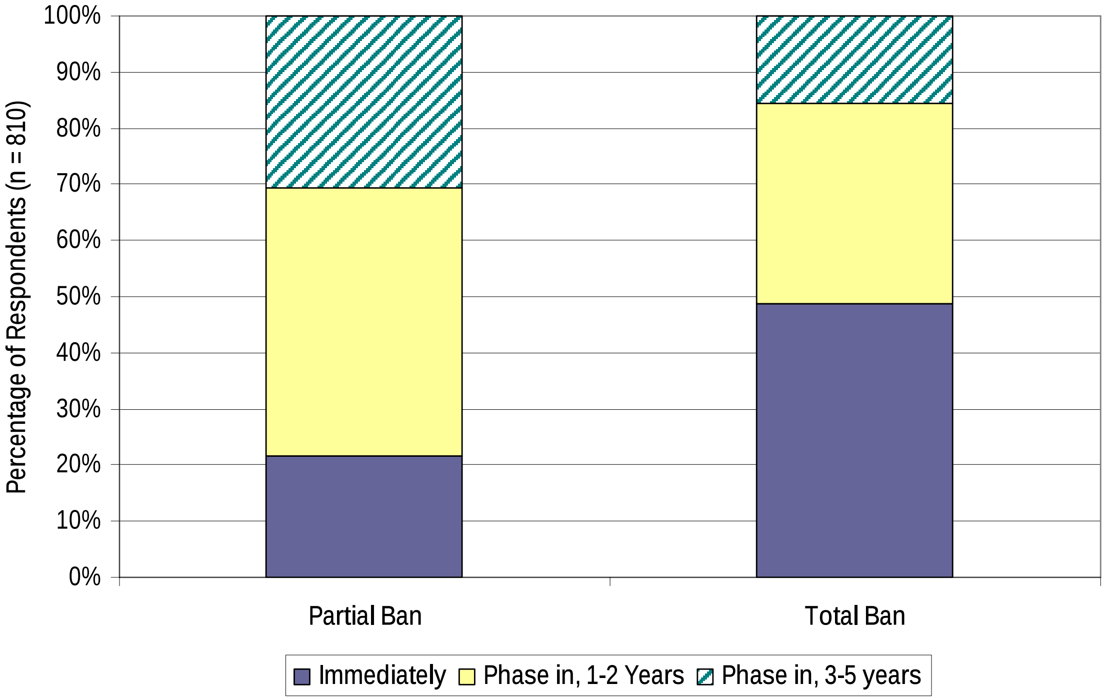
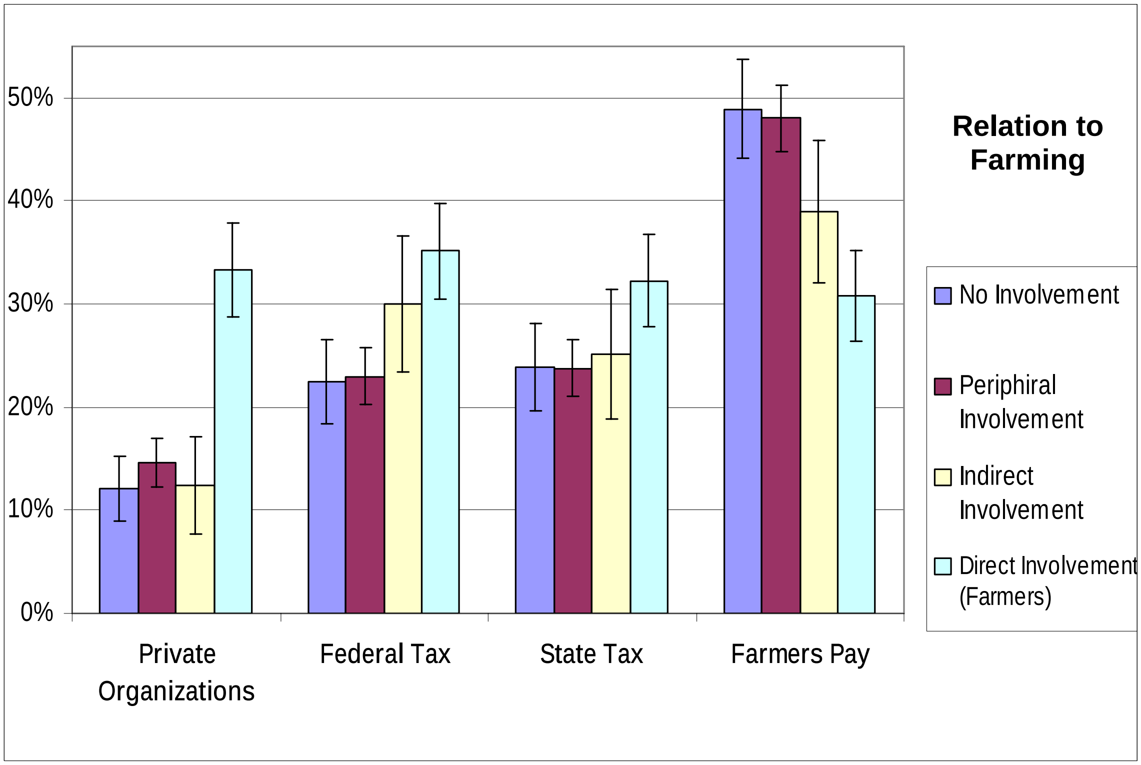


Figure 3. Cross-tabulation between relation to farming and preferred source of compensation for costs associated with a potential burn ban on bluegrass seed residue in Idaho.



**TIMELINE:** Summer 01 establish plots, collect residue and soil samples, applied residue management treatments (Lewis Co. only); Fall 01 - install weather station, collect additional samples; Spring 02 - applied residue management treatments and herbicide, collect residue and soil samples; Summer 02 - field tours, harvest plots (yr 1), collect samples, apply residue management treatments; Fall 02 (both locations) - collect residue and soil samples; Spring 03 through summer 05 - same sequence of events as previously stated, except grass seed harvest occurred only at Kootenai Co. site in 05. This completed phase I of the study. Phase II will be fall 05 through summer 08 with a similar sequence of activities (Kootenai Co site). The Latah Co. site was established in spring 04. Sampling and harvest sequence will be similar to the Kootenai Co site in 05-08.

**PUBLICATIONS, REPORTS, AND PRESENTATIONS FOR THE CURRENT YEAR:**

Holman, J., C. Hunt, and D. Thill. 2006. An evaluation of structural composition, growth stage, and cultivar affects on Kentucky bluegrass forage yield and nutrient composition. Agronomy Journal. (accepted)

Holman, J., C. Hunt, J. Johnson-Maynard, L. Van Tassell, and D. Thill. 2006. Integration of livestock into Kentucky bluegrass seed production systems as a non-thermal residue management practice. Agronomy Journal. (accepted)

Holman, J.D. and D.C. Thill 2005. Kentucky bluegrass growth, development, and seed production. UI Bull. 843, p.12.

Holman, J. D. and D.C. Thill. 2005. Kentucky bluegrass production. UI Bull. 842, p. 12.

Holman, J., D. Thill, J. Johnson-Maynard, K. Umiker, C. Hunt, and J. McCaffrey. 2005. Effect of reduced-burn and no-burn residue management on Kentucky bluegrass seed production. Proc. Western Soc .Crop Sci.

Reed, J., J. Holman and D. Thill. 2006. Downy brome control in established Kentucky bluegrass. West. Soc. Weed Sci. Res. Prog. Report. 127-128.

Reed, J. and D. Thill. 2006. The effect of adjuvants on weed control with flucarbazone in Kentucky bluegrass. West. Soc. Weed Sci. Res. Prog. Report. 129-130.

Thill, D.C. 2006. University of Idaho Kentucky bluegrass field tour. Potlatch, ID. June 7.

Thill, D.C. 2006. University of Idaho Kentucky Bluegrass Field Tour. Worley, ID. May 23.

Wolfley, Jared, Larry Van Tassell, Donn Thill, and John Holman. "Evaluation of Non-Thermal Methods in the Production of Kentucky Bluegrass Seed." Selected paper at the 2006 Western Agricultural Economics Association Meetings, Anchorage, AK. June 2006. Abstract: Journal of Agricultural and Resource Economics. 31,3 (2006): in print

Wolfley, J., Van Tassell, L., Smathers, R., Holman, J., Thill, D., Reed, J. (2006). Economic analysis of experimental thermal and non-thermal residue mangement systems for Kentucky bluegrass seed. University of Idaho Extension Bulletin (in press).

Wulfhorst, J.D., L. Van Tassell, B. Johnson, J.Holman, and D. Thill. 2006. An industry amidst conflict and change: Practices and perceptions of Idaho's bluegrass seed producers. UI Res. 165. 19 pg.

Wulfhorst, J. D., Stephanie L. Kane, Larry W. Van Tassell, Beth Johnson, Romuald Afatchao, Katelyn Peterson, and Bernardo Alvarez. 2006. Public Attitudes and Perceptions of Air Quality and Bluegrass Seed Residue Burning in Northern Idaho. UI Res. 166. 45 pg.