PROCEEDINGS

WESTERN SOCIETY OF WEED SCIENCE

Volume 66, 2013

ISSN: 0091-4487

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2013

PROCEEDINGS

OF

THE WESTERN SOCIETY OF WEED SCIENCE

VOLUME 66

PAPERS PRESENTED AT THE ANNUAL MEETING

MARCH 11-14, 2013

CATAMARAN RESORT
SAN DEIGO, CALIFORNIA

PREFACE

The Proceedings contain the written abstracts of the papers and posters presented at the 2013 Western Society of Weed Science Annual Meeting plus summaries of the research discussion sections for each Project. The number located in parenthesis at the end of each abstract title corresponds to the paper/poster number in the WSWS Meeting Program. Authors and keywords are indexed separately. Index entries are published as received from the authors with minor formatting editing.

This e-document is available at the WSWS website (www.wsweedscience.org) or from the WSWS Business Manager, 205 W. Boutz, Building 4, Suite 5, Las Cruces, NM 88005 (wsws@marathonag.com). Print copies may be ordered from Curran Associates (http://www.proceedings.com/agriculture-conference-proceedings.html) 866-964-0401.

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Proceedings Editor: Bill McCloskey, University of Arizona

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POSTER SESSION

Project 1. Weeds of Range and Natural Areas

Identifying Areas Susceptible to Invasion by Rush Skeletonweed within the Frank Church Wilderness and Nez Perce National Forest. Larry W. Lass*, Timothy S. Prather; University of Idaho, Moscow, ID (001)

The long-term goal of this study is to reduce the effect of invasive weeds by proactive management. The objectives were to identify potential wind dispersal paths of known rush skeletonweed locations and predict susceptible invasion sites in the Gospel Hump Wilderness and part of Frank Church – River of No Return Wilderness in central Idaho.

Site susceptibility data were established using training and validation sites of rush skeletonweed infestations outside the wilderness area near Riggins, Idaho. National Agricultural Imaging Program (NAIP RGB+NIR) images at 1 m spatial resolution were trained to develop a vegetation matching model. These data were post processing with environmental and topographic variables to make a susceptibility model. Logistic regression was used for post-processing where the independent variable were vegetation match, elevation, heat units, cold units and sun radiance on the training sites. Results were validated and applied to the study area to show susceptible sites in the wilderness area.

Wind dispersal data was from Dr. Sandya Rani Kesoju's dissertation work and presented at WSWS in 2012. A dispersion distance model was applied to known infestation based on the average wind speed and direction. Susceptible sites within the dispersal pattern were identified for survey.

A survey crew from the Nez Perce Tribe found the areas identified as susceptible either had rush skeletonweed or looked like the site should have the weed even if it was not found. The crew did not find new rush skeletonweed infestations outside the areas marked as susceptible. Susceptibility modeling offers the potential of knowing where to look before conducting a random search.

Spring Applied Glyphosate and Imazapic for Medusahead Control. Trevor M. Peterson*, Katie Stoker, Corey V. Ransom, Ralph E. Whitesides; Utah State University, Logan, UT (002)

Medusahead, an invasive winter annual grass, has invaded millions of acres in the Western U.S. Control with preemergence herbicides in Northern Utah has been inconsistent, potentially due to variability in rainfall, thatch, soil textures, and medusahead germination patterns. To eliminate some variability, spring postemergence treatments were evaluated in two trials established in the southern portion of Cache County, Utah. Plots were 3 by 9 m and organized in a randomized complete block design with four replications. Treatments included: Untreated; imazapic at 105, 140 and 175 g ai ha^{-1}; and glyphosate at 96, 193, 289 and 385 g ai ha^{-1}. Each treatment was applied at two different timings from mid to late May using a CO_2-pressurized backpack sprayer calibrated to deliver 167 l ha^{-1}. Medusahead response was determined by visual evaluations, measuring plant heights, harvesting biomass, and counting medusahead seed heads from two 232 cm^2 quadrats in each plot. At maturity, 10 seedheads from each plot were collected, the number of seeds counted, and seed germination tested in petri dishes. All treatments controlled medusahead, with glyphosate exhibiting greater control than imazapic. Seed numbers were higher with glyphosate treatments, possibly due to the loss of mature seeds by other treatments and retention of immature seeds in glyphosate plots. All treatments reduced seed germination, with glyphosate at 193 g ai ha^{-1} or higher and imazapic at all rates reducing germination to 0 to 5.4% compared to 90% in the untreated. Late spring herbicide applications made when seedheads were emerged or emerging resulted in significant suppression of medusahead and more importantly reduced seed viability, which holds promise for medusahead management.

Investigating Herbicide Mixtures for Buffelgrass Management. William B. McCloskey[1], Bryan C. Pastor*[1], Dana Backer[2];[1]University of Arizona, Tucson, AZ,[2]Saguaro National Park, Tucson, AZ (003)

Buffelgrass (*Pennisetum ciliaris*, L.; PESCI) is an invasive C4 perennial bunchgrass introduced from Africa. Buffelgrass is spreading across southern Arizona, including the region's signature saguaro forests in Saguaro National Park and Coronado National Forest, and is the greatest non-native species threat facing the Sonoran Desert ecosystem. It competes with native plants for resources, creates dense stands which inhibit native plant growth and fuels fires (burning at 1300-1600°F) in a community dominated by plants and animals (e.g., saguaros and desert tortoises) that are not adapted to fire. Buffelgrass has invaded steep slopes and rocky terrain where it is difficult for workers to safely spray plants with glyphosate, and the extent of infestation is outpacing the human resources available for treatment and control. The alternative is aerial herbicide applications with helicopters and fixed-wing aircraft.

The objectives of this project were to investigate buffelgrass susceptibility to broadcast applications of glyphosate, alone and tank mixed with graminicides. We primarily used a greenhouse testing protocol while simultaneously beginning field experiments, with the hope that tank mixtures could be used to reduce the collateral damage to desirable vegetation caused by glyphosate. In greenhouse experiments, plants were grown until they had 10-20 tillers, were clipped, allowed to regrow, and then were sprayed. Herbicides were applied at 10 GPA using a CO_2 pressurized backpack sprayer with a 3 nozzle boom and XR8001 nozzles. About 3 to 4 weeks after spraying, shoot fresh and dry weights were measured and the pots were returned to the greenhouse. About 3 weeks after the first biomass harvest, shoot regrowth, if any, was harvested and fresh and dry weights were measured. Field experiments have been carried out in multiple locations around Tucson, Arizona. Plants were scouted, flagged, and pre-spray and post-spray measurements (tillers, basal diameter, visual 'green' rating) were collected. Buffelgrass grown in the greenhouse was susceptible to glyphosate; growth was suppressed at low rates but it was often difficult to determine whether plants were dead based on shoot biomass at first harvest data. The efficacy of the herbicide treatments was best determined by measuring shoot regrowth. Although there was a great deal of variation between experiments, 0.1 to 0.2 kg ae/ha of glyphosate was usually sufficient to kill buffelgrass plants in the greenhouse; much higher rates were required in the field. One source of variation was the size of plants when sprayed, best represented by number of tillers. Larger plants produced more biomass at a given herbicide rate and died at higher rates. The rate of clethodim or sethoxydim required to kill buffelgrass plants varied between 0.2 and 0.5 kg ae/ha depending on the experiment and size of treated plants. No consistent interaction between glyphosate and clethodim, or glyphosate and sethoxydim, that was synergistic or even additive, was found in either field or greenhouse experiments. Thus, our preliminary conclusion is that it does not appear to be possible to reduce the rates of glyphosate used in the field by tank mixing with sethoxydim or clethodim.

Creeping Bentgrass Mitigation Program: Alternatives for Seed Head Reduction. Sasha Twelker*, Gustavo M. Sbatella; Oregon State University, Madras, OR (004)

Glyphosate resistant creeping bentgrass (*Agrostis stolonifera* L.) accidentally escaped from production fields in 2003, and now grows along irrigation ditches in Jefferson County. Labeled herbicide control options are limited during the year due to the proximity to irrigation water. The objective is this study was to evaluate the use of diquat and propane burners applied at the boot and flowering stage for creeping bentgrass seed head reduction. Results suggest that these can indeed be effective tools of a mitigation control program. A significant reduction in the number of seed heads per plant was observed with all treatments 21 days after treatment (DAT), although results varied among treatments and with the time of application. Delaying diquat applications until the flowering stage improved seed head reduction. Diquat applied with Class Act NG® at flowering reduced seed head production by 98 % compared to 93 % with Liberate® as a surfactant. Seed head reduction 90 DAT was highest with diquat + Class Act NG® applied at flowering with 97 %, and differences between application timing were still significant. A 7 % increase in the number of seed head between evaluations was recorded for Diquat + Liberate® when applied at flowering. Nevertheless, the most effective treatment in reducing seed production was the flaming of the bentgrass plants with a propane burner either at the boot or flowering stage.

Reclaiming Downy Brome Infested Oilfield Sites for Wildlife Habitat. James R. Sebastian*; Colorado State University, Ft. Collins, CO (005)

Reclaiming Downy Brome Infested Oilfield Sites for Wildlife Habitat. James R. Sebastian, K.G. Beck, and Derek Sebastian (Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523) Downy brome (*Bromus tectorum*, BROTE) is an invasive winter annual that competes with desirable native grass and forb species for early spring moisture on rangeland, roadsides and dry, disturbed habitats. Management strategies are needed to rapidly restore productivity and biodiversity of degraded rangelands that have been invaded by downy brome. Two experiments were established with similar treatments near Rulison and Parachute, Colorado on past oil shale drill site pads to be reclaimed for wildlife habitat. Sites were 10 miles apart at approximately 5,100 ft elevation with 13 average inches of annual precipitation, on critical elk and muledeer winter range. The objective of this study was to examine the effects of imazapic, rimsulfuron, sulfometuron + chlorsulfuron, and imazapic + glyphosate, used to control BROTE, on seeding success of 6 native perennial grasses, 6 forb, and 2 shrub species that provide essential food and cover for wildlife. Imazapic was applied preemergence to BROTE on September 9, 2010. All other treatments were applied at 1 to 2 leaf growth stage on November 7, 2010. Four rows of each species per subplot were drilled in December 2010 or 2011, approximately 1 or 12 months after herbicide treatments to determine if an extended interval between spraying and drilling dates influenced seedling recruitment. There was excellent spring moisture in 2011 and poor moisture in 2012. The 6 native grass species included in the experiment were Western wheatgrass (*Pascopyrum smithii*, PASSM), bluebunch wheatgrass (*Pseudoroegneria spicata*, PSESP), Indian ricegrass (*Achnatherum hymenoides*, ACHHY), sandburg bluegrass (*Poa secunda*, POASE), bottlebrush squirreltail (*Elymus elymoides*, ELYEL), and sand dropseed (*Sporobolus cryptandrus*, SPOCR). The 6 native forb species included low fleabane (*Erigeron pumilus*, ERIPU), Maple Grove Lewis flax (*Linum lewisii*, LINLE), dusty penstemon (*Penstemon comarrhenus*, PENCO), lobeleaf groundsel (*Senecio multilobata*, SENMU), scarlet globemallow (*Sphaeralcea coccinea*, SPHCO), and Sulfur buckwheat (*Eriogonum umbellatum*, ERIUM). The shrub species (Wyoming big sagebrush, *Artemisia tridentata*and four-wing saltbrush, *Atriplex canescens*) are not included in this report. Density (plants per subplot) and frequency (presence or absence at 1' intervals in each of 4 rows per sub-plot) data were collected in 2011 and 2012, however, only Rulison frequency data that were collected in 2012 are reported. Visual evaluations for BROTE control and BROTE or Russian thistle (*Salsola kali, SALKI) canopy cover* were collected in 2011 and 2012. Rimsulfuron, sulfometuron + chlorsulfuron, and imazapic + glyphosate controlled 87 to 100% and 64 to 90% of BROTE in 2011 and 2012, respectively. Sulfometuron + chlorsulfuron was the only herbicide with excellent frequency ratings for all 6 grass species drilled in 2010. Both imazapic + glyphosate and rimsulfuron had 4 of 6 grass species with excellent ratings drilled in 2010. Imazapic + glyphosate had good to excellent frequency ratings for all 6 grass species and fair to good ratings for 3 of the 6 forb species drilled in 2010. Sulfometuron + chlorsulfuron had excellent frequency ratings for all 6 grass species and fair ratings for 2 forb species drilled in 2010. Sulfometurnon + chlorsulfuron had the benefit of suppressing SALKI. There was 35% SALKI canopy cover in sulfometuron + chlorsulfuron treatments v 70 to 85% SALKI cover in rimsulfuron, and imazapic + glyphosate treatments. There was less SALKI (26 or 28% cover) in checks or imazapic plots in 2011; however, there was 0 and 18% BROTE control and 66 to 87% BROTE canopy with only fair density grass ratings in imazapic or checks. Three of the 6 forbs (PENCO, SPHCO, and ERIUM) failed to establish in any treatments drilled in 2010. ERIPU, SENMU, and LINLE that was drilled in 2010 had fair to good frequency ratings. SENMU was the most successful forb drilled in 2010 and had fair frequency ratings in every treatment but the control. There was 1 good, 9 fair and 20 failure ratings with forbs drilled in 2010 and 2 excellent, 4 good, 10 fair, and 14 failures from forbs drilled in 2011. Having an additional growing season between spraying and drilling dates tended to benefit forbs drilled in 2011. This was not consistent with the different 2010 and 2011 grass drilling dates. There were 14 excellent grass frequency ratings and 0 failures from the 2010 drilling date v 4 excellent and 15 failures from the 2011 drilling date. The exceptionally hot, dry spring in 2012 tended to negatively impact 2011 drilled grass; however, grass drilled during the wet 2010 spring were successful where BROTE was controlled. There were no negative impacts on drilled grass frequency with any herbicide treatments from the 2010 seeding. In most cases drilled grass species responded favorably to the release from BROTE competition compared to the untreated plots. Native forbs continue to be difficult to establish in harsh environments similar to this site. This study has shown that certain forb species may respond favorably to drilling after herbicide applications. We will evaluate these studies again in 2013.

Sublette Invasive Species Taskforce: Cheatgrass Survey and Treatments. Julie A. Kraft*; Sublette County Weed and Pest, Pinedale, WY (006)

Sublette County, Wyoming is 3.2 million acres comprised mostly of the sagebrush steppe plant community, but surrounded by mountains on three sides. Cheatgrass or downy brome is probably the most threatening invasive plant to our area, because of our vast sagebrush ecosystems. In 2010, the Sublette County Invasive Species Taskforce was formed. This group was initiated to combine all concerned parties interested in the cheatgrass invasion of Sublette County. Right now the focus is on cheatgrass, but subgroups can be formed for any invasive species. Taskforce members include county, state and federal agencies, local industry companies, landowners and anyone interested in cheatgrass in Sublette County.

Taskforce members understood that there was cheatgrass invading our native range and wanted to understand how much as well as exactly where it was. So the group sought funding for an invasive plant survey. We have been surveying for all invasive plants within our county and will treat located infestations. Using invasive species management principles we have surveyed major corridors and vectors in the county, as well as areas of know disturbance. With a few areas of exception, most of the located cheatgrasss in Sublette County is associated with roadways or previous disturbance. We have an infestation in the Southwest corner of the county that is associated with a nearly 100 year old oil development and a large infestation along the Wind River Front in the Boulder Lake area that is associated with south facing slopes and historic fires.

The Boulder Lake infestation is thousands of acres and the Taskforce works each year to acquire grant funding to treat cheatgrass by air. We have small and large scale product trials out to see which herbicide is the most effective tool in our area. The large scale trials are with Imazapic and Rimsulfuron. We had some non-typical results with the Rimsulfuron in the 2011 treatment, in which the cheatgrass was reduced from 68% to 15% of the total plants cover. We continue to monitor and put out new trials with these herbicides to understand effectiveness and limit non-target damage. This heavily invaded area is important wildlife habitat located within the sage grouse core area. It is used for recreation and livestock grazing, so it is important to limit non-target damage and limit spread. The taskforce has designated a Hold-the-Line type of approach where all areas West of this line will be treated. We will continue to control the large infestation on the east side of the line as funding is available. The Taskforce understands that cheatgass may not ever be completely eradicated in Sublette County but with these cooperative projects we hope to better understand and slow the invasion of our sagebrush community.

Management of Austrian Fieldcress (*Rorippa austrica*). Andy Currah*, Julie A. Kraft; Sublette County Weed and Pest, Pinedale, WY (007)

Austrian fieldcress, *Rorippa austriaca* (Crantz) Spach is a noxious perennial weed in the *Brassicaceae* family that was introduced from Europe. In Wyoming, the only known infestation is located in Sublette County near the town of Pinedale. This mustard is a deep rooted perennial that was first discovered in 2006. It invades meadows, specifically in standing or irrigation water, making this weed a very difficult management challenge. Currently, the population is being treated with aquatic glyphosate and 2,4-D. These control methods are effective in the irrigation system but not practical in the meadows. Since 2010, Julie Kraft and Andy Currah of Sublette County Weed and Pest District have conducted field trials on *Rorippa austriaca* using different rates of chlorsulfuron, 2,4-D paired with two different surfactants. There were 8 test plots in our study that measured 6' x 44'. The chemical rates we used were selected to equal 2 and 3 ounces of chlorsulfuron per acre and with and without the addition of 2,4-D. Backpack treatments took place in September 2010, just after blooming, but while vegetation was green. This fall treatment showed little to no control. In August of 2011, we repeated the same treatment rates as before, but while the plants were in full bloom. Results showed that treatment of Rorippa austriaca with 2,4-D plus surfactant during full bloom showed reasonable control. This still leaves Sublette County Weed and Pest with the management challenge of treatment in hay meadows in mid-summer when meadows are both being irrigated and have natural sub-irrigation and treatment is with backpack crews only.

Feasibility of Solar Tents for Hydrothermal Inactivation of Weedy Plant Propagative Material. James J. Stapleton*; University of California, Parlier, CA (008)

Validation of a Weibull Model Predicting Mortality of *Brassica nigra* Seeds Under Diurnal Heating Simulating Soil Solarization. R. M. Dahlquist[1], E. F. Holtman[1], D. G. McCurry[1], T. Fischer[1], K. Loper[1], M. N. Marshall[2], J S. VanderGheynst[3], and J J. Stapleton[4]*. [1]Department of Biology, Fresno Pacific University, Fresno, CA; [2]Department of Biological and Agricultural Engineering, The Pennsylvania State University, University Park, PA; [3]Department of Biological and Agricultural Engineering, University of California, Davis, California; [4]Statewide Integrated Pest Management Program, UC Kearney Agricultural Center, Parlier, CA.

Solarization is an alternative to soil fumigation that reduces populations of weed seeds and other pest organisms. In order to develop effective guidelines for the use of solarization, data are needed to predict the duration of heat treatment needed for weed seed mortality. A Weibull model generated using seed mortality data obtained at constant temperatures was used to predict mortality under a fluctuating, diurnal temperature regime. Four trials were conducted with seeds of black mustard (Brassica nigra). To simulate conditions in soil during solarization, moistened seeds were placed in organdy bags, moistened, and buried in jars filled with moistened semi-sterile silica sand. Jars were exposed to 9 hours of daily heating in an incubator. Daily maximum temperatures were set to 44-51 °C and minimum temperatures to 16-24 ^{o}C. Seeds were removed at intervals ranging from 1 to 14 days and monitored daily for seed germination. Mortality was calculated as (1 – germination %) and confirmed with tetrazolium staining. Temperatures recorded within the jars were used in the Weibull model to generate predicted mortality. At each sampling interval, observed mortality was compared to predicted mortality with a t-test. At 16 of 19 sampling intervals across the four trials, observed mortality was not significantly different from predicted mortality. These results indicate that the Weibull model developed from seed mortality data obtained at constant temperatures also can effectively predict mortality under fluctuating temperatures similar to those occurring during solarization.

Aminocyclopyrachlor Gives Selective Control of Barb Goatgrass in California Annual Rangeland. Guy B. Kyser*[1], Josh S. Davy[2], Joseph M. DiTomaso[1]; [1]University of California, Davis, CA, [2]University of California Cooperative Extension, Red Bluff, CA (009)

The Mediterranean annual barb goatgrass may pose a greater threat than medusahead on low-elevation rangeland in California. Grazers avoid its tough, silica-rich foliage, and it tolerates serpentine soils, competing with some California endemic species. It is difficult to selectively remove barb goatgrass from grasslands. Because it flowers late in the season, it is possible to control barb goatgrass seed production by burning in early summer. However, burning is not always practical. Timely use of graminicides and mowing has been effective on a small scale. The pyridine herbicide aminocyclopyrachlor, although generally broadleaf-selective, has been reported to suppress barb goatgrass. To confirm this, we established a trial near Red Bluff, California, 220 m elevation, in blue oak woodland. The trial was a randomized complete block design with 3-m by 9-m plots in four replications, and plots were treated using a CO_2 backpack sprayer, 3-m boom, and a spray volume of 187 L ha^{-1}. Treatments included low and high rates of aminocyclopyrachlor (140 and 280 g ae ha^{-1}), aminocyclopyrachlor + chlorsulfuron (111 + 44 and 221 + 88 g ae or ai ha^{-1}), and aminopyralid (123 and 245 g ae ha^{-1}). Chemicals were applied 7 October 2011 (before germination), 30 January 2012 (barb goatgrass seedlings about 5 cm tall), and 3 April 2012 (barb goatgrass beginning to tiller). We also applied sequential treatments of low rates in October followed by low rates in January. On 8 June 2012, when barb goatgrass was heading but still green, we recorded percent cover of all plant species in three 1-m^2 quadrats per plot. For all times of application, plots treated with 140 g ha^{-1} aminocyclopyrachlor had 41% to 48% of the barb goatgrass cover in untreated plots, and plots treated with 280 g ha^{-1} had 9% to 13%. The split application of 140 g ha^{-1} in October followed by 140 g ha^{-1} in January gave better than 99% control. Our data suggest that a split application gives sufficient soil residual to control germination through the end of the rainy season in spring. October and October/January applications of aminocyclopyrachlor resulted in an increase in desirable annual grass cover by 3.1- to 4.7-fold compared to untreated plots. Aminocyclopyrachlor + chlorsulfuron treatments were slightly less effective at controlling barb goatgrass and releasing other grasses. Although aminopyralid has been shown to suppress medusahead when applied preemergence at 123 to 245 g ae ha^{-1}, it gave no control of barb goatgrass in this study.

The Effects of Litter on Demography of Ventenata dubia. Taylor E. Ortiz*, John Wallace; University of Idaho, Moscow, ID (010)

Ventenata dubia is an exotic winter annual grass that is native to Mediterranean Europe and is increasingly invasive in the Pacific Northwest in rangeland and managed perennial grass systems. Ventenata infestations form thick litter layers which can positively or negatively affect plant establishment and development. Litter may directly affect factors such as shading, soil evaporation and temperature that alter micro-environments for plant growth, and may also indirectly affect microbial activity and nutrient cycling. In this study, we sowed 100 ventenata seedlings into 0.05 m^2 pots and imposed a range of ventenata litter treatments (0, 5, 10, 20 g) that correspond to 0, 33, 66 and 100% litter cover using a randomized complete block design and four replications. We collected data at three dates in the fall growing season to determine seedling emergence, survival and growth. We also monitored soil temperature and moisture across litter treatments. Results indicate that increasing levels of ventenata litter had positive effects on seedling emergence, survival and growth. The high litter treatments (10, 20 g) contained 100% germination at the first date and no seedling mortality was observed at subsequent dates. In comparison, the control treatment contained 36% seedling emergence at the first date and seedling density declined at later dates. Environmental data indicates that higher levels of litter result in higher levels of soil moisture throughout the fall growing season and mediates the max and min temperatures in the upper soil profile.

Russian olive (*Elaeagnus angustifolia* L.) Control with HBT. Katheryn M. Christianson*, Rodney G. Lym; North Dakota State University, Fargo, ND (011)

Herbicide Ballistic Technology (HBT) is a new approach of delivering herbicide using an encapsulated gel (ball) with a compressed air gun. Research conducted in Hawaii found that HBT was useful to control invasive weeds in remote locations or areas unreachable with conventional weed control equipment. An experiment was established near the Sheyenne National Grassland in southeastern North Dakota to evaluate the efficacy of triclopyr and imazapyr applied with HBT for Russian olive control. Herbicide application was made using gel capsules (balls) filled with a single herbicide concentration of imazapyr at 19 mg ae/capsule or triclopyr at 400 mg ae/capsule. Herbicide rate was controlled by the number of capsules that hit each tree and included 6, 12, 18 or 24 capsules/tree equal to imazapyr at 114, 228, 342, and 456 mg, respectively, or triclopyr at 2400, 4800, 7200, and 9600 mg, respectively. Treatment evaluation was based on percent visual injury which ranged from 0% (no injury) to 100% (complete leaf drop and no new growth) compared to an untreated control. The experiment was a randomized complete block design with four replicates. A plot consisted of one tree and the replicates were grouped according to tree size based on measurements of trunk circumference. The trees ranged from an average of 31 cm in diameter in replicate one to 90 cm diameter in replicate four. Initial injury was 39 and 62% with imazapyr and triclopyr, respectively, 1 month after treatment (MAT) averaged over all application rates. In general, injury increased as application rate (capsules/tree) increased. For instance, injury averaged 57% with 2400 mg of triclopyr (6 capsules/tree) to 92% when 9600 mg (24 capsules/tree) 9 MAT. In general, triclopyr provided better control than imazapyr, but many larger trees began to regrow 13 MAT regardless of herbicide or application rate. Although all trees were severely injured, less than 50% were completely killed. HBT could be used to control established trees in areas unreachable with traditional field equipment but likely would require retreatment to control regrowth and kill larger trees.

Economics of Duncecap Larkspur Control with Aminocyclopyrachlor. Brandon J. Greet*, Andrew R. Kniss, Brian A. Mealor; University of Wyoming, Laramie, WY (012)

Duncecap larkspur is an important perennial weed on high elevation rangelands because of significant cattle losses due to toxic alkaloids in the plant. Aminocyclopyrachlor plus chlorsulfuron and aminocyclopyrachlor plus metsulfuron-methyl were evaluated for their economic potential of controlling duncecap larkspur. Aminocyclopyrachlor plus chlorsulfuron and aminocyclopyrachlor plus metsulfuron-methyl were compared to picloram and metsulfuron-methyl based on a herbicide efficacy study completed at a high elevation site in Wyoming. Herbicides were applied to two sites in a randomized complete block design with four replicates each. Recommended rates of picloram and metsulfuron-methyl were compared economically with the rates of aminocyclopyrachlor plus chlorsulfuron and aminocyclopyrachlor plus metsulfuron-methyl providing 90% larkspur control. Cost of herbicide plus application by spot, boom, and aerial methods were compared with the net present value of accepting a 2.5% death loss, 5% death loss, and leasing a similar pasture that is free of duncecap larkspur. The cost was found for each subsequent year following herbicide application to determine the years until the break-even point was reached. Results indicated that it was always more profitable to lease larkspur-free pasture instead of accepting either amount of death loss under the conditions evaluated. Two to six years of larkspur control was required for aminocyclopyrachlor plus chlorsulfuron to reach the break-even point, compared to two to five years for aminocyclopyrachlor plus metsulfuron-methyl depending on the method of herbicide application. Aminocyclopyrachlor plus metsulfuron-methyl was found to be the least expensive option.

Control of Giant Hogweed (*Heracleum mantegazzianum*) to Ensure Public Safety and Economic Efficiency in a Herbicide Restricted Region of Coastal British Columbia. Jennifer B. Grenz*; Invasive Species Council of Metro Vancouver, Richmond, BC (160)

Giant Hogweed (*Heracleum mantegazzianum*) is a plant species prioritized for control in the Metro Vancouver region of British Columbia due to the significant hazards the plant poses to public safety. Giant Hogweed contains a toxic sap that causes severe phytophotodermatitis which can include welts, rashes, blistering and scarring that may persist for up to a decade. The dermatitis can resemble third degree burns and eye exposure to the sap can also result in permanent blindness. Control of the plant in the mild coastal climate with herbicide restrictions has posed significant challenges in establishing effective and economically efficient control. Giant Hogweed has been found to have approximately 4 growing cycles throughout one season and established sites have extensive seed beds which can be viable for up to 10 years. Issues surrounding pesticide use in a highly urbanized region with multiple local government bans on cosmetic pesticide use and the limited products accepted for use in the wet, coastal climate has lead to historically high costs associated with manual control and/or multiple herbicide treatments in one growing season. Given these parameters, treatment trials began in 2011 to find a methodology that would yield a fast kill to reduce public safety risk and give long term control of the seed bed using available herbicides in the region (glyphosate, aminopyralid and triclopyr). From these trials, a combination treatment using glyphosate and aminopyralid was found to achieve these goals. While aminopyralid has been demonstrated to be tolerated by the *Apiacea* family, and our own trials confirmed this as it was ineffective in controlling mature Giant Hogweed plants, it worked well on new germinates. Given the public safety risk, the fast action of glyphosate on the more mature plants was desirable. The combination of these two products, applying glyphosate to mature plants and applying aminopyralid to the soil underneath the mature plants, worked well to quickly eliminate mature plants and provided season long control of new germinates from the seed bed. In the 2012 field season, sites using this methodology required very little to no follow up treatments within the single growing season. Overall efficacy rates after one treatment have improved by 85% over historic treatments using only glyphosate or manual control thus increasing public safety, spreading available budgets to treat more infestations and significantly reducing control costs. The multi-year residual effect of aminopyralid on these sites will be evaluated in the spring of 2013.

Project 2. Weeds of Horticultural Crops

Prevalence of Metribuzin and Terbacil Resistant Redroot Pigweed (*Amaranthus retroflexus*), Powell Amaranth (*Amaranthus powellii*) and Common Lambsquarters (*Chenopodium album*) in Washington. Rick Boydston*; USDA-ARS, Prosser, WA (013)

Potato and peppermint are grown in the Pacific Northwest and weed management in both crops relies primarily on two photosystem II inhibitor herbicides, metribuzin and terbacil, respectively. Seed of redroot pigweed (*Amaranthus retroflexus*), Powell amaranth (*Amaranthus powellii*) and common lambsquarters (*Chenopodium album*) were collected from escape weeds in potato and peppermint fields throughout the irrigated Columbia Basin region of Washington in 2010 to ascertain the presence of herbicide-resistant weeds. Collected weed biotypes were tested for susceptibility to metribuzin and terbacil in greenhouse dose-response trials and compared to known susceptible biotypes. Fifteen of 27 redroot pigweed and eight of 25 common lambsquarters biotypes collected from potato fields in the Columbia Basin were resistant to metribuzin. ED50 values for plant dry weight response to metribuzin ranged from 2- to 28-fold greater in resistant biotypes than susceptible controls of redroot pigweed and from 40- to 70- fold greater in common lambsquarters. Ten of 22 pigweed biotypes from mint tested resistant to terbacil with E50 values for plant dry weight ranging from 3- to 18-fold greater than susceptible controls. In subsequent tests, all confirmed metribuzin- and terbacil- resistant weed biotypes were cross-resistant to the other herbicide. All pigweed and common lambsquarters biotypes resistant to metribuzin were controlled by normal use rates of herbicides with other modes of action (rimsulfuron, ethalfluralin, EPTC, S-metolachlor, dimethenamid-p, trifluralin, and flumioxazin). Terbacil- and metribuzin- resistant redroot pigweed and common lambsquarters biotypes susceptibility to postemergence applied bromoxynil and bentazon was similar to susceptible control biotypes. These results confirm the presence of metribuzin- and terbacil-resistant weed biotypes in the Columbia Basin potato and peppermint growing region of Washington, and this information could be used to improve management or delay development of herbicide-resistant weed populations.

Development of Vegetation Management Strategies to Rehabilitate Riparian Agricultural Sites in Western Oregon. R.E. Peachey*, Jessica Green; Oregon State University, Corvallis, OR (014)

Successful establishment of native tree and shrub seedlings is a critical first step towards rehabilitation of riparian agricultural sites. Invasive weeds must be controlled before and after planting or seedling survival will suffer. Many approaches can be used, but herbicides are an efficient and cost-effective approach to control weeds and limit competition. This study evaluated eight common preemergent herbicides to determine which might be suitable for restoration applications. Dormant native broadleaved trees and shrubs of black cottonwood, Oregon ash, redosier dogwood, snowberry, and Pacific ninebark were transplanted in May into plots at both irrigated and non-irrigated sites in a split-plot arrangement with 4 replications. At the non-irrigated site, all treatments controlled weeds sufficiently to prevent tree and shrub mortality. Unregulated weed growth in the non-treated plots caused 41% mortality of trees and shrubs. Flumioxazin provided near complete suppression of emerging weed seedlings, and significantly improved tree survival by the end of summer because of reduced competition for water. At the irrigated site, saflufenacil injury ratings on black cottonwood and Pacific ninebark were 5.3 and 3.0 of 10.0 respectively. Mesotrione also injured Pacific ninebark.

Review of Flumioxazin use in Dormant Bermudagrass to Control Annual Bluegrass, Broadleaf Winter Annuals, Crabgrass and Goosegrass. Todd Mayhew*[1], Joe Chamberlin[2], Jason Fausey[3]; [1]Valent Professional Products, Gilbert, AZ, [2]Valent Professional Products, Snellville, GA, [3]Valent Professional Products, Fremont, OH (015)

In 2011, EPA granted registration for the use of flumioxazin to manage grass and broadleaf weeds in dormant bermudagrass turf. Field trials were established in Alabama, Arizona, California, Georgia, North Carolina, South Carolina, and Texas to evaluate turf safety and efficacy of flumioxazin (commercial product name SureGuard Herbicide) in common and hybrid bermudagrass turf. Rates of 0.1875 to 0.375 lbai/A were evaluated from September through April. Turf tolerance was acceptable when applied to dormant or semi dormant bermudagrass. A flumioxazin application at any rate in September or April caused unacceptable discoloration of bermudagrass, but was temporary and turf recovered fully.. September application caused premature turfgrass dormancy, but not delay spring greenup. Application to fully dormant turf (December through February) did not cause any injury or delay in spring greenup. When applied in November or December at 0.3125 to 0.375 lbai/A, flumioxazin provided excellent, season long control of Poa annua and a broad spectrum of broadleaf winter annual weeds. January and February application provided lower Poa annua control compared to late fall application. Flumioxazin alone did not provide acceptable control of perennial broadleaf winter weeds, but a tank mix of flumioxazin + metsulfuron provided excellent control. When applied in February or early March 0.375 lbai/A, flumioxazin provided good to excellent preemergence control of crabgrass and goosegrass.

Effect of Stale Seedbeds, Herbicides, and Flame on Cucurbits. Carl R. Libbey*, Timothy W. Miller; Washington State University, Mount Vernon, WA (016)

Stale seedbeds, herbicides, and flame were evaluated for weed control in cucurbits at Mount Vernon, Washington in 2011and 2012. Acorn squash (cv. 'Table Ace'), miniature pumpkin (cv. 'Jack Be Little'), and pickling cucumber (cv. 'Vlasset T') were seeded into strips of land that had been prepared for seeding 7 days or 3 days prior to the seeding date; a control strip was also seeded into a freshly prepared seedbed. Four residual herbicides (clomazone, s-metolachlor, halosulfuron, and ethalfluralin) were applied early preemergence and two nonselective herbicides (glyphosate and paraquat) or propane flame were applied immediately prior to cucurbit shoot emergence, but postemergence to many weed seedlings. Weed control in 2011 was improved in the 7-day stale seedbed, followed by the 3-day seedbed (85 and 82%, respectively). When averaged over the nonselective herbicide applications, weed control was maximized by glyphosate or paraquat (89 and 87%, respectively). Weed control did not differ by stale seedbed or by nonselective herbicide treatment in 2012. Flaming did not affect weed control as compared to the non-flamed cucurbits in either year. Weed control with residual herbicides ranged from 84 to 89% control in 2011 and from 97 to 100% in 2012. There was no significant crop injury from any of the treatments either growing season. For each cucurbit type the average fruit weight at harvest did not significantly differ among the treatments either year. Total fruit yield was not affected by stale seedbed or herbicide combinations either year and total fruit number did not differ in 2011. More squash fruits were produced following clomazone + halosulfuron treatment in 2012.

Weeds as Sources of Inoculum for Tomato Spotted Wilt Virus in CA Vegetable Crops.
Michelle Le Strange*[1], R. Gilbertson[2], O. Batuman[2], N. McRoberts[2], D. Ullman[2], T. Turini[3], S. Stoddard[3], G. Miyao[3]. [1]University of California Cooperative Extension, Tulare and Kings Counties, CA, USA, [2]Plant Pathology & Entomology Departments, University of California, Davis, CA, USA, [3]University of California Cooperative Extension, Fresno, Madera, Merced, Sacramento, Solano, and Yolo, Counties, CA, USA (017)

Tomato spotted wilt (TSW) caused by the thrips-transmitted virus *Tomato spotted wilt virus* (TSWV), has steadily increased in California's Central Valley since 2003 and is causing economic losses in peppers, tomatoes, radicchio, and lettuce. A team of researchers began investigating the sources of virus inoculum, the population dynamics of thrips, and how to effectively manage TSW with the objective to develop an integrated pest management (IPM) strategy. TSWV is found worldwide with an extensive host range (over 900 species). It is transmitted by at least nine species of thrips, but western flower thrips (*Frankliniella occidentalis*) is the most important vector in California. The only known means of virus transmission is via thrips vectors and only first instar larvae can acquire the virus from an infected plant. After acquisition, the virus replicates in the vector and the viruliferous thrips is capable of transmission for the duration of its life. Not all hosts are equally important in the epidemiology of this disease. In general, TSW susceptible plants on which thrips can complete their entire lifecycle play the most important role. Extensive winter and spring surveys of common weeds found in and around TSW susceptible crops in Fresno, Kings, Merced and Yolo counties from 2005-2012 reveal very low TSW infection incidence (annual average approximately 2.0%). For example in 2012, 602 weed samples (20 weed species) were collected from areas with TSWV outbreaks and only 10 samples (3 species) tested positive for the virus (<2.0%). Over the years the main weeds found to be infected were field bindweed (very rarely), jimsonweed, little mallow (symptomless), black nightshade, pineapple weed, prickly lettuce and annual sowthistle. To date, we have not found evidence of any weed that is extensively infected by TSWV in the Central Valley of California. Fallow fields can have large populations of weeds and in 2010 we found relatively high numbers of TSWV-infected plants (7% annual sowthistle and 5% prickly lettuce), so the weeds in these non-cropped sites are now considered important potential inoculum sources. The overall low incidence of weeds infected with the virus suggest that they may provide initial virus inoculum, perhaps along with ornamental plant hosts, but that it is the crop plant hosts that amplify this small amount of initial inoculum and thus the crops are more important in driving disease epidemics. RT-PCR testing of thrips revealed that most thrips were not carrying the virus early in the season, however many of the thrips samples collected from tomato flowers after mid-June were positive for the TSWV. Peppers and tomatoes (known hosts) were proven to be capable of amplifying the virus during the summer growing season. Another potential inoculum source of TSWV in peppers and tomatoes are "bridge" hosts, which are TSW susceptible crops grown during winter months when peppers and tomatoes are not grown. These crops, lettuce, radicchio, and fava bean, were surveyed for thrips and TSWV infection over the past five years and confirmed to be hosts of TSWV. In particular, radicchio is a very susceptible host and sustains high thrips populations.

Testing Herbicides for Weed Control and Crop Safety in Conifer Nurseries. Timothy W. Miller*[1], R.E. Peachey[2], Carl R. Libbey[1]; [1]Washington State University, Mount Vernon, WA, [2]Oregon State University, Corvallis, OR (018)

Several herbicides were tested for selectivity on seedling conifers during 2011-12. Trials were conducted at two sites operated by the Weyerhaeuser Company, at the Mima Forest Nursery, near Olympia, WA and the Aurora Forest Nursery near Aurora, OR. Douglas fir (*Pseudotsuga menziezii*) seedlings were included at both sites, while western hemlock (*Tsuga heterophylla*) seedlings were included at Aurora. In 2011, weed control at Mima exceeded 90% for all treatments in August. All PRE treatments provided excellent control at Aurora, although control with indaziflam had decreased to 71% by August. POST treatments were uniformly poor, perhaps due to the lateness of the application in relation to date of evaluation. At Mima, Douglas fir seedlings were injured by PRE applications of flumioxazin and flumioxazin + pyroxsulam, and by POST applications of imazamox and fluroxypyr. Height of Douglas fir trees treated with flumioxazin, flumioxazin + pyroxsulam, and fluroxypry was reduced, while trees treated with imazamox were of similar height as non-treated trees. At harvest, trees treated with flumioxazin, fluroxypyr, and to a lesser extent, flumioxazin + pyroxsulam, displayed lower shoot fresh weight and caliper, while fluroxypyr reduced stem length. At Aurora, Douglas fir seedlings were most sensitive to saflufenacil while western hemlock appeared to be tolerant. Flumioxazin reduced the growth of hemlock but not Douglas fir seedlings. Mesotrione applied twice at 12 fl.oz/A caused significant foliar injury and reduced hemlock seedling height, while Douglas fir seedlings were unaffected. At harvest, Douglas fir seedlings were impacted most by fluroxypyr, imazamox, and saflufenacil, while western hemlock seedling shoot weight was reduced by indaziflam and fluroxypyr, while imazamox and the split-applications of mesotrione also decreased hemlock shoot height at harvest. In 2012 at Mima, mesotrione cause severe bleaching of Douglas fir seedlings through August, although harvested tree weight, height, and caliper were not reduced by that treatment. Weed control with indaziflam and mesotrione was equal to hand-weeded plots in August. Caliper of trees treated with indaziflam, dithiopyr, and dimethenamid-p + pendimethalin was about 1 mm greater than trees treated with trifluralin + isoxaben. At Aurora, indaziflam, mesotrione, dimethenamid-p + pendimethalin, imazamox, and fluroxypyr all caused severe injury to western hemlock and reduced shoot weight.

Distribution of Glyphosate-resistant Junglerice (*Echinocloa colona*) in Perennial Crops of the Central Valley of California. Marcelo L. Moretti*[1], Alejandro M. Garcia[1], Albert J. Fischer[1], Bradley D. Hanson[2]; [1]UC Davis, Davis, CA, [2]University of California - Davis, Davis, CA (019)

Glyphosate-resistant (GR) populations of horseweed, hairy fleabane, and Italian ryegrass are widely distributed in California. GR junglerice has been documented in the northern Central Valley but no information is available about the distribution of GR junglerice in other parts of the region. The objectives of this study were (1) to evaluate the distribution of GR junglerice in

California, and (2) to assess post-emergence (POST) control of GR junglerice with currently registered herbicides. Mature junglerice seed was collected from 28 orchard and vineyard production areas during 2010-11. These samples represent populations from nine Central Valley counties ranging from Kern County in the south to Butte County in the north. The junglerice populations were tested simultaneously in a glyphosate dose response study in the greenhouse, and the experiment included one known GR and one known susceptible (GS) population. Plants were sprayed at the four-leaf stage with 0, 0.130, 0.260, 0.390, 0.522, 0.870, 1.350, 1.740, or 3.480 kg ae ha^{-1} glyphosate. In a separate greenhouse experiment, the known GR and the GS junglerice populations were treated with various POST herbicides, alone or in combinations, including: glyphosate, glufosinate, paraquat, rimsulfuron, penoxsulam/oxyfluorfen, flumioxazin, clethodim, sethoxydim, and fluazifop. Plants were treated at the 2- to 3-tiller stage (15 to 20 cm height) using a spray chamber calibrated to deliver 230 L ha^{-1}. In the dose response experiment, 5 of the 28 tested populations had at least a two-fold level of resistance to glyphosate when compared to GS junglerice. The GS population required 0.123 kg ae ha^{-1} glyphosate to reduce biomass by 50% (GR_{50}) while the five GR populations required 2- to 3.9-fold more glyphosate to be similarly affected. GR populations were found in Colusa, Madera, and Kern counties, spanning over 480 km of the Central Valley. In the POST experiment, glufosinate controlled both junglerice populations at 1.7 kg ai ha^{-1} but not at 1 kg ai ha^{-1}. Excellent control of both populations was provided by paraquat (0.34 and 1 kg ai ha^{-1}), rimsulfuron (0.035 kg ai ha^{-1}), and the ACCase inhibitor herbicides. Additional research is on-going to verify the efficacy of these treatments under field conditions.

Effects of Post-emergence Herbicides on Glyphosate and Paraquat-Resistant Hairy Fleabane Seed Production. Lynn M. Sosnoskie*[1], Bradley D. Hanson[1], Marcelo L. Moretti[2], Seth Watkins[1], Casey Erickson[1]; [1]University of California - Davis, Davis, CA, [2]UC Davis, Davis, CA (020)

Weed pressure, and the resulting competition for water and nutrients, can significantly impact orchard establishment. In commercially bearing orchards, weeds must be managed to improve irrigation efficiency, provide equipment access for other pesticide applications, and ensure that nuts can be harvested effectively and economically. Furthermore, weeds may harbor insect, vertebrate, and pathogenic pests that can significantly reduce tree health. Pesticide use data suggest that many orchards are being treated multiple times each year with both pre- and post-emergence herbicides. Unfortunately, complete weed control is not assured, even when the most effective chemical programs are employed. Seed produced by rogue plants may develop into management problems in subsequent seasons. While herbicide efficacy is often diminished when products are applied to mature plants, there is evidence to suggest that weed seed production can be significantly reduced by late-season, pre-harvest chemical applications. Shade-house/green-house studies were initiated to evaluate the effects of late-season POST herbicides on the growth and reproductive potential of glyphosate-resistant (GR) hairy fleabane (HF). Specifically, sub-lethal (one-half label-rate) and label-rate applications of glyphosate (2 lb ae/A), glufosinate (0.86 lb ai/A), paraquat (0.75 lb ai/A) and saflufenacil (0.044 lb ai/A) were made to each HF accession at varying phenological stages (mature rosette, bolting, budding and flowering). All products were applied using a pressurized cabinet sprayer calibrated to deliver 20 gallons per acre. Visual injury and plant height measurements were recorded bi-weekly, starting one week after treatment (WAT). Mature seedheads were counted and collected (3 to 6 times per week) from each plant.

At 9 WAT, final plant heights were recorded and any remaining unopened flower buds were counted; and above-ground biomass of each plant was determined. Although some mortality was observed, many plants survived POST herbicide applications, resumed growth, and achieved reproductive maturity. Plants treated at the rosette or bolting stages were more likely to be significantly injured by herbicide applications than plants that were budding or flowering at the time of treatment. In one study, herbicide applications made at the rosette and bolting stages reduced final plant height of GR HF by up to 42% although total plant biomass accumulation was less severely affected due to compensatory growth from axillary buds. Significant initial injury and delayed compensatory growth were also associated with reductions in seedhead and flower bud production; averaged over all growth stages glyphosate, glufosinate, paraquat and saflufenacil reduced the total reproductive output in GR HF by 2, 24, 36 and 32%, respectively. In general, similar trends were observed across all studies. Although seedhead production by GR HF was not always reduced by glyphosate applications, seedheads collected from the treated plants were often stunted and malformed; this suggests that seed viability could be impacted. In the coming year, results from the preliminary trials will be validated in on-farm orchard studies.

Evaluation of C14-Glufosinate Translocation in Young Almond (*Prunus dulcis*) Trees. Rolando S. .Mejorado*[1], Marcelo L. Moretti[2], Joi M. Abit[2], Bradley D. Hanson[3]; [1]UC Davis, Davis, CA, [2]UC Davis, Davis, CA, [3]University of California - Davis, Davis, CA (021)

Glufosinate is an important herbicide for weed control in California orchards. Although glufosinate is generally used as a contact herbicide, almond growers have expressed concern about injury to young almond trees suspected to be from translocation of the herbicide. The objective of this study was to evaluate uptake and translocation of glufosinate, in comparison to glyphosate, in young almond trees. ^{14}C-radiolabeled glufosinate or glyphosate was applied to leaf, green bark, or old bark (rootstock) of two-year-old almond nursery stock. Tissues were destructively harvested 1, 3, and 7 days after treatment. Absorption of glyphosate was greater than glufosinate regardless of application site. Most of the herbicide applied to old bark remained in the treated area (52% of the glufosinate and 94% of the glyphosate). In contrast, when applied to leaf or green bark, only 17 to 19% of the glufosinate and 32 to 43% of the glyphosate remained in the treated area. For both herbicides, ^{14}C was recovered in roots, which suggests that there is long distance translocation of glufosinate that is comparable to glyphosate. However, more research is needed to determine whether the radioactivity recovered in almond roots was in the form of the parent compound or a metabolite. This work addresses almond grower concerns and increases our understanding of the mobility of glufosinate in woody specialty crops in California.

Fluridon a New Tool for *Orobanche ramosa* Control in Potato. Mustapha A. Haidar*, Rami El Hussieni; American University of Beirut, Beirut, Lebanon (022)

A field study was conducted to evaluate the efficacy of fluridon (Pestanal[R]) for *Orobanche ramosa* control in potato. Fluridon was applied POST at 1, 5, 10, 20 and 30g ai/ha. Each rate was tested for single and sequential application at 20 and 30 days after potato emergence (DAPE). Results indicated that fluridon at all the tested rates (Single or two applications) significantly reduced O*robanche* infestation and shoot number compared to the controls. Fluridon at 5 g ai/ha reduced *Orobanche* infestation by 89% when applied once or twice (20 or 30 DAPE). All tested rates except for single application of fluridon at 20 or 30 g ai/ha (Single or two applications) produced compact potato plants with yellow leaves. However, potato plants recovered with time. All tested rates except fluridon at 30 g ai (single or two applications) produced small potato tubers.

Weed control options in organic vineyards. Anil Shrestha*[1], Kaan Kurtural[2], Srinivasa Konduru[2]; [1]California State University - Fresno, Fresno, CA, [2]California State University, Fresno, CA (023)

Weed management can amount to substantial costs in organic vineyards because of the lack of cost-effective, reliable, and organically acceptable herbicides. A previous study compared a tree and vine cultivator, steam, and an organic herbicide in which the tree and vine cultivator was the least expensive and most effective treatment. However, the vineyard was cultivated only once during the growing season in that study and data showed that more than one application during the growing season may be necessary in organic vineyards. Therefore, a study was conducted to test the effect of number and the timing of these applications with a tree and vine cultivator in an organic vineyard in 2012. The treatments included untreated control, single application in April, one application in April followed by a second one in May, single application in May, and one application in May followed by a second one in June. Weed biomass at different times of the growing season was estimated, grape yield and fruit composition was assessed. Although weed biomass was different in these treatments, none of the treatments affected yield. However, differences occurred between the treatments in some of the grape quality parameters (pH and titratable acidity). An economic analysis of the treatments is being conducted.

Multiple-resistance in *Lolium* spp *perenne multiflorum*. Mingyang Liu*, Andrew Hulting, Carol Mallory-Smith; Oregon State University, Corvallis, OR (024)

Multiple-resistance in *Lolium perenne* spp *multiflorum* has evolved in many areas worldwide. In Oregon, the number of populations with multiple-resistance is increasing. To manage the resistant populations, the resistance patterns must be determined. In this study, one population (CT), which was suspected to be resistant to sulfometuron and hexazinone, was collected from a Christmas tree plantation. The CT population is resistant to five herbicides with four different mechanisms of action: diuron (2.4-fold), atrazine, hexazinone (8.6-fold), glyphosate (3.1-fold), and sulfometuron. The resistant indices for sulfometuron and atrazine could not be calculated because the 50% growth reduction for the CT population was not reached even with the highest rates applied, 3.9 kg ai $ha^{-1}$and 16 kg ai ha^{-1}, respectively, which are 48 and 16 times the recommended field application rates of sulfometuron and atrazine, respectively. Acetolactate synthase (ALS) sequencing in the CT population identified a Trp591 to Leu mutation which previously has been reported to provide high level ALS resistance to three ALS inhibiting chemical families. A Ser264 to Gly mutation was identified in the *psb*A gene which has been reported to impart photosystem II resistance. No previously reported mutation in the 5-enolpyruvylshikimate-3-phosphate synthase gene was found in the CT population. The mechanism of glyphosate resistance has not been identified. There were lower levels of shikimatic acid accumulation in the CT biotype than in the susceptible biotype after treatment with glyphosate at 0.65 kg ai ha^{-1}. In Oregon, gulfosinate, clethodim, sethoxydim, or fluazifop are registered for use in Christmas tree production and could be used to manage this population.

Effect of Mustard Seed Meal Incorporation on Weeds and Cavity Spot in Carrot. Matthew Helm*[1], Anil Shrestha[2]; [1]California State University, Fresno, CA, [2]California State University - Fresno, Fresno, CA (025)

The objective of this study was to assess the ability of mustard seed meal to control weeds and carrot cavity spot disease (*Pythium* sp.), and to evaluate the phytotoxicity of mustard meal on carrots. Treatment comparisons included pelletized mustard seed meal (BioFence**®)** at 2, 4, and 6 T/ac, a standard herbicide (Linuron@ 2 lbs/ac applied pre-emergence), and a non-treated control. The experimental design was a randomized complete block with four replications. The seed meal was pre-plant incorporated on the bed-tops in early September and carrot seeds cv. SugarSnax were planted two weeks later. Weed densities, carrot stand counts, and weed biomass were evaluated on October 5, October 19, and November 9, respectively. Weed densities in the 4 and 6 T/ac seed meal were similar to the linuron plots whereas, the 2 T/ac plots had significantly more weeds but still 45% fewer than the non-treated control plots. All the treatments, including linuron, reduced carrot stands similarly by almost 50% compared to the non-treated control. Weed biomass was significantly lowered by the linuron, 2 T/ac, and 4 T/ac seed meal treatments compared to the non-treated control. However, weed biomass in the 6 T/ac seed meal plot was similar to the non-treated control. Carrot yield was similar in all the plots including the non-treated control. None of the treatments had any effect on carrot cavity spot. Therefore, the study showed that although mustard seed meal reduced weed emergence and biomass, its phytotoxicity to carrots negated this benefit.

Project 3. Weeds of Agronomic Crops

When Life Hands You Glyphosate Resistant *Amaranthus*, Make Something. Jessica Davenport*, Kelly M. Young; University of Arizona, Phoenix, AZ (026)

Glyphosate resistant palmer amaranth, *Amaranthus palmeri* has set roots in cotton fields across the United States. Weed management strategies that do not rely on glyphosate have been proposed as the desired method of best managing the encroachment. Another strategy to manage fields that have been colonized by glyphosate resistant palmer amaranth is to surrender to the weed. The weedy nature of the plant, including rapid growth and high water use efficiency make it an excellent competitor. Amaranth's potential as a viable crop is well known in many parts of the world, but is relatively unexploited in the U.S. The leaves and seeds of amaranth are edible, both raw and cooked, and are considered nutrient dense foods. In addition to food for humans, leaves and grain from amaranth can used to feed livestock. Fast growth and rapid biomass accumulation may point to potential as a cellulosic ethanol feedstock or hot weather green manure.

Control of Italian Ryegrass with Flufenacet plus Metribuzin and Pyroxasulfone Systems. Alan J. Raeder*, Nevin Lawrence, Shawn P. Wetterau, Ian C. Burke; Washington State University, Pullman, WA (027)

Italian ryegrass is a common and troublesome spring annual weed in the inland Pacific Northwest (PNW). Pyroxasulfone is a new very long chain fatty acid inhibiting herbicide that appears to control Italian ryegrass. Studies were conducted in 2011 and 2012 to study pyroxasulfone control of Italian ryegrass in wheat. Treatments consisted of pyroxasulfone applied preemergence in the fall at 60, 80, 100, 160, or 200 g ai ha^{-1}; flufenacet plus metribuzin applied preemergence in the fall at 381 and 95 g ai ha^{-1}; and pyroxsulam applied postemergence in the spring at 18 g ai ha^{-1}. Sequential treatments consisted of fall applied pyroxasulfone at 80 or 100 g ha^{-1}, and fall applied flufenacet plus metribuzin (381 and 95 g ha^{-}1); all three treatments were followed by (fb) spring applied pyroxsulam at 18 g ha^{-1}. Injury to wheat, ranging from 10 to 18 percent, was observed in 2011 and 2012 when pyroxsulam was applied alone and in 2011 when pyroxasulfone or flufenacet plus metribuzin was applied with pyroxsulam. In 2012, treatments of pyroxasulfone plus pyroxsulam resulted in greater control than flufenacet plus metribuzin applied alone. Yields were similar among treatments in 2011 and 2012. Pyroxasulfone preemergence fb pyroxsulam postemergence is an effective control option for Italian ryegrass in the PNW; rate of pyroxasulfone will determine the necessity of pyroxsulam postemergence.

Common Lambsquarters Response to Glufosinate as Influenced by Humidity. Carl W. Coburn*, Andrew R. Kniss; University of Wyoming, Laramie, WY (028)

The efficacy of many POST herbicides is influenced by environmental conditions before, during, and after spraying. Relative humidity (RH) is known to alter herbicide activity and may explain the limited efficacy of certain herbicides in low RH environments. Glufosinate is rarely used in the arid regions of the western United States because of variable efficacy on key weed species. The objective of the present study was to evaluate the efficacy of glufosinate on common lambsquarters (Chenopodium album) in low and high RH environments. Common lambsquarters were grown in growth chambers kept at 38% or 86% RH. Glufosinate plus ammonium sulfate was applied alone or in combination with nonionic surfactant or methylated seed oil. Following herbicide application, plants were returned to chambers such that all combinations of low and high humidity before and after application were obtained, totaling four humidity treatments relative to application time. A three-parameter log-logistic model was used to quantify the effect of RH environment on glufosinate efficacy. The glufosinate rate required to cause 50% control (ED_{50}) values were lowest for plants in the high RH block after application. Herbicide injury for plants in the low RH environment after spraying never exceeded 80%. Glufosinate at 451 g ai ha^{-1} adequately controlled plants in high RH environment before and after application but had limited effect on plants exposed to low RH either before or after treatment. The results suggest RH after glufosinate application is an important factor in control of common lambsquarters.

Paper 29 was withdrawn

Pea, Lentil, and Chickpea Affected by Pyroxsulam and Florasulam in Prior Wheat Crop.
Joan Campbell*, Traci Rauch, Donn Thill; University of Idaho, Moscow, ID (030)

Research was initiated to determine the effect of tillage effect on pyroxsulam carryover to lentil and to evaluate spring legume crops affected by soil residual among similar group 2 herbicides. Tillage effect was evaluated by treating winter wheat with 0, 3.5 and 7 oz/a (product) pyroxsulam in 2011. After harvest, half the experiment was chisel plowed in the fall and cultivated in spring 2012. Pardina lentil was seeded to compare conventional till to direct seed and lentil seed was harvested at maturity. The experiment was a split block design with four replications performed at locations near Genesee and Moscow, Idaho. Main plots were tillage and subplots were pyroxsulam rate. Soil pH was 5.5 at Genesee and 4.9 at Moscow. In another study, group 2 herbicide soil residual effects on legumes were evaluated following Brundage winter wheat and Alturas spring wheat. Herbicide treatments were pyroxsulam, fluroxypry/florasulam, and sulfosulfuron in winter wheat and pyroxsulam/ florasulam/fluroxypyr, fluroxypyr/florasulam, and flucarbazone + 2,4-D ester in spring wheat. Herbicides were applied at one, two, and four times the labeled rates to wheat in spring 2011 and the experiments included an untreated check. Wheat grain was harvested at maturity and Pardina lentil, Aragorn pea, and Billy Beans chickpea were direct-seeded in spring 2012. Legume injury was evaluated throughout the season and seed was harvested at maturity. The experimental design was a split block with four replications. Main plots were crops and subplots were the ten herbicide treatments. Soil pH was 5.6 and 4.5 in the winter and spring wheat experiments, respectively. Plants were visibly stunted, stand was reduced, and lentil seed yield was lower in the direct seed treatments compared to the tilled treatments at the Moscow site. Averaged over pyroxsulam treatments, seed yield was 998 and 806 lb/a at Genesee and 640 and 172 lb/a at Moscow, for the tilled and direct seed treatments, respectively. Lentil seed yield was lower with the 7 oz/a rate compared to the untreated. Averaged over tillage and location, lentil seed yield was 793, 633 and 558 lb/a with 0, 3.5 and 7 oz/a pyroxsulam, respectively. At the winter wheat location of the group 2 herbicide studies, lentil and chickpea seed yield were reduced 58 and 16%, respectively, compared to the untreated check (1075 and 2317 lb/a, lentil and chickpea, respectively) with sulfosulfuron at four times the labeled rate. Pea yield did not differ among treatments. At the spring wheat location, lentil seed yield was reduced 74 and 94% and chickpea seed yield was reduced 51 and 51% with pyroxsulam/florasulam/fluroxypyr at the two and four times labeled rates, respectively, compared to the untreated check (501 and 1212 lb/a, lentil and chickpea, respectively). Pea seed yield was reduced 55% with pyroxsulam/florasulam/fluroxypyr at four times the labled rate compared to the untreated check (918 lb/a).

Weed Control with Corn Herbicides that Allow Rotation to Dry Bean and Sugarbeet. Jared C. Unverzagt*[1], Andrew R. Kniss[1], Ryan E. Rapp[2]; [1]University of Wyoming, Laramie, WY, [2]Monsanto Company, Scott, MS (031)

Corn is an important rotational crop with sugarbeet and dry bean in the High Plains region of Wyoming, Nebraska, and Colorado. Identifying herbicide programs for corn that allow safe planting of dry bean and sugarbeet the following year is imperative for a successful crop rotation. Field studies were conducted in 2011 and 2012 to evaluate corn herbicide programs that: (1)

effectively control the weed spectrum in the High Plains; (2) allow rotation to sugarbeet or dry bean the following season; and (3) include multiple herbicide modes of action for herbicide resistance management. Corn was planted on May 6, 2011 and May 8, 2012in 76 cm rows. Plots were 3 m by 9 m and arranged in a two-factor factorial randomized complete block design with four replications. Factor one consisted of three PRE herbicides and an untreated check, while factor two included three POST herbicides and an untreated check. PRE herbicides included saflufenacil plus dimethenamid-P at 70 and 612 g ai ha^{-1} respectively, acetochlor at 2100 g ai ha^{-1}, and *S*-metolachlor at 1390 g ai ha^{-1}. POST herbicides consisted of glufosinate at 350 g ai ha^{-1}, glyphosate at 1270 g ae ha^{-1}, and diflufenzopyr plus dicamba at 56 and 140 g ai ha^{-1}. Weed control was evaluated approximately 5, 8, and 15 weeks after planting. All PRE/POST combinations provided >90% control of all species evaluated in 2011. Dry weather in 2012 reduced efficacy of PRE herbicides. Saflufenacil plus dimethenamid-P followed by glyphosate and acetochlor followed by diflufenzopyr plus dicamba provided >90% control of all species evaluated.

Long-term Dryland Organic Crop Rotation Effects on Weed Population and Biomass Production. Rachel Unger*[1], Misha R. Manuchehri[1], Ian C. Burke[1], E. Patrick Fuerst[1], Kristy Borrelli[1], Richard Koenig[1], Robert S. Gallagher[2], Dennis Pittmann[1], Amanda Snyder[3], Lori Hoagland[4]; [1]Washington State University, Pullman, WA, [2]The Pennsylvania State University, University Park, PA, [3]University of Idaho, Moscow, ID, [4]Purdue University, West Lafayette, IN (032)

Intensive tillage practices are the primary means of weed control in organic production systems. The erodible loess soil of the Palouse makes intensive tillage unsustainable and poses a serious problem for organic farmers. A long-term dryland organic field study was established on the Boyd farm near Pullman, WA to determine the effect of crop rotations under reduced tillage on weed population and biomass production. Crop rotations were: continuous alfalfa (ALF), ALF – ALF – winter wheat (WW), ALF – WW – spring barley (SB), winter pea (WP) – winter triticale (WT) – WP, WT – WP – WT, WP – WW – WP, WW – WP – WW, spring wheat (SW) – WP – WW, and WW – SW – WP. Weed species abundance and biomass were sampled from 2010 through 2012 and samples were taken four to five times throughout the growing season. The WP – WW – WP, WP – WT – WP, and WW – SW – WP had significantly higher percentage of weed biomass than the WW – WP – WW, Alf – Alf – WW, continuous Alf, SW – WP – WW, and WT – WP – WT rotations. The lowest weed biomass was found in WT – WP – WT, which was 14% of the total biomass. Percent of weed biomass as a function of total biomass was significantly higher in 2012 compared to 2010 and 2011. Weed species richness at the Boyd farm has remained unchanged over the three years of the study with field bindweed, downy brome, and jointed goat grass as the dominant weed species. Though the weed species richness has remained constant, the biomass and population of each weed species has increased.

Preemergence Residual Herbicides: A Valuable Tool for Weed Control in Glyphosate-Resistant Corn. Prashant Jha*[1], Vipan Kumar[1], Mandeep K. Riar[1], Nicholas A. Reichard[1], Jaya R. KC[2]; [1]Montana State University, Huntley, MT, [2]Montana State University, Huntley, MT (033)

Field experiments were conducted at the Southern Agricultural Research Center in Huntley, MT, in 2011 and 2012, to compare preemergence (PRE) herbicide programs for weed control in glyphosate-resistant corn. Experiments were conducted in a randomized complete block design with four replications. Treatments included: atrazine (Aatrex® 4 L) at 1.12 kg ai ha^{-1}, pyroxasulfone (Zidua®) at 0.149 and 0.298 kg ai ha^{-1}, dimethenamid (Outlook®) at 0.840 kg ai ha^{-1}, saflufenacil + dimethenamid-P (Verdict®) at 0.737 kg ai ha^{-1}, acetochlor (Harness®) at 1.960 kg ai ha^{-1} alone or in combination with pendimethalin (Prowl H_2O®) at 1.064 kg ai ha^{-1}. Herbicides were applied with a hand-held boom calibrated to deliver 94 L ha^{-1} at 276 kPa. Corn injury and weed control were visually estimated using a scale of 0 to 100, 0 being no injury or no control and 100 being plant death or complete control. No crop injury was observed with any of the herbicide programs, including pyroxasulfone. Irrespective of addition of pendimethalin, atrazine and saflufenacil + dimethenamid-P were the best treatments for kochia control, which averaged 91% 30 DAA. Kochia control with dimethenamid + pendimethalin and pyroxasulfone + pendimethalin averaged 78%, and was higher than the control from dimethenamid alone or pyroxasulfone alone at high or low rate. Dimethenamid alone and acetochlor alone were the least effective treatments for kochia control, which averaged 47% 30 DAA. Common lambsquarters control 30 DAA with atrazine and saflufenacil + dimethenamid-P applied alone or tank mix with pendimethalin ranged from 89 to 95%. Addition of pendimethalin improved pyroxasulfone (low rate) and acetochlor activity on common lambsquarters. Pendimethalin + pyroxasulfone provided 78% control of common lambsquarters. For wild buckwheat control, atrazine with and without pendimethalin provided 93% average control, which was superior to all other treatments, except saflufenacil + dimethenamid-P + pendimethalin and acetochlor + pendimethalin. Saflufenacil + dimethenamid-P and dimethenamid-P alone provided 80% wild buckwheat control 30 DAA. Addition of pendimethalin did not improve wild buckwheat control by dimethenamid or pyroxasulfone. Pyroxasulfone (low rate) alone and acetochlor alone were less effective on wild buckwheat, and control averaged 65%. Corn yield with pendimethalin- and atrazine-based herbicide programs were superior to all other programs, except pyroxasulfone at the high rate (0.298 kg ai ha^{-1}) and saflufenacil + dimethenamid-P. In conclusion, these soil residual herbicides can be potentially utilized as a valuable tool for weed control in glyphosate-resistant corn, especially for management of glyphosate-resistant kochia

Effect of Grain Type and Application Timing on the Safety of Small Grain Herbicides in Northern California. Steve B. Orloff*[1], Steven D. Wright[2], Robert G. Wilson[3]; [1]University of California, Yreka, CA, [2]University of California Cooperative Extension Tulare and Kings Counties, Tulare, CA, [3]University of California, Tulelake, CA (034)

Field trials were conducted in 2010 and 2011 to evaluate herbicide safety on three small grain varieties, Yecora Rojo (hard red spring wheat), Alpowa (soft white spring wheat) and Metcalfe (spring barley). The intent of the experiment was to evaluate the effect of herbicides on crop growth and yield and the plots were nearly free of weeds. The experiment was a factorial design with a split-plot restriction and 4 replications. Main plots were herbicide treatment and the subplots were small grain variety. Herbicide treatments were applied at two timings: 3-leaf stage and at early tillering (9-12 leaves). Herbicides were applied with a handheld boom calibrated to deliver 20 gpa at 40 psi. Treatments consisted of 2,4-D (0.5 lbs ae/acre), 2,4-D + dicamba (0.5 + 0.12 lbs ae/acre), penoxaden (0.0538 lbs ai/A), pyraflufen-ethyl (0.0016 lbs ai/A), carfentrazone (0.03 lbs ai/A), 2,4-D + carfentrazone (0.5 lbs ae + 0.03 lbs ai/A), pyroxulam (0.211 lbs ai/A), fenoxaprop-p-ethyl (0.083 lbs ai/A), carfentrazone + fenoxaprop-p-ethyl (0.03 + 0.083 lbs ai/A), carfentrazone + penoxaden (0.03 + 0.0538 lbs ai/A), and MCPA + penoxaden (0.5 + 0.0538 lbs ai/A). Small grain varieties differed in their sensitivity to the herbicides. Metcalfe (barley) had the highest injury followed by Yecora Rojo and Alpowa. Injury in the 2011 trial was significantly less than what occurred in 2010. Minimum temperatures were colder in 2010 and it is believed that the hard frosts combined with the herbicide injury to make symptoms worse. In 2010 injury across herbicide treatments averaged around 25% for the early application compared with approximately 15% for the later treatment. This may have been due to the fact that the grain was smaller at the time of application but could also have been due to the fact that colder temperatures occurred after the first application than after the second application. Early-season injury did not translate into a significant yield decrease for registered herbicides.

Feral rye (Secale cereale L.) Control in Winter Canola (Brassica napus) in the Pacific Northwest. Frank L. Young*[1], Dale K. Whaley[2], Ian C. Burke[3], Dennis Roe[4], Larry M. McGrew[1]; [1]USDA-ARS, Pullman, WA, [2]WSU, Watertown, WA, [3]Washington State University, Pullman, WA, [4]WSU, Pullman, WA (035)

In the Pacific Northwest (PNW), where feral rye (*Secale cereale L.*) is considered a noxious weed in WA, very little research has been conducted on its biology, ecology, and management. Thus far, one study in 1977 evaluated paraquat and barban for control of feral rye in winter wheat (*Triticum aestivum*) and a second study in 1984 evaluated the effect of various herbicides on feral rye seed germination. Since then no research has been conducted with feral rye in PNW crops. With the introduction of winter canola into the winter wheat/fallow region an opportunity exists for growers to better manage feral rye in their production systems. In OK, clethodim, quizalofop, and glyphosate effectively controlled cereal rye in winter canola as measured by weed seed reduction compared to the nontreated check. In north central WA a study is being conducted to evaluate these three herbicides on a natural stand of feral rye in winter canola. In the 2010-2011 growing season fereal rye seed production was decreased 79%, 99% and 100% by spring applications of clethodim, quizalofop, and glyphosate respectively. Winter canola treated with these three herbicides increased yield 31% to 33% compared to the nontreated canola yield. In the 2011-2012 growing season the most effective treatments were when quizalofop and glyphosate were split-applied in the fall and spring. These treatments decreased greatly feral rye plant population and seed population and increased substantially canola yield compared to the nontreated check.

Herbicide Resistant Wild Oat Occurrence in a Diverse Cropping System: A Case study. Edward S. Davis*, Fabian Menalled, William E. Dyer; Montana State University, Bozeman, MT (036)

Herbicide resistant wild oat (Avena fatua) populations have evolved in many locations including Montana in response to continued use of a single herbicide family. Management recommendations to avoid or reduce the likelihood of selecting for resistance include rotating herbicides with different modes of action, combining or tank-mixing herbicides with different modes of action, and rotating crops. This paper describes the herbicide and crop histories leading to the development of multiple herbicide resistant wild oats at two sites with very different cropping systems, one with continuous malt barley and the other with a highly diverse crop rotation. Our objectives are to understand the factors leading to the occurrence of multiple herbicide resistant wild oats and to develop management recommendations to prevent or manage resistant weeds. In 2007, a population of wild oats was identified near Fairfield, Montana which was not successfully controlled by pinoxaden the first year it was used. The crop production program was continuous irrigated malt barley. Herbicide use history included consecutive years of triallate use until it no longer controlled wild oats. One group 2 herbicide was used, imazamethabenz, from 1997-1999. In 2000 Thereafter several group 1 herbicides were used including tralkoxydim, clodinafop, and pinoxaden. A field herbicide screening trial was conducted in 2007 which confirmed the majority of the wild oat population was resistant to pinoxaden, clodinafop, fenoxaprop, tralkoxydim, imazamethabenz and difenzoquat. Follow-up greenhouse herbicide screening trials with seed collected from the field trial confirmed resistance to these herbicide active ingredients as well as the group 2 herbicides flucarbazone, and pyroxsulam. The wild oat population was susceptible to imazamox and EPTC. The mechanism(s) of multiple herbicide resistance demonstrated by this population is currently under investigation in the Dyer, Weed Physiology Laboratory at Montana State University. In contrast, a producer with a highly diverse cropping system near Amsterdam, Montana reported lack of wild oat control with sethoxydim in 2011. This producer uses a rotation of spring wheat, dry pea, and seed potato. In 2012 the field was planted to spring wheat and treated with a combination of pyroxsulam + fluroxypyr + florasulam (Goldsky), which did not provide acceptable wild oat control. A field herbicide screening trial showed that the wild oats were resistant to clodinafop, pinoxaden, fenoxaprop, tralkoxydim, pyroxsulam, and flucarbazone, and a greenhouse trial is now underway to confirm these results and test other modes of action

The Use of Safened Herbicides with Mesosulfuron Reduces Injury to Wheat. Shawn P. Wetterau*, Ian C. Burke, Jared L. Bell, Nevin Lawrence, Alan J. Raeder, Misha R. Manuchehri; Washington State University, Pullman, WA (037)

Mesosulfuron can cause chlorosis and stunting of winter wheat under stressful environmental conditions. To identify mixtures that reduced injury, studies were established in Pullman, WA in 2010 and 2012 to evaluate early crop growth and development of six winter wheat varieties treated with mesosulfuron alone, mesosulfuron mixed with bromoxynil plus MCPA, or mesosulfuron mixed with pyrasulfotole plus bromoxynil. Pyrasulfotole plus bromoxynil and mesosulfuron formulations contain 11 g ai ha-1 and 30 g ai ha-1 mefenpyr-diethyl, respectively. The experimental design was a randomized complete block, strip plot with four replications. Main plots with six winter wheat varieties (Bauermister, Bruehl, Eddy, Eltan, Madsen, and ORCF-102) and sub-plots were the three aforementioned herbicide treatments or a weed-free non-treated control. Treatments were applied on April 7, 2010 and April 12, 2012. Five plants were harvested from the nontreated plots of each variety on the day of treatment, and then from all plots and treatments 14 and 21 DAT. Growth inhibition was observed when wheat was treated with mesosulfuron only, except ORCF-102. When mesosulfuron was applied with bromoxynil plus MCPA, significant injury was observed with all varieties except ORCF-102 each year 21 DAT. When mesosulfuron was applied with the mefenpyr-diethyl-containing pyrasulfotole plus bromoxynil product, injury was similar to mesosulfuron applied alone, and for Bruehl and Madsen, injury was less. When applying mesosulfuron in mixture with a broadleaf weed control product, the use of a product that contains additional herbicide safener can minimize injury caused by mesosulfuron with Madsen and Bruehl.

Effect of Pre-Harvest Desiccants on Canola Yield and Seed Quality. Brian M. Jenks*, Tiffany D. Walter, Gary P. Willoughby; North Dakota State University, Minot, ND (038)

A study was conducted in 2012 to evaluate the use of desiccants applied preharvest on canola yield, seed moisture, and seed quality. A Clearfield Brassica juncea variety was used in this study. The desiccation treatments were applied when at least 60% of the seeds had started to turn color. Treatments included saflufenacil at 50 g ai/ha; glyphosate at 840 g ae/ha; saflufenacil plus glyphosate (25 g + 840 g); glufosinate plus glyphosate (82 g + 840 g); glufosinate at 594 g/ha; and diquat at 280 and 420 g/ha. A swathed treatment and straight cut only treatment were also included. Treatments were evaluated at 3, 7, 10, 14 days after treatment (DAT). Seed moisture at harvest was estimated by a hand-held moisture tester. Yield and test weight were determined by harvesting the middle 1.3 m of each plot with a small plot combine. Seed samples were evaluated for green count. At 3 and 7 days after treatment (DAT), diquat generally provided faster visual pod and stem desiccation. Hot and dry conditions enhanced crop desiccation in all treatments, which resulted in few treatment differences by 10 DAT. Diquat at 280 g showed similar desiccation and crop quality as the 420 g treatment. Yield and test weight were not impacted by any of the desiccants. In previous desiccation studies, we did not observe yield reductions from diquat or paraquat treatments compared to swathing when the desiccants were applied at the correct timing. We observed greater seed loss with Brassica juncea in this study (157 kg/ha) compared to previous studies with LL InVigor canola varieties (<56 kg/ha). The study will be repeated in 2013.

Paper 39 was withdrawn

Paper 40 was withdrawn

Evaluation of Pyroxasulfone for Crop Safety and Downy Brome Control in Winter Wheat. Mandeep K. Riar*[1], Nicholas A. Reichard[1], Prashant Jha[1], Vipan Kumar[1], Jaya R. KC[2]; [1]Montana State University, Huntley, MT, [2]Montana State Universtiy, Huntley, MT (041)

Field experiments were conducted at the MSU Southern Agricultural Research Center near Huntley, MT, in 2011-2012, to compare downy brome control with pyroxasulfone and other standard herbicide programs in CLEARFIELD winter wheat. Pyroxasulfone (89.25 g ai/ha) was applied preemergence (PRE) only or PRE followed by imazamox postemergence (POST). Standard programs included propoxycarbazone-sodium (29.4 g ai/ha) applied PRE only or followed by imazamox (43.75 g ai/ha) POST, imazamox POST only, and pyroxsulam (31.85 g ai/ha) POST only. PRE herbicides were applied in the fall of 2011 at winter wheat planting (September 27, 2011), and POST herbicides were applied in the spring of 2012 to 1- to 3-tiller CLEARFIELD winter wheat. POST imazamox applications included MSO (1% v/v) and UAN and pyroxsulam applications included NIS (0.5%v/v) and UAN. Herbicides were applied with a hand-held boom calibrated to deliver 94 L/ha at 276 kPa. No wheat injury was observed with any of the herbicides, including pyroxasulfone. Downy brome end-season control with pyroxasulfone followed by imazamox was 98%, which was superior to all other treatments, except propoxycarbazone followed by imazamox program. End-season control with a PRE only application of pyroxasulfone was comparable to propoxycarbazone, and averaged 75%. Furthermore, it did not differ from the control obtained with imazamox or pyroxsulam POST only program. Wheat yield with pyroxasulfone or propoxycarbazone PRE followed by imazamox POST averaged 3,125 kg/ha, which did not differ from any of the other treatments, except pyroxsulam POST only program (1,814 kg/ha). Even in the absence of a POST program, a 3.5-fold increase in wheat yields was observed with pyroxasulfone or propoxycarbazone compared with the weedy check treatment. In conclusion, pyroxasulfone applied PRE (fall) followed by imazamox POST (spring) would be an effective strategy to manage downy brome infestations in CLEARFIELD winter wheat.

Does Fertilizer Nitrogen Influence Crop-Weed Competition and Weed Response to Herbicides? Vipan Kumar*[1], Prashant Jha[1], Mandeep K. Riar[1], Nicholas A. Reichard[1], Jaya R. KC[2]; [1]Montana State University, Huntley, MT, [2]Montana State Universtiy, Huntley, MT (042)

Fertilizer nitrogen (N) is one of the most expensive inputs in cereal production. It is hypothesized that reductions in N availability alter crop competitive ability and herbicide efficacy on weed control. To test these hypotheses, field and greenhouse experiments were conducted at MSU Southern Agricultural Research Center, Huntley, MT, in 2011 and 2012. In field experiments with malt barley (model crop), treatments included: N (urea) rates– 56, 112 and 168 kg/ha; seeding rates– 38, 76 and 152 kg/ha; and weed removal timing –weedy check, weed free, weed removal at 3- to 4-leaf, and at 8- to 10-leaf stage of barley. In greenhouse experiments, effect of N on efficacy of different herbicides for wild oat and kochia control was tested. Treatments included: N (ammonium nitrate) rates – low (56 kg/ha) and high (168 kg/ha); and herbicide doses – 0, 1/8X, 1/4X, 1/2X and X; where X represents recommended rate of herbicide. Randomized complete block design was utilized with a factorial arrangement of treatments and four replications. Results indicate that N rates ≥ 112 kg/ha and high seeding rates (≥ 76 kg/ha) increased barley competitiveness against weeds. Based on I_{50} (50% control) values from the dose response curves, kochia plants grown under low N required 1.2- to 2.4- fold doses of metsulfuron, thifensulfuron plus tribenuron, and bromoxynil plus pyrasulfotole compared with plants grown under high N. For wild oat, 1.2- to 1.4- fold doses of tralkoxydim, fenoxaprop, and glyphosate were needed to control plants grown under low compared to high N. In conclusion, more intensive weed management will be needed in soils with low N levels.

Pyroxasulfone: Grass Weed Control and Winter Wheat Tolerance. Traci Rauch*, Joan Campbell, Donn Thill; University of Idaho, Moscow, ID (043)

Pyroxasulfone is a new active ingredient that will soon be registered in winter wheat to control grass weeds. It is a group 15 herbicide that inhibits very long chain fatty acid synthesis. Pyroxasulfone is most active as a preemergence herbicide and inhibits seedling growth but not seed germination. Studies were conducted between 2010 and 2012 to evaluate winter wheat tolerance and rattail fescue, Italian ryegrass and downy brome control with pyroxasulfone. The experimental design in all studies was a randomized complete block with four replications. Pyroxasulfone was applied alone fall preemergence, tank mixed with other fall preemergence herbicides, or sequentially applied with spring postemergence herbicides. Grass weed control and winter wheat response were evaluated visually where 0% represented no control or injury and 100% represented complete weed control or crop death. Pyroxasulfone injured winter wheat

0 to 10% in studies where winter wheat was direct-seeded, and 0 to 11% in studies where winter wheat was seeded into a conventionally tilled seedbed. Winter wheat seed yield was greater than or not different from the untreated check. Rattail fescue, Italian ryegrass, and downy brome control was 95, 72 to 89, and 62%, respectively, with pyroxasulfone. Winter wheat tolerance and grass weed control with pyroxasulfone was similar to flufenacet/metribuzin, a group 15/5 herbicide registered in winter wheat for grass weed control. Winter wheat injury was 0 to 9% with flufenacet/metribuzin. Rattail fescue, Italian ryegrass, and downy brome control was 90 to 96, 81, and 50%, respectively, with flufenacet/metribuzin.

Arundo donax Response to Preemergence and Postemergence Herbicides. Amir Attarian*, Carol Mallory-Smith, Andrew Hulting; Oregon State University, Corvallis, OR (044)

Giant reed is a potential biomass crop and is a candidate to provide feedstock for the Portland General Electric (PGE) power plant in Boardman, Oregon. Greenhouse and field studies were conducted at Oregon State University, Corvallis, Oregon, to determine giant reed tolerance to preemergence and postemergence herbicides. Giant reed plants were evaluated for injury and biomass accumulation for greenhouse and field studies. For both studies the experimental design was a randomized complete block with four replications. In the greenhouse study, bromoxynil plus MCPA at 0.84 kg ha^{-1}, nicosulfuron at 0.035 kg ha^{-1}, and dimethenamid-p at 0.73 kg ha^{-1} did not cause injury and did not reduce giant reed biomass. Bromoxynil plus pyrasulfotole applied at 0.27 kg ha^{-1} and mesotrione applied at 0.21 kg ha^{-1} caused the greatest injury and reduction of both above and belowground biomass. In the field study, a preemergence application of 0.735 kg ha^{-1} dimethenamid-p plus a postemergence application of 0.56 kg ha^{-1} 2,4-D amine and a postemergence application of 0.84 kg ha^{-1} bromoxynil plus MCPA resulted in the least injury to giant reed plants and the best weed control. A preemergence application of acetochlor at 1.67 kg ha^{-1} followed by a postemergence application of 2.4-D amine at 0.56 kg ha^{-1}, a preemergence application of premixed acetochlor plus atrazine at 2.53 kg ha^{-1} alone and when followed by a postemergence application of 2,4-D amine at 0.56 kg ha^{-1}, controlled the weeds but caused crop injury.

Spring Wheat Response to Tank Mixing Fungicides with a Pyroxsulam Formulation and 2,4-D. Patricia L. Prasifka*[1], Joseph P. Yenish[2], Neil A. Spomer[3], Roger E. Gast[3]; [1]Dow AgroSciences, West Fargo, ND, [2]Dow AgroSciences, Billings, MT, [3]Dow AgroSciences, Indianapolis, IN (045)

Cereal leaf diseases are a major concern across northern U.S. spring wheat acres. Higher commodity prices increase the return on fungicide investment. A common recommendation is to include a fungicide with applications for grass weed control. Applying fungicide at this timing provides effective control and reduces the potential for and the impact of later infections while saving time and money by avoiding a second pass to apply fungicide. The crop safety of herbicide/fungicide tank mixes in cereals has not been thoroughly studied in North America. Therefore, three trials were conducted in 2012 to examine the crop safety of a phenoxy herbicide and various fungicide tank mix partners with an oil dispersible formulation containing pyroxsulam, florasulam, and fluroxypyr (GoldSky®herbicide). Trials were conducted with the following fungicides: propiconazole (PropiMax®), pyraclostrobin (Headline®), and a formulated blend of propiconazole and trifloxystrobin (Stratego®); with and without a phenoxy

(2,4-D ethylhexyl ester) and with and without GoldSky® as well as an untreated check. Overall, levels of observed injury were acceptable with all treatments resulting in less than 10% injury at all evaluation intervals when averaged across trials. Injury with fungicide-only treatments ranged from 0 to 0.7% across all evaluation intervals. Injury with 2,4-D and GoldSky® applied alone was slightly greater, with average injury below 5% at all evaluations. Combining 2,4-D with GoldSky® caused a slight increase in crop response compared to either alone. The application of a fungicide with the combination of 2,4-D and GoldSky® did not significantly increase crop injury.

Control of Downy (*Bromus tectorum*) and Japanese (*Bromus japonicum*) Brome in Winter Wheat (*Triticum aestivum*) in Western Canada. Eric N. Johnson*[1], Cindy A. Gampe1, Brian L. Beres[2], William M. Hamman[3], Ken Coles[4], Michael Gretzinger[4]; [1]Agriculture and Agri-Food Canada, Scott, SK, [2]Agriculture and Agri-Food Canada, Lethbridge, AB,[3]Hamman Ag Research, Lethbridge, AB, [4]Farming Smarter, Lethbridge, AB (046)

Winter wheat is primarily grown in a no-till system on about 400,000 ha (1,000,000 acres) annually in Western Canada. No-till winter wheat is very competitive with spring germinated annual weeds; however, winter annual broadleaf and grass weeds can be problematic. Two field studies were conducted at three locations in Western Canada (Scott, SK; Coaldale, AB; Lethbridge, AB) to determine the efficacy of a number of grass herbicides on Japanese and downy brome. The treatments included PRE applications of flumioxazin (88 g ai ha^{-1}), pyroxasulfone (112,150 g ai ha^{-1}), flumioxazin and pyroxasulfone tank-mix (88 and 112 g ai ha^{-1}, respectively), POST fall and spring applications of pyroxsulam (15 g ai ha^{-1}), flucarbazone-sodium 70 WDG formulation (30 g ai ha^{-1}), flucarbazone-sodium SC formulation (30 g ai ha^{-1}), and thiencarbazone-methyl (5 g ai ha^{-1}). PRE applications did not negatively affect winter wheat establishment as no significant reduction in plant counts were recorded either in the fall or spring. Visual injury (chlorosis, stunting) of the PRE applications were acceptable as well. POST applications were generally more injurious to winter wheat when applied in the fall compared to the spring, particularly at Scott. Most herbicide treatments were effective in reducing Japanese brome biomass by greater than 90%, with the exception of PRE flumioxazin and spring applied thiencarbazone-methyl which provided an 82 and 65% reduction, respectively. PRE treatments containing pyroxasulfone resulted in >95% reduction in downy brome biomass while pyroxsulam POST treatments resulted in an 80 to 90% reduction in downy brome biomass. All other PRE and POST treatments resulted in a biomass reduction of 40 to 80%. PRE applications that included pyroxasulfone provided excellent control of both Japanese and downy brome with acceptable crop tolerance. POST applications of pyroxsulam also provided good to excellent control of both brome species.

Evaluation of Sulfentrazone plus s-Metolachlor for Weed Control in No-Till Sunflower. Robert K. Higgins*[1], Drew J. Lyon[2]; [1]University of Nebraska Panhandle Research & Ext. Center, Sidney, NE, [2]Washington State University, Pullman, WA (047)

Field studies were conducted at the University of Nebraska High Plains Agricultural Lab near Sidney, NE in 2011 and 2012 to evaluate crop tolerance and efficacy of sulfentrazone + s-metolachlor in no-till sunflower. Studies were located on a Keith silt loam (1.6% organic matter) in 2011 and an Alliance silt loam (2.7% organic matter) in 2012. Sulfentrazone + s-metolachlor was applied at four different rates (0.77, 0.98, 1.2, and 1.64 lb ai/A) EPP and three different PRE rates (0.77, 0.98, and 1.2 lb/A) in 2011. In 2012, only EPP treatments were applied at 0.98, 1.2, and 1.42 lb/A. The primary weeds observed in 2011 were witchgrass and horseweed, and in 2012 were stinkgrass and tumble pigweed. In 2011, EPP treatments were intended to be applied two weeks before planting, but due to above-normal precipitation in May, sunflower planting was delayed and EPP treatments were applied four weeks prior to planting. This likely resulted in reduced weed control with the EPP treatments. The above-normal May precipitation in 2011 may have also resulted in increased crop injury with the EPP treatments. Sulfentrazone + s-metolachlor PRE treatments provided excellent weed control of both witchgrass and horseweed. Sunflower yields in 2011 were reflective of the level of weed control provided by the various treatments. In 2012, EPP treatments were applied seven days before planting. No crop injury was observed in 2012. Sulfentrazone + s-metolachlor applied EPP provided excellent control of tumble pigweed at all three application rates. Stinkgrass control, as well as seed yield, tended to increase with increasing rates of sulfentrazone + s-metolachlor. Weather differences between 2011 and 2012 resulted in different levels of weed control, crop injury and yield. Sulfentrazone + s-metolachlor generally provided good to excellent weed control, although EPP treatments in 2011 were less than desirable as a result of above-average rainfall between the time of application and delayed planting four weeks later. This weather also resulted in increased crop injury. Sulfentrazone + s-metolachlor provide producers with a new tool for grass and broadleaf weed control in no-till sunflower.

Performance of Glyphosate for Weed Control in Colorado Under Dry Weather Conditions when Mixed with Two Acidic AMS Replacements. Jim T. Daniel*[1], Philip Westra[2], Scott K. Parrish[3]; [1]Colorado State University, Keenesburg, CO, [2]Colorado State University, Ft. Collins, CO, [3]AgraSyst, Inc., Spokane, WA (048)

The 2012 growing season along the Front Range of Colorado was considerable hotter and dryer than average with most areas receiving less than 3 inches of rainfall, daytime relative humidity often less than 10% and temperatures often above 100 F between May and September. Eight replicated small plot field trials were conducted in the area with glyphosate and two AgraSyst Acidic AMS Replacement Adjuvants, AQ 010 and AQ 127. Of the eight trials, three were conducted under dry land conditions, and five under light irrigation. The eight trials all had components with the objective of measuring the effects of the additives on the herbicidal activity of glyphosate on a variety of weeds. Data was combined from the similar parts of each trial. Visual percent control measurements across trials and weed species showed glyphosate performing better in each trial when either or both of the acidic water conditioners was added as compared to the ammonium sulfate plus nonionic standards. The differences were greater in the three dry land trials than in the trials receiving light irrigation. AQ 010 is marketed by AgraSyst Inc. under the trade name, Load Out, and AQ 127 as Full Load.

Herbicide Programs for Weed Control in Clearfield® lentils. Jaya R. KC*[1], Prashant Jha[2], Vipan Kumar[2], Nicholas A. Reichard[2], Mandeep K. Riar[2]; [1]Montana State University, Huntley, MT, [2]Montana State University, Huntley, MT (049)

A field experiment was conducted at the Montana State University, Southern Agriculture Research Centre near Huntley, MT, to evaluate pendimethalin (1,064 g ai/ha) and saflufenacil

(18.7 g ai/ha) alone or tank-mixed applied PRE along with glyphosate (burndown) followed by imazamox applied POST for crop injury and weed control in Clearfield® lentil. One of the PRE treatments included glyphosate only prior to the standard POST program. Glyphosate (840 g ai/ha) treatments included NIS (0.25% v/v) and AMS (2% w/v), and imazamox (43.75 g ai/ha) was applied with MSO (1% v/v) and UAN (2.5% v/v). Additionally, hand-weeded and weedy check plots were included for comparison, with a total of 6 treatments in a randomized complete block design with four replications. Herbicides were applied with a hand-held boom calibrated to deliver 187 L ha^{-1} at 276 kPa. POST treatments were applied when the weeds were 8 to 10 cm tall. Weeds present at the test site were kochia, prickly lettuce, and Russian thistle. Weed control was visually estimated on a scale of 0 to 100 (0 being no control and 100 being complete control) at 35 days after PRE, 15 and 48 days after POST. Lentil yield (kg/ha) was recorded at harvest. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test at $P < 0.05$. Kochia control end-season (48 days after POST application of imazamox) was least (56%) in the absence of a PRE residual program. Pendimethalin based program provided 82% control of kochia end-season, which was higher than saflufenacil (71% control), although comparable to pendimethalin + saflufenacil based program (77% control). Saflufenacil and pendimethalin alone or tank-mixed PRE followed by imazamox POST provided 85 to 92% control of prickly lettuce end-season. Prickly lettuce control was least (70%) with the POST only program. Saflufenacil had lower residual activity on Russian thistle compared with pendimethalin, and addition of pendimethalin improved control. In the absence of a PRE residual herbicide, Russian thistle end-season control with the imazamox only program was 71%, which was lower than the 86% control with saflufenacil + pendimethalin PRE followed by imazamox POST. Consistent with weed control, lentil yields were higher with PRE followed by POST compared to POST only program. Furthermore, pendimethalin + saflufenacil based program had higher lentil yield compared to saflufenacil alone program. In conclusion, pendimethalin and saflufenacil applied PRE in conjunction with imazamox POST would be an effective tool for weed control in Clearfield® lentil.

Dose-Response Analysis of Glyphosate-Resistant Kochia Populations in Greenhouse and Outdoor Conditions. Amar S. Godar*[1], Phillip W. Stahlman[2]; [1]Kansas State University, Manhattan, KS, [2]Kansas State Univ., Hays, KS (050)

A study was conducted to compare the response of previously confirmed glyphosate-resistant (GR) kochia (*Kochia scoparia*) populations from Kansas to glyphosate in greenhouse and outdoor conditions. In June-July 2012, individual plants of GR kochia populations (Phillips88 and Scott100) and a known glyphosate-susceptible population (Ellis) were grown in 4-inch pots in a greenhouse and in 6-inch pots in outdoor conditions. Six doses of glyphosate ranging from 0 to 3.36 and 0 to 6.72 kg ae/ha, respectively for GS and GR populations, with 2% ammonium sulfate were applied on 15-20 cm tall plants. The study was conducted in a completely randomized design with 6 replications and was repeated. ED_{50} (a dose that causes 50% mortality) and GR_{50} (a dose that causes 50% growth reduction) at 4 weeks after treatment were estimated using log-logistic regression model. The ED_{50} were 0.45, 1.85 and 2.29 kg ae/ha in greenhouse and 0.84, 2.76, and 4.17 kg ae/ha outdoor for Ellis, Phillips88 and Scott100, respectively. The GR_{50} were 0.32, 1.25 and 1.48 kg ae/ha in greenhouse and 0.49, 2.0 and 2.6 kg ae/ha outdoor, respectively for Ellis, Phillips88, and Scott100. ED_{90} (a dose that causes 90% growth reduction) were 0.8, 3.5 and 4.8 kg ae/ha for outdoor-grown Ellis, Phillips88 and Scott100, respectively. The ED_{50} or GR_{50} were 1.5 to 1.9 higher for outdoor-grown plants compared to the values for greenhouse-grown plants. However, resistance indices (RI=ED_{50} or $GR_{50(Resistant)}/ED_{50}$ or $GR_{50(Susceptible)}$) were similar under both growing conditions. Results of this study can be useful in estimating field level resistance of GR kochia populations studied in greenhouse condition.

Project 4. Teaching and Technology Transfer

BASF's On-Target Application Academy: Educating Growers. John C. Frihauf*, Walter E. Thomas, Steven J. Bowe, Luke L. Bozeman, Daniel Pepitone; BASF Corporation, Research Triangle Park, NC (051)

The On-Target Application Academy is a one-of-a-kind educational opportunity to provide growers extensive hands-on training for better awareness of herbicide application best practices that help mitigate spray drift – which is a continuous area of focus for the agricultural industry. Understanding that today's herbicide environment is more complex, BASF wants to continually support growers and help them achieve the most effective weed control possible with today's emerging product and equipment innovations. According to the BASF Grower Perception Survey conducted in 2011, 80% of the respondents indicated that they self-apply herbicides to their crops. In addition, more than one-third said they were interested in taking a herbicide self-application training seminar. Based on the responses from growers, BASF and TeeJet® jointly initiated the On-Target Application Academy to provide field based training utilizing recognized application technology experts. The Academy has focus areas that are derived from herbicide application best practices including proper nozzle selection, appropriate calibration and boom placement and impact of environmental conditions. The On Target Application Academy will be conducted at various locations throughout the US in 2013.

Extension Program Development for Weed Prevention. Earl Creech*, Ralph E. Whitesides; Utah State University, Logan, UT (052)

To deal with new weed threats, an agricultural producer or land manager has two general options: to be reactive or to be proactive. In a reactive strategy, the land manager waits until after a weed arrives, becomes established, and impacts production or environment before control measures are implemented. Due to the persistent and aggressive nature of newly introduced weeds they will likely become permanent fixtures on operations where a reactive strategy is employed. A proactive weed management strategy is geared toward prevention; that is, taking steps to keep weeds from becoming a problem in the first place. Weed prevention can best be broken down into three sub-categories or lines of defense: prevent arrival, prevent establishment, and prevent spread. Management of every plant that has the potential to become a weed on a given farm or ranch, and for which preventive measures should be employed, will fit into at least one of the lines of defense. The goal of an agricultural producer for most of the world's weeds is to prevent arrival. Preventing undesirable plant introduction includes consideration of introduction through water, by animals, in contaminated products, on contaminated vehicles and equipment, through intentional introduction, and invasion from within (selection for herbicide resistant biotypes). Weeds that slip through the cracks and arrive on a farm or ranch become subject to the second line of defense, prevent establishment. Establishment of newly arrived weeds can be prevented by practices related to early detection and rapid response (EDRR) and through biological practices that promote competition from desirable plants, including crops species and native plants. The only recourse for management of weeds that become established is to minimize the impact of the weed by preventing spread. Once a weed is established in an area, weed spread preventive activities, such as reducing weed seed production, and all reasonable types of control efforts, must be implemented to contain the invasive weed and to minimize the impact of the new species on un-infested areas.

A Cost Calculation Model for Estimating Backpack Herbicide Treatment Using a Smart Wand, Slope, Weed Density, Weed Visibility, and Terrain. Bryan E. Dayton*, Ralph E. Whitesides; Utah State University, Logan, UT (053)

Herbicide treatment bids are requested based primarily on acreage without taking into account variables that increase treatment time and cost. Often neither the individual, the organization/agency, contracting the project nor the contractor has a clear idea of the costs involved. A model has been developed that can predict herbicide application expenses utilizing four variables, weed density, weed visibility, area terrain, and slope, which influence time and treatment costs. A partnership was established with the Department of Plants, Soils, and Climate at Utah State University and Providia Management Group (PMG Environmental) to develop data acquisition processes and to evaluate herbicide treatment data over several seasons. From 2010 to 2012, PMG's backpack crews treated hundreds of acres in Utah, Colorado, Idaho and Nevada. Using "smart" backpack equipment PMG gathered millions of data points including a GPS point each time a weed was sprayed. Each GPS data point included the GPS location, herbicide flow, elevation, and application time. Slope, treatment time per area, and weed density were determined to evaluate the relationship between the variables, and to develop a cost calculation model.

A Novel Microbially-Based Herbicidal Compound with Systemic Activity. Louis G. Boddy*, Ratnakar Asolkar, Christy Morgan, Matthew Robinson, Pam Marrone; Marrone Bio Innovations, Davis, CA (054)

Natural products derived from microbial sources offer new opportunities for the discovery and use of environmentally benign herbicides with chemically novel modes of action. MBI-010 is a recently discovered microbial strain that produces multiple novel herbicidal compounds. One or more of these compounds may inhibit the plant glutamate synthetase pathway. Laboratory testing suggests a pattern of strong leaf and root uptake in broadleaves as well as xylem mobility. When applied to seeds, efficacy extends to grasses. MBI-010 appears to be particularly effective on legumes and amaranths.

Project 5. Basic Biology and Ecology

Physiological and Genetic Comparison and Host Assay of Purple Nutsedge (*Cyperus rotundus*) and other plant species in Response to the Southern Root-Knot Nematode (*Meloidognye incognita*) and Nutsedge Root-Knot Nematode. Leslie A. Holland*[1], Jill Schroeder[1], Steve Thomas[1], Leigh Murray[2]; [1]New Mexico State University, Las Cruces, NM, [2]Kansas State University, Manhattan, KS (055)

Purple nutsedge (*Cyperus rotundus L.,* PNS) is common in the Southern region. Perennial nutsedges serve as hosts for the southern root-knot nematode (*Meloidognye incognita,* SRKN), a sedentary endoparasite. PNS interacts with SRKN forming a beneficial relationship that exacerbates their problem as agricultural pests. Recently, we have discovered a root-knot nematode species (NSRKN) that causes galling of PNS roots, a symptom rarely seen after infection with SRKN. Observation of yellow nutsedge (*Cyperus esculentus L.,* YNS), collected from the same fields as infected PNS, showed no galling caused by this NSRKN. We hypothesize that the host range and virulence of this NSRKN is different than SRKN, which has a very wide host range. We inoculated PNS and tomato with approximately 1000 juveniles of NSRKN or SRKN. The experimental design was a randomized complete block with 13 blocks and three nematode treatments. Physiological measurements of photosynthesis and stomatal conductance were taken and plants were harvested and weighed at six and nine weeks after inoculation, respectively, to observe the response of the plants to treatment. No differences were observed for photosynthesis or stomatal conductance when inoculated plants were compared to noninoculated controls. PNS inflorescence weight, tuber count and weight, were greater in the presence of either nematode species compared to the control, although not all differences were significant. Post-harvest root extractions showed tomatoes host only SRKN while PNS hosts both species. Follow up studies include repeating the described study and characterization of NSRKN through understanding its life cycle, host range, morphological and molecular identity.

Role of Fungal Endophytes in Locoweed Wound Response. Barbara K. Keith*, David K. Weaver, Tracy M. Sterling; Montana State University, Bozeman, MT (056)

Locoweeds are legumes that contain swainsonine (SWA), an alkaloid that causes severe economic losses through the livestock disease ‘locoism’. The fungal endophytes, *Undifilum* spp., are primarily or completely responsible for SWA in locoweeds. To date, the locoweed-fungal endophyte complex seems physiologically asymptomatic. However, collection of volatile compounds released from greenhouse-grown locoweed plants experiencing mild-simulated leaf herbivory (mechanical injury) indicated that biosynthesis of multiple secondary metabolites were altered between *A. mollissimus* var. *mollissimus* plants with its fungal-endophyte (E+) and plants with the fungal endophyte mechanically removed (E-). Collection of the sesquiterpenoid (*E*)-ß-caryophyllene which is typically induced in response to mechanical injury, pathogen infection and insect herbivory, was decreased 89% in E+ plants. Similarly the phenolic benzyl benzoate, another secondary metabolite with antibiotic properties against herbivory and pathogens, was reduced by 43%. Conversely, collection of other defense compounds such as methyl salicylate are greater from E+ plants, suggesting the plant may be compensating for the reduction of other secondary metabolites in order to maintain herbivory and/or pollinator cues in the presence of the fungus. These findings are the first indication that the fungal endophyte is influencing metabolic pathways in the plant.

Characterizing Shade Avoidance Responses in Sugarbeet. Louise Lorent*[1], Ryan E. Rapp[2], David A. Claypool[1], Andrew R. Kniss[1]; [1]University of Wyoming, Laramie, WY, [2]Monsanto Company, Scott, MS (057)

Even without competing for resources with crops, weeds can affect crop growth by affecting the quality of light reaching the crop canopy. Altered red to far-red light ratio (R:FR) is can trigger physiological responses, known as shade avoidance responses, in plants. Previous research has shown that shade avoidance responses can result in yield loss in corn and soybean. As sugarbeet is a biennial root crop, the outcome of shade-avoidance responses is unclear. A field study was conducted in 2012 to evaluate the effect of altered light quality on sugarbeet development and yield. Plots were 3 meters wide by 3 meters long and were planted east to west; each plot contained 16 sugarbeets. Treatments consisted of plastic mulch of 6 different colors: blue, red, green, silver, black and clear; plus a non-treated check that was not covered with plastic mulch. Each plot was surrounded by a 3 meter wide border to avoid any interference between treatments. Canopy growth was monitored throughout the season and end-of season measurements included individual beet weight, sugar content and tare. Plastic mulch color had no effect on individual beet weight or sugar content. Beets planted in plots covered in black mulch had greater tare than in any other treatment (p-value= 0.053). Tarp color also had no significant effect on canopy growth rate.

A Survey of the Distribution of Glyphosate-Resistance in Hairy Fleabane in California.
Lynn M. Sosnoskie*[1], Bradley D. Hanson[1], Anil Shrestha[2], Marie Jasieniuk[1]; [1]University of California - Davis, Davis, CA, [2]California State University - Fresno, Fresno, CA (058)

Glyphosate is the most commonly used herbicide in California's orchard and vineyard cropping systems. This reliance on glyphosate has not come without problems, several weed species common to tree and vine crops, including horseweed, hairy fleabane and junglerice, have developed resistance to this herbicide. In order to understand the magnitude of the problem, and develop sustainable weed management problems, it is necessary to accurately describe the distribution and level of glyphosate resistance (GR) among weed populations. A study was conducted to characterize GR in hairy fleabane (HF) in the Sacramento and San Joaquin Valleys. In 2010 and 2011, seeds (bulked samples) were collected from 143 HF populations located throughout the central valley of California; samples were collected from as far north as Colusa County (Lat. 39 deg. 12'N) and as far south as Kern County (Lat. 35 deg. 22'N). Samples were collected from within or adjacent to orchards and vineyards. Seeds were sown in potting media for germination and seedlings transplanted into 2x2 inch pots and maintained in the greenhouse. When plants reached the 5 to 8 leaf growth stage, they were treated with 0, 210, 420, 840, 1680, 3360, 6720 or 13440 g ae/ha of glyphosate. Population-by-dose combinations were replicated four times; individual plants were considered as experimental units. At one month after treatment (MAT), estimates of visual injury were obtained and above-ground fresh weights (FW) measured; all FW data was standardized against the non-treated checks. Populations were subsequently grouped into nine regional and crop-based clusters and the resultant FW data regressed against the log10 glyphosate doses using the Seefeldt model. Predicted mean GR50 values (rate required to reduce plant biomass by 50%) for HF collected from throughout the central valley ranged from 813 to 2951 g/ha, which are 5- to 18.-times higher than the GR50 for the susceptible check (162 g ae/ha). However, additional analyses suggest that biomass accumulation can be affected by external influences (specifically, temperature and light duration, intensity and quality) and that the magnitude of the response may vary across populations. Predicted mean GR50 values from dose-response experiments that were conducted during May, June, July and August ranged from 851 to 4365 g ae/ha; estimated GR50 values for experiments conducted during November, January and February were between 148 to 2042 g ae/ha. Although predicted mean GR50 values for most populations were reduced when plants were screened in the winter versus the summer, the amount of the change varied dramatically among the region-crop clusters (decreases between 9 and 94%); an increase in the estimated GR50 value was observed for only one cluster.

Soil Moisture Effects on Viability of Physically Dormant Weed Seeds. Brian J. Schutte*, Nina Klypin, Manoj Shukla; New Mexico State University, Las Cruces, NM (059)

Anecdotal evidence from previous studies suggests mortality in weed seedbanks is promoted by increased soil moisture. The objectives of this study were to: 1) quantify seed mortality responses to increasing soil moisture, and 2) gain insights on the specific below-ground life-stage (seed or seedling) negatively impacted by increased soil moisture. We focussed on two weed species characterized by physical seed dormancy, velvetleaf (*Abutilon theophrasti*) and tall morningglory (*Ipomoea purpurea*), reflecting a desire to initiate the study with only viable seeds capable of remaining ungerminated for prolonged periods. Under laboratory conditions, seeds were buried in soil mesocosms that were hydrated to specific soil water potentials (0 kPa, -30 kPa, -45 kPa, -60 kPa and -180 kPa). Additional soil moisture treatments included saturated soil under 3.5 cm of standing water ("flooded") and soil that was dried to constant weight ("dried"). Mortality assays ran for four months at 15 C, followed by one month at 15/25 C. Assay temperatures were considered unfavorable and favorable, respectively, for germination. Soil chemical analyses indicated that anaerobic conditions developed in flooded and 0 kPa treatments within one month of initiation. For all other moisture treatments, aerobic conditions persisted throughout the study. Seed mortality was not affected by soil moisture at 15 C. At 15/25 C, velvetleaf seedbank losses from mortality were greater in flooded and 0 kPa treatments compared to -30 kPa, -45 kPa, -60 kPa and dried treatments. These results suggest saturated soil conditions promote seedbank mortality by inducing death of seedlings rather than seeds, however, definitive conclusions require further research with additional species featuring water permeable seed coats. Enhanced understanding of soil moisture effects on seedbank dynamics will guide improved approaches for weed seedbank depletion.

Bioactivity and Dissipation of Pyroxasulfone Herbicide in Saskatchewan Soils. Anna M. Szmigielski*[1], Jeff J. Schoenau[1], Eric N. Johnson[2]; [1]University of Saskatchewan, Saskatoon, SK, [2]Agriculture and Agri-Food Canada, Scott, SK (060)

Because pyroxasulfone mode of action is distinctly different from the many herbicides to which weeds developed resistance, use of pyroxasulfone in rotation or in combination with other herbicides offers a new alternative in combating the weed resistance problems. Pyroxasulfone is a seedling shoot growth inhibitor, and is used for control of most annual grass and small seeded broadleaf weeds in wheat, corn and soybean. Limited information is available on pyroxasulfone behavior in western Canadian prairie soils. A laboratory bioassay was developed for the detection of pyroxasulfone in soil. Shoot length inhibition of sugar beet grown for seven days was found to be the most sensitive and reproducible parameter for measurements of soil-incorporated pyroxasulfone. The sugar beet bioassay was then used to examine the effect of soil properties on pyroxasulfone bioactivity and dissipation in five Saskatchewan soils. Bioactivity was assessed at 0 to 184 ppb, and GR_{50} values were estimated from the dose-response curve. The GR_{50} values ranged from 33 to 179 ppb and increased generally in the same order as percent organic carbon ($p = 0.001$) thus indicating that pyroxasulfone adsorption to organic matter lowers pyroxasulfone bioactivity and may result in decreased pyroxasulfone efficacy.

Dissipation was examined under laboratory conditions of 25 C and moisture content of 85% field capacity. Soil incubation was carried out for 16 weeks. Soils were sampled every two weeks and residual pyroxasulfone was determined using the sugar beet biossay. The dissipation half-lives estimated from the dissipation curves varied from 16 to 69 days, and were primarily related to soil pH ($p = 0.008$) and organic carbon content ($p = 0.034$). Faster pyroxasulfone dissipation occurred in soils of higher pH and higher organic carbon content probably due to conditions in which microbial decomposition is enhanced.

Is There a Cost of Herbicide Resistance?: Effects of Environmental and Biological Stressors on Herbicide Susceptible and Multiple Herbicide Resistant Wild Oat (*Avena fatua* L.) Biotypes. Ethan Mayes*, Zachariah J. Miller, Fabian Menalled; Montana State University, Bozeman, MT (161)

Multiple herbicide resistance (MHR) is growing problem in agricultural systems as it can lower crop yields and increase production costs. In Montana, herbicide use has resulted in the selection of wild oat (*Avena fatua* L.) biotypes that are resistant to at least three herbicide modes of action that are commonly used to control this weed in cereal crops. Specifically, one biotype is resistant to difenzoquat (membrane disruptor), imazamethabenz (ALS inhibitor) and flucarbazone (ALS inhibitor), and the other biotype is resistant to those herbicides plus tralkoxydim (ACCase inhibitor). An understanding of fitness costs associated with MHR is required to inform the management of this trait. In this study, MHR wild oat plants were tested to see if any fitness cost was associated with the evolved resistance. Specifically, two MHR and two herbicide-susceptible biotypes were grown in greenhouse conditions. The plants were exposed to an environmental stressor (nitrogen stress) and a biological stressor (simulated herbivory). Wild oat biomass and seed production were used to estimate fitness. The fitness of the MHR plants was lower in the absence of herbivory compared to the wild type, but with simulated herbivory, there was no cost in fitness between biotypes. This result was consistent across nitrogen treatments. This evidence suggests that in the absence of these herbicides, natural selection will favor herbicide susceptible biotypes and, over time, the frequency of MHR traits will decrease.

GENERAL SESSION

Presidential Address. Kai Umeda*; University of Arizona Cooperative Extension, Phoenix, AZ (061)

Welcome to the 75th Anniversary Meeting of the Western Society of Weed Science. The Society has been fostering cooperative research, education, and policy for weed management solutions for 75 years. All members attending this meeting received a commemorative desk clock to remind us of the rich history of WSWS and its fostering of the cooperative three-pronged approach for weed management solutions.

Since the 1860's, the land grant institutions generated research and transferred new technologies through extension and instruction. Many non land grant institutions like Southern Illinois University (my alma mater); Arizona State University Polytechnic; California Polytechnic State

University, San Luis Obispo; and California State University, Fresno fill niches by teaching and training students for agricultural careers.

Traditionally, the agrichemical industry has been a major beneficiary of students generated by academia. Today, the agrichemical industry has evolved to become seed businesses cooperating with breeders and molecular biologists. The equipment businesses among allied industries are cooperating with engineers. The policy arena includes cooperation with regulatory agencies at the state and federal levels. Weed management requires interdisciplinary cooperation. Approaches to weed management solutions can include entomologists, plant pathologists, soil scientists, water experts, ecologists, marine biologists, chemists, birds and other vertebrate specialists, meteorologists, breeders, molecular biologists, mechanical engineers, finance and marketing professionals, computer scientists, lawyers, and food safety experts.

All of the academic institutions, allied agricultural industries, governmental agencies, and individuals across all professions ultimately come together to seek solutions to satisfy our stakeholders. The people seeking weed management solutions are the farmers and producers, land managers, crop production consultants, and land and homeowners, private and public.

Arnold Appleby, emeritus weed scientist from Oregon State University and a Fellow and former president of WSWS, compiled the history of *The Western Society of Weed Science, 1938-1992*. "In the beginning", the origins of WSWS date back to 1936 with the Western Plant Quarantine Board where thirteen states were represented and reported about problem species, regulatory control, and educational programs. It was proposed to conduct an annual symposium to bring together weed workers in western states, interchange suggestions for weed problems, and study weed problems as a unit.

Today, we still study weed problems as a unit within institutions in an interdisciplinary manner. However, land grant institutions no longer have the tripartite weed scientists in research, extension, and instruction. Many extension weed specialists have responsibilities for doing all three components. Most federal grants encourage multi-state and multi-institutional collaborations as well as bringing to the table new collaborators from non-governmental organizations or weed management areas. Members of WSWS are in touch with national issues, federal agencies, and policymakers through the Director of Science Policy of Weed Science Society of America or subject matter experts serving as liaisons. Internationally, many WSWS scientists contribute to research efforts such as the recent Global Herbicide Resistance Conference in Perth, Australia. We have members who are members of the International Weed Science Society, Asian-Pacific Weed Science Society, Canadian Weed Science Society, European and Latin American weed organizations, and other weed science organizations.

WSWS weed scientists do well and are successful because we know our stakeholders and interact with them day-to-day. We listen and understand our clientele needs. We are inclusive and pick and choose new partners that are reliable collaborators.

WSWS offers opportunities for its members to meet in glamorous and alluring locations for its members to give and listen to papers, posters and symposia. It provides members time to network and to meet new and renew old acquaintances at annual meetings. Thank you to Bob Stougaard, WSWS Member-at-Large, for conducting a member survey this past year to evaluate and determine our member needs and desires. Thank you to Vanelle Peterson, WSWS Immediate Past President, for having the vision and creating new opportunities for WSWS student members. It is critical that we nurture and mentor our up-and-coming student and younger early career members for the future of WSWS.

WSWS fosters educational opportunities for every land manager, student, crop consultant, golf superintendent, landscaper, applicator or landowner who should have in their truck a copy of *Weeds of the West*. We also provide every office with another weed identification resource, *Weed of California and Other Western States*. Most recently, we began offering *Weed Control in Natural Areas in the Western United States* through our WSWS website. With all of these valuable resources for the on-the-ground practitioners and stakeholders, WSWS needs to find innovative and creative means to market and sell its goods and services. There will be a brainstorming session this week on Wednesday morning to which all members are invited.

Last year in the general session of the WSWS annual meeting, Bob Zimdahl, emeritus weed scientist from Colorado State University and WSWS Fellow, challenged our membership to develop an ethics statement for our Society. An *ad hoc* committee that included Ralph Whitesides and Frank Young edited a draft statement and a final ethics statement should be available for membership approval on the next ballot later this year.

In closing, everybody should keep in perspective the balance of work and family. WSWS has been a "home" for me to share weed science. More importantly, I want to thank my family for the understanding, support, and tolerance for the nights and weekends that I've spent at work.

WSSA and Regional Weed Science Societies & NDASH; Director of Science Policy Update.
Lee Van Wychen*; WSSA, Washington, DC (062)

See WSWS Board of Directors Minutes for complete report.

Two Centuries of Invasive Plants in Southern California. Carl Bell*[1], Edith Allen[2], Kim Weathers[2], Milton McGiffen, Jr[2], Chris McDonald[3], John Eckhoff[4], Marti Witter[5]; [1]University of California Cooperative Extension, San Diego, CA, [2]University of California Riverside, Riverside, CA, [3]University of California Cooperative Extension San Bernardino, San Berandino, CA, [4]California Department of Fish and Wildlife, San Diego, CA, [5]US National Park Service, Santa Monica, CA (063)

Native Americans were active managers of the California landscape for millennia; they tended and manipulated plants and landscapes in order to enhance food and material resources. Juan Cabrillo, the first European explorer arrived in San Diego Bay in 1542, but European settlement did not begin until 2.5 centuries ago with the Mission period starting in 1769 in San Diego. Spanish settlement was accomplished by 700 land grants for Ranchos comprising 8 million acres for crops and livestock. The cattle population numbered about 1.5 million, with similarly large numbers of sheep and horses. With statehood in 1850, American settlement was rapid; people were drawn by the gold rush and the agricultural potential of the land. Europeans and Americans all brought weeds with them. Today there is powerful interest in California to preserve and restore natural habitat. Restoration projects to date have been typically small scale, very expensive ($5,000 to $40,000 per acre) and seldom successful. We have investigated large scale, low cost passive restoration of coastal prairie and coastal sage scrub habitats. Our methodology is based upon repeated annual applications of herbicides in the early rainy season (January to March). California native plant species are well-adapted winter/spring rains followed by summer drought, but so are the weedy annuals. They tend to germinate earlier, more quickly and occupy their space on the land before the natives have a chance. Killing these weeds early in the rainy season give the natives have a chance to grow. The repeated annual herbicide treatments reduce or exhaust the weedy seed bank. At one preserve we established an experiment with three treatments; glyphosate (840 gram/ha) once, glyphosate two times, and an untreated control. Glyphosate treatments were made from 2006 through 2009. In 2010 we used fluazifop-P–butyl because of the extensive presence of native forbs in the treated plots. Data recorded are cover by species and species richness. The herbicide treatments increased native cover to 50% of total cover, compared to less than 5% in the untreated controls. Non-native grass, principally wild oats and ripgut brome, cover decreased to less than 10% after one year of herbicide treatment and then to 0% the following year. Redstem filaree is still abundant and seems to have a very resilient seedbank. At another preserve, an experiment was established in 2007 and again in 2008. Each experiment compared several herbicides applied annually for three years for selectivity (e.g. injury) on purple needlegrass, efficacy on the suite of weeds in the plots, and for the interaction of these two effects on purple needlegrass cover and biomass. Herbicides tested included glyphosate, fluazifop-P-butyl, clethodim, aminopyralid, triclopyr, rimsulfuron, and imazapic, some in combinations. Results varied considerably, but some treatments, including fluazifop plus triclopyr and low rates of glyphosate, significantly increased needlegrass cover and biomass compared to the controls and eliminated most of the weeds in the plots. In order to inform and encourage adoption of these methods by our clientele, we have established demonstration sites that range from 2 to 26 acres on various preserve properties throughout southern California.

Setting Priorities and Building Partnerships: A Key for UC IPM Success in Challenging Times. Kassim Al-Khatib*; University of California - IPM, Davis, CA (064)

No abstract submitted

Herbicide-Resistant Weeds Worldwide. Ian Heap*; International Survey of Herbicide Resistant Weeds, Corvallis, OR (065)

The International Survey of Herbicide-Resistant Weeds (www.weedscience.org) has been online since 1993 and is a collaborative effort of over 1,500 weed scientists from over 60 countries. There are currently 397 unique cases (species x site of action) of herbicide-resistant weeds globally, with 217 species (129 dicots and 88 monocots). Weeds have evolved resistance to 21 of the 25 known herbicide sites of action and to 148 different herbicides and are found in 64 crops in 61 countries.

The ALS inhibitors have selected 129 resistant species and are the most prone site of action to resistance because of the numerous mutations that confer resistance to them, in addition to their extensive use over a long time period. For the same reasons the triazines (70 species) and ACCase inhibitors (42 species) are also considered high risk herbicides for the selection of resistance.

Glyphosate was long considered a low risk herbicide, however a massive increase in the area treated with glyphosate alone because of the rapid adoption of Roundup Ready crops in the mid 1990’s in the USA and South America has led to a rapid increase in the evolution of glyphosate-resistant weeds. Twenty-four weed species have evolved resistance to glyphosate from 18 countries. Although only 13 of the 24 species evolved resistance to glyphosate in Roundup Ready cropping systems these 13 species account for more than 95% of the area of glyphosate-resistant weeds globally. *Amaranthus palmeri. Amaranthus tuberculatus, Conyza canadensis* and more recently *Kochia scoparia* are the most widespread glyphosate resistant weeds in the USA, and *Sorghum halepense* and *Digitaria insularis* are the most widespread glyphosate-resistant weeds in South America.

The "Global Herbicide Resistance Challenge" conference was held in Perth in February of 2013 bringing together herbicide-resistance researchers from 32 countries. Research on glyphosate-resistant weeds dominated the conference even though the economic damage caused by ALS inhibitor and ACCase inhibitor herbicides is orders of magnitude greater than the current economic damage caused by glyphosate-resistant weeds. Management of weed seed banks through mechanical destruction of weed seeds at harvest was a highlight of the conference. In the years ahead the greatest threat to sustained weed control in agronomic crops is the increase in the incidence of multiple-resistance in weeds combined with the lack of discovery of novel herbicide modes of action. New herbicide-resistant crops traits and new herbicide modes of action will provide a short term solution however for sustainable weed control growers must transition to integrated weed management that uses all other economically available weed control techniques, in addition to herbicides and herbicide resistance management strategies.

PROJECT 1: WEEDS OF RANGE AND NATURAL AREAS

Influence of Plant Litter and Application Rate and Timing on Efficacy of Imazapic for Controlling Downy Brome. Krista A. Ehlert*, Jane Mangold, Richard Engel; Montana State University, Bozeman, MT (066)

Controlling downy brome with imazapic can be highly variable across sites and years. We tested the effect of application rate and timing on downy brome control and desired plants in range and Conservation Reserve Program (CRP) lands over two years (2011, 2012), applying a factorial combination of four rates (0, 80, 160, and 240 g a.i. ha^{-1}) and two timings (early, 1-2 leaf downy brome growth stage; late, 3-4 leaf). At the rangeland site, control was affected by rate ($P = 0.0029$) and year ($P = 0.0256$). Cover and biomass were up to 65% lower than the control regardless of rate. Perennial grass cover ($P = 0.0283$) and biomass ($P = 0.0338$) nearly doubled in response to imazapic. Downy brome and perennial grass cover and biomass were lower in 2012 compared to 2011 across all treatments. At the CRP site, rate, timing, and year interacted to influence downy brome cover ($P = 0.0105$). In 2011, early application reduced cover to < 10%, regardless of rate. Late application reduced downy brome cover only with the high rate compared to the control (12 versus 38%). In 2012, all treatments had similar cover (< 1%). Only timing ($P = 0.0208$) affected perennial grass biomass. Late application increased biomass by 50% compared to early application. Imazapic efficacy was highly variable across sites, years, and treatments. However, when applying to older versus younger downy brome seedlings, rate became more important. Chemical control of downy brome is challenging because of annual variability in populations.

Crossing Yellow Starthistle and Meadow Knapweed to Determine if Hybrids Will Be Produced. John J. Miskella*, Andrew Hulting, Carol Mallory-Smith; Oregon State University, Corvallis, OR (067)

Yellow starthistle and meadow knapweed are invasive weeds which typically occur in very different environments. Their ranges do not overlap in Europe and most of North America, but they occur together in southwest OR. Hybrids between the two species have been reported based on morphological traits. To verify that these two species can produce hybrids, controlled crosses were made under greenhouse conditions, using two methods, hand-pollination and blue bottle flies as pollinators. Of the 3654 seeds produced, 78 germinated (2.14%). Many seeds lacked endosperm, and were therefore not viable. Flow cytometry was used to measure the genome size, the entire complement of nuclear DNA within one cell (reported as 2-C value), of the seedlings produced from the crosses, of five putative hybrids collected in the field, and of the parent species. Four of the putative hybrids found in the field had 2-C values approximately halfway between the 2-C value of yellow starthistle and the 2-C value of meadow knapweed. Most of the F_1 plants had 2-C values similar to their maternal parent, and were the result of self-pollination. However, six (0.16%) F_1 plants had 2-C values similar to the putative hybrids collected in the field, confirming these species can hybridize. These results may have implications for management, particularly if the hybrids are more fit than either parent species or change the ecological amplitude of the species complex.

Ecosystem Resiliency and Tamarisk (saltcedar, Tamarix spp.) Management. Cameron Douglass*, Scott J. Nissen; Colorado State University, Fort Collins, CO (068)

Invasive species management occurs within the context of an ecosystem's condition and its ongoing ecological processes. The selection of particular control strategies and regimes for targeted invasives can impact the managed ecosystem via both predictable and unintended or indirect effects. There is growing evidence that the probability that invasive plant control efforts will have a negative impact on the managed ecosystem increases proportionally with the selection pressure exerted by the chosen method, and inversely with the resilience of the ecosystem.

The overall success of ecosystem management efforts can be gauged in part by the impact of invasive species removal on passive plant community recovery. This objective requires minimizing negative ecosystem impacts from management events while simultaneously maximizing ecosystem resiliency, and is based on a comprehensive understanding of interactions between these activities. We sought to identify and quantify the relationships between ecosystem impacts and resiliency within semi-arid riparian habitats invaded by *Tamarix* species. This study system was particularly informative because controlling woody invasive species such as *Tamarix* spp. involves two phases of management (mortality + biomass removal), presumably affecting the chances for negative ecosystem impacts. Furthermore, the resiliency of semi-arid riparian systems has been compromised by water regulation and re-allocation as well as more recently by climate change.

In 2009 we established four sites in southeastern Colorado to simultaneously investigate the effectiveness of tamarisk removal methods and their impacts on passive understory re-vegetation patterns. Primary treatment plots (aerial imazapyr applications, mulching, excavation, untreated controls) were installed at each site the first year, and secondary treatments (releases of

Diorhabda carinulata beetles, and individual plant treatments (IPTs) of imazapyr and triclopyr) were installed in 2010. Multi-scale, nested sampling plots were randomly located within each treatment plot to monitor tamarisk survival and understory re-vegetation.

Three years after treatment whole tree extraction caused higher tamarisk mortality than aerial imazapyr applications or mulching. Tamarisk mortality from secondary treatments was significantly increased by IPT imazapyr and triclopyr applications, and only minimally by beetle herbivory. However, tamarisk biomass removal followed by biological control releases was more cost effective than other treatments. Aerial imazapyr applications resulted in a depauperate plant community dominated by *Bassia scoparia*. Plant species richness and diversity was slightly higher in plots where mechanically-removed tamarisk was treated with *Diorhabda* beetles compared to those that received IPT herbicide applications.

This study confirmed that there are strong trade-offs between invasive species management strategies and ecosystem impacts. It is possible to effectively control tamarisk and similar species using integrated strategies that do not detrimentally affect the extant plant community. In general, the application of non-selective herbicides negatively impacted ecosystem resiliency, not only from direct toxicity but also by undesirably shifting plant community assembly patterns. It is ultimately critical to holistically address larger scale environmental stressors and the underlying causes of site degradation to ensure plant community recovery following the removal of tamarisk or other dominant invasive species.

Logging Debris and Herbicide Treatments for Controlling Scotch Broom. Timothy B. Harrington*[1], Robert A. Slesak[2], David H. Peter[1]; [1]USDA Forest Service, Olympia, WA, [2]University of Minnesota, Minneapolis, MN (069)

Scotch broom is an aggressive, non-native shrub that often invades forest sites in western Washington and Oregon. Soil-stored seed of broom continues to germinate for years after the initial invasion, especially following disturbance events such as forest harvesting. To investigate the potential of logging debris and herbicide combinations to inhibit germination and development of Scotch broom seedlings, a forest site dominated by mature Douglas-fir scheduled for harvest was selected near Matlock WA. The forest understory included occasional Scotch broom plants that had invaded from a previous disturbance, indicating the likely presence of soil-stored seed. Three soil surface treatments (light debris, heavy debris, and machine trails), with debris depths averaging 17, 32, and 16 cm, respectively, were replicated six times after harvesting the study site in December 2011. Density of current-year seedlings of Scotch broom doubled from June (1,800 seedlings ha^{-1}) to July 2012 (3,800 seedlings ha^{-1}). In July, broom density was lower in heavy debris (400 seedlings ha^{-1}) than on machine trails (6,000 seedlings ha^{-1}), but it did not differ significantly from that in light debris (2,500 seedlings ha^{-1}). In August, triclopyr ester (2.2 kg ae ha^{-1}) and aminopyralid (0.12 kg ae ha^{-1}) were applied via backpack sprayers, either alone or in combination, to 0.04-ha plots within each soil surface treatment. Seven weeks after the herbicide treatments, broom density in plots receiving the combination herbicide treatment (500 seedlings ha^{-1}) was 11% of that in non-treated plots (4,500 seedlings ha^{-1}), but it did not differ significantly from that of plots treated with either triclopyr (1,000 seedlings ha^{-1}) or aminopyralid (1,800 seedlings ha^{-1}) by itself. Effects of the soil surface treatments on broom density were no longer detectable following the herbicide treatments. These first-year results suggest that either heavy debris or combined applications of triclopyr and aminopyralid are effective at reducing broom seedling density. Large increases in broom seedling density are expected in the second and third years of the study, and potential effects of the soil surface and herbicide treatments will continue to be monitored.

Do Source-Sink Population Dynamics Explain the Distribution of Anthriscus caucalis within Canyon Grassland Systems of Idaho? John M. Wallace*, Timothy S. Prather; University of Idaho, Moscow, ID (070)

Species distribution models (SDMs) may be utilized to address both research and management objectives related to biological invasions at intermediate stages of invasion. In this study, we produce SDMs for an exotic annual forb, *Anthriscus caucalis*, undergoing range expansion in the Snake River canyon grasslands using a correlative and mechanistic SDM approach. Utilizing a snapshot view of species occurrence and environmental relationships, we fitted correlative SDMs using environmental, remote sensing and land-use history data. A previous demographic study determined that source-sink dynamics among habitat patches potentially contribute to invasive spread, so we also fitted mechanistic SDMs using plant community maps and source-to-sink metrics (distance and area) as predictor variables. For the correlative SDM, *A. caucalis* distributions were best described as a function of vegetation index (NDVI) and the grazing regime. For the mechanistic SDMs, *A. caucalis* distributions were best described as function of plant community type, the relative area of source habitat and grazing regime. Our results suggest that source-sink dispersal dynamics are one of the primary ecological processes underlying *A. caucalis* invasion. In addition, *A. caucalis* occurrence probabilities were greater in ungrazed areas compared to spring grazed areas, which suggests that livestock spring-grazing may act to limit *A. caucalis* distribution patterns at landscape scales by decreasing propagule pressure from source habitats, which results from increased trampling and disturbance within source habitats that are used for livestock refuge. Our results demonstrate the utility of comparing correlative and empirical SDMs to test hypotheses about the dynamic processes that influence invasions.

Sublette County Invasive Species Taskforce; Cheatgrass Control a Growing Problem. Julie A. Kraft*; Sublette County Weed and Pest, Pinedale, WY (071)

Sublette County, Wyoming is 3.2 million acres comprised mostly of the sagebrush steppe plant community, but surrounded by mountains on three sides. Cheatgrass or downy brome is probably the most threatening invasive plant to our area, because of our vast sagebrush ecosystems. In 2010, the Sublette County Invasive Species Taskforce was formed. This group was initiated to combine all concerned parties interested in the cheatgrass invasion of Sublette County. Right now the focus is on cheatgrass, but subgroups can be formed for any invasive species. Taskforce members include county, state and federal agencies, local industry companies, landowners and anyone interested in cheatgrass in Sublette County.

Taskforce members understood that there was cheatgrass invading our native range and wanted to understand how much as well as exactly where it was. So the group sought funding for an invasive plant survey. We have been surveying for all invasive plants within our county and will treat located infestations. Using invasive species management principles we have surveyed major corridors and vectors in the county, as well as areas of know disturbance. With a few areas of exception, most of the located cheatgrasss in Sublette County is associated with roadways or previous disturbance. We have an infestation in the Southwest corner of the county that is associated with a nearly 100 year old oil development and a large infestation along the

Wind River Front in the Boulder Lake area that is associated with south facing slopes and historic fires.

The Boulder Lake infestation is thousands of acres and the Taskforce works each year to acquire grant funding to treat cheatgrass by air. We have small and large scale product trials out to see which herbicide is the most effective tool in our area. The large scale trials are with Imazapic and Rimsulfuron. We had some non-typical results with the Rimsulfuron in the 2011 treatment, in which the cheatgrass was reduced from 68% to 15% of the total plants cover. We continue to monitor and put out new trials with these herbicides to understand effectiveness and limit non-target damage. This heavily invaded area is important wildlife habitat located within the sage grouse core area. It is used for recreation and livestock grazing, so it is important to limit non-target damage and limit spread. The taskforce has designated a Hold-the-Line type of approach where all areas west of this line will be treated. We will continue to control the large infestation on the east side of the line as funding is available. The Taskforce understands that cheatgass may not ever be completely eradicated in Sublette County but with these cooperative projects we hope to better understand and slow the invasion of our sagebrush community.

Aquatic Plant Management Challenges in Flowing Water Systems. Celestine A. Duncan*[1], John Halpop[2]; [1]Weed Management Services, Helena, MT, [2]CES, Thompson Falls, MT (072)

Eurasian watermilfoil (*Myriophyllum spicatum*) and curly leaf pondweed (*Potamogenton crispus* L.) are non-native, perennial plants that threaten the ecological integrity of aquatic environments in Montana. Eurasian watermilfoil was reported in Montana in 2007 and occupies about 400 acres in the lower Clark Fork reservoirs, less than an acre in Beaver Lake, and multiple sites in the lower Jefferson River, Missouri River headwaters, and Fort Peck Reservoir. Curly-leaf pondweed was first reported in Montana in 1974 and is known to infest more than 1000 acres within major water bodies both east and west of the Continental Divide. The majority of infestations occur in flowing water systems including rivers, sloughs, and impoundment reservoirs used for power generation.

Management strategies initiated in 2009 include long-term containment and control efforts with bottom barriers, hand removal, diver dredging, and herbicide treatments. Herbicide field trials on Eurasian watermilfoil and curly-leaf pondweed were conducted in 2009 and 2010 in the lower Clark Fork reservoirs to determine efficacy of herbicide treatments in flowing water systems, and impacts to non-target aquatic plants. Results from these studies led to operational herbicide applications in 2012. Herbicide treatments were applied with the Littline® system to increase herbicide concentration and exposure time. Application swath width was about 50 feet and vessel speeds averaged 3 to 5 miles per hour depending on water depth. Larger block treatments received application of either endothall alone at 3 parts per million (ppm), or endothall plus triclopyr at 2 and 1 ppm respectively. Narrow strip treatments along shorelines received applications of either endothall at 3 ppm or diquat at 0.37 ppm. Visual percent injury evaluations were taken 6 weeks after treatment (WAT). Results of block treatments indicated that the combination of triclopyr and endothall, or endothall alone provided from 85 to 100% control of Eurasian watermilfoil 6 WAT. Results were similar in the strip treatments for endothall and diquat applied alone with the exception of one treated plot with less than 50% control. Curly leaf pondweed control was 100% in both strip and block treatments; however, the plant may recover from turions that sprout over the winter. Results of herbicide treatments in 2012 were similar to those in 2009 and 2010, and suggest that good to excellent control will be maintained 52 WAT.

Bottom barriers provided 100% control of aquatic vegetation near boat launches and docks. High cost of barriers, maintenance, and damage from recreationists limit their use on large-scale infestations. Effectiveness of hand removal and diver dredge varied between sites from 0 to 100% control based on plant density, water clarity, sediment type, and size of infestations.

Aminopyralid Research Summary for Aquatic Labeling. Vanelle F. Peterson*[1], John J. Jachetta[2], Patrick L. Havens[2], Louise A. Brinkworth[2], William N. Kline[3], William T. Haller[4], John L. Troth[2]; [1]Dow AgroSciences, Mulino, OR, [2]Dow AgroSciences, Indianapolis, IN, [3]William N Kline, LLC, Ball Ground, GA, [4]University of Florida, Gainesville, FL (073)

Aminopyralid is a member of the pyridinecarboxylic acid family of herbicides and controls noxious and invasive broadleaf weeds in rangeland, permanent grass pastures, Conservation Reserve Program (CRP) acres, non-cropland areas including industrial sites, rights-of-way (such as roadsides, electric utility and communication transmission lines, pipelines, and railroads), non-irrigation ditch banks, natural areas (such as wildlife management areas, wildlife openings, wildlife habitats, recreation areas, campgrounds, trailheads and trails), and grazed areas in and around these sites. It is currently registered in products either alone (Milestone®) or with other active ingredients such as metsulfuron, clopyralid, triclopyr, or 2,4-D (for example, Opensight®, Sendero®, Capstone®, or ForeFront® HL, respectively). The current labels state, "*It is permissible to treat non-irrigation ditch banks, seasonally dry wetlands (such as flood plains, deltas, marshes, swamps, or bogs) and transitional areas between upland and lowland sites. Milestone can be used to the water's edge. Do not apply directly to water and take precautions to minimize spray drift onto water*." The labels also state, "*Do not contaminate water intended for irrigation or domestic purposes. Do not treat inside banks or bottoms of irrigation ditches, either dry or containing water, or other channels that carry water that may be used for irrigation or domestic purposes.*" Aminopyralid degradation rate in water in sunlight (photolytic half-life of 0.6 days) is similar to triclopyr, an active ingredient registered for aquatic uses (half-life of 0.5 days). Therefore, to expand the utility of aminopyralid containing products, research was conducted in 2010 to gather data for a submission to support the addition of aquatic uses to aminopyralid product labels. Research studies in ponds and in moving water generated residue data in order to establish tolerances for fish, shellfish and crustaceans and define the dissipation kinetics in water and sediment over time. Pond studies were conducted in Texas and Indiana and moving water studies in Oregon and Florida. Data were used in submissions to support aquatic uses for Milestone, GrazonNext® HL, ForeFront HL, Capstone, and PasturAll®. Following approval labels are expected to have no restrictions on recreational or livestock use of water after applications but use will not be permitted on the inside banks of irrigation ditches. Use precautions and restrictions on use of water treated with Milestone for irrigation will likely be included on the new label. Registration is anticipated for the use season in 2014. ®™Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow

Prescribed Burning and Imazapic Control on Downy Brome under Rangeland Conditions. Kallie C. Kessler*, K. George Beck, Scott J. Nissen, James R. Sebastian; Colorado State University, Ft. Collins, CO (074)

Downy brome is a non-native, cool-season annual grass that is highly invasive on rangeland across much of the western United States. Previous research suggests that downy brome can be controlled by prescribed burning followed by imazapic applications before the tiller stage of growth. The variable success of this strategy indicates a need for further research. Our study objectives were to evaluate downy brome control and native perennial grass response resulting from prescribed burning alone and in combination with imazapic and glyphosate applications. In January 2012, a prescribed burn was conducted at two sites near Loveland, Colorado. Herbicides were applied at the two to three leaf growth stage of downy brome in March 2012. Applications consisted of 105 g ai ha^{-1} imazapic, 370 g ai ha^{-1} glyphosate and imazapic plus glyphosate at the same rates. We used aboveground biomass collected in August 2012 to evaluate downy brome control and perennial grass response. Our results indicated herbicide treatments decreased downy brome biomass by an average of 96% compared to untreated checks and there was no herbicide by burning interaction on downy brome control (P=0.4864). The prescribed burn alone had no impact on downy brome biomass in check plots during the growing season following burning (burned 26 g m^{-2} and unburned 26 g m^{-2}, P=0.0889). Burned treated plots had more aboveground native grass biomass than unburned treated plots (burned 188 g m^{-2} and unburned 165 g m^{-2}, P=0.0013). We will continue to evaluate year after treatment effects in 2013.

Does Spotted Knapweed Alter Pollinator Visitation in Native Plant Communities? Christina Herron-Sweet*, Jane Mangold, Erik Lehnhoff, Laura Burkle, Jeffrey Littlefield; Montana State University, Bozeman, MT (075)

Most research investigating effects of weeds on native plants has focused on direct interactions (eg. competition for resources). However, other factors such as competition mediated through higher trophic levels may influence weed-native plant interactions as well. Many weeds rely on insect pollinators which they may share with native plants resulting in competitive, facilitative or neutral consequences for native plant reproduction. We investigated indirect impacts of spotted knapweed on native plant communities by observing pollination networks at nine knapweed infested sites in western Montana. To assess effects of spotted knapweed on community-level pollination patterns, we recorded pollinator visitation weekly at each site from July through August 2012. Pollinator interaction networks showed that all 22 forbs occurring at our sites shared pollinators with spotted knapweed, and that hairy goldenaster (*Heterotheca villosa*(Pursh) Shinners) and aspen fleabane (*Erigeron speciosus* (Lindl.) DC.) had the greatest taxonomic overlap of visitors. Non-native honey bees (*Apis mellifera)* visited spotted knapweed with higher frequency than any other forbs and accounted for up to 80% of visits to knapweed at one site. Overall, there was little evidence that knapweed received more pollinator visits than other co-flowering forbs. During peak knapweed bloom, all other forb species together received fewer visitors per flower in high knapweed density plots than in plots without knapweed. These findings suggest that knapweed may be decreasing the quantity and quality of pollinator visitation to native forbs through pollen limitation or heterospecific pollen deposition, thereby negatively impacting native forb reproduction.

Integrating Imazapic and a Fungal Pathogen to Control Downy Brome (*Bromus tectorum*). Jane Mangold*, Krista A. Ehlert, Richard Engel; Montana State University, Bozeman, MT (076)

Downy brome (*Bromus tectorum*) is a prolific seed producer, and its seedbank can germinate from the fall through early spring, depending on environmental conditions. Herbicides control emerged seedlings, but minimally impact the seedbank. Integrated strategies that couple inoculation with a seed killing pathogen and herbicide application may provide more effective control. Our objective was to determine whether the fungal pathogen *Pyrenophora semeniperda* (PYSE) combined with a single imazapic application would provide greater control of downy brome than either strategy used alone. A greenhouse pot experiment was conducted with control, PYSE, imazapic, and PYSE + imazapic treatments. Treatments were tested across three downy brome seeding depths (litter, soil surface, and subsurface). Two trials were conducted, each with eight replications. PYSE reduced downy brome emergence by 30 to 60%, depending on seeding depth ($P < 0.0001$). Downy brome biomass was affected by PYSE, imazapic, and the integration of PYSE and imazapic ($P < 0.0001$). Biomass averaged 1.9, 0.8, 0.4, and 0.2 g per pot for control, PYSE, imazapic, and PYSE + imazapic treatments, respectively. Imazapic and PYSE + imazapic treatments resulted in similar biomass. Although PYSE and imazapic did not synergistically reduce downy brome biomass, integrating these two control tools holds promise as long as inoculation costs are minimized and non-target grasses are not affected. Long-term downy brome management could be improved because PYSE can reduce the seedbank, potentially limiting future downy brome populations, and imazapic can control seedlings that escape pathogen-caused mortality.

Restoration Species Tolerance to Herbicides. Thomas J. Getts*[1], Philip Westra[2], Tim D'Amato[3], Bobby Goeman[3]; [1]Colorado State University, Fort Collins, CO, [2]Colorado State University, Ft. Collins, CO, [3]Larimer County Weed District, Fort Collins, CO (077)

Noxious weeds are legally required to be controlled in Colorado. Herbicides are often the chosen control method, however their impact on desirable vegetation is often unknown. We conducted a field study in Northern Colorado investigating the tolerance of 16 native species to four timings of herbicide application. Four warm season grasses, four cool season grasses, and eight broadleaf species were tested. Soil residual tolerance was examined with two application timings of 12 herbicide treatments in July and September of 2010, where foliar tolerance was examined with two application timings of 15 herbicide treatments in July and September of 2011. Stand counts and injury ratings were collected in 2011 and 2012, where final biomass samples were only collected in 2012. Across all herbicide applications, broadleaf plants appeared to suffer more injury than grasses. Applications of picloram at 0.58 kg a.i./ha in 2010 caused large biomass reductions for blue flax (*Linum perenne*). September 2010 application of metsulfuron at 0.04 kg a.i./ha reduced biomass of blue flax and prairie coneflower (*Ratibida columnifera*), where little reduction was observed in either species for the July 2010 applications. More injury was observed for most species after 2011 applications compared to 2010 applications. In particular foliar application of imazapic 0.21 kg a.i./ha in July 2011 reduced the biomass of green needlegrass (*Nassella viridula*), canada wildrye (*Elymus Canadensis*), slender wheatgrass (*Elymus trachycaulus*) and Palmer's penstemon (*Penstemon palmeri*). Metsulfuron at 0.04 kg a.i./ha greatly reduced blanket flower (*Gallardia spp.)* biomass for both 2011 application timings. This study was not intended to demonstrate comprehensive understanding, but instead act as a starting point for quantifying herbicide injury to restoration species.

An Ecologically Based Integrated Management approach to Control Sericea Lespedeza (*Lespedeza cuneata*) in Native Rangeland. Valerie K. Cook Fletcher*; Oklahoma State University, Stillwater, OK (078)

Invasion of sericea lespedeza (*Lespedeza cuneata*) across the tallgrass prairie has resulted in altered microbial and native plant communities, and reduced forage availability and grazing efficiency for ranching operations. Chemical control efforts to suppress sericea within native rangeland are costly, relatively ineffective, and cause high collateral damage. We propose the integration of chemical efforts and patch-burn grazing to produce an improved approach to sericea control, which is both cost-effective and biologically efficient. We sought to determine the environmental and management factors most influential on prevalence of suppression. We established 21 (2010) and 14 (2011) transects within recently burned patches in the Tallgrass Prairie Preserve of Oklahoma. Each transect contained four treatment blocks; for each block, we quantified sericea density, cover, and stems grazed within four 1-m^2 permanent subsamples. Following fire and grazing, each block received spot-spray treatments of early- or mid-season (triclopyr), late-season (metsulfuron-methyl), or no treatment. Using mixed-effects ANOVA and multiple regression, we analyzed post-treatment sericea density each growing season after treatment (GSAT). One GSAT, densities were 0.24, 0.23, 0.52, and 1.08 times the pre-treatment density for early-, mid-, late-season spray, and control treatments. Two GSAT, densities were 0.56, 0.39, 1.17, and 1.56 times the pre-treatment density for respective treatments. At two GSAT, spray-timing, patch-burn treatment, pre-treatment density, and fire return interval (FRI) were best predictors of control. Results indicated a 3-yr FRI applied in spring + summer patch-burns combined with mid-season treatments of triclopyr produced the greatest control, though drought and effective stocking rate were conditional factors to consider.

Response of Duncecap Larkspur and Associated Vegetation to Aminocyclopyrachlor. Brandon J. Greet*, Andrew R. Kniss, Brian A. Mealor; University of Wyoming, Laramie, WY (126)

Duncecap larkspur is an important perennial weed on high elevation rangelands because of significant cattle losses due to toxic alkaloids in the plant. Aminocyclopyrachlor was evaluated at rates between 17.5 and 315 g ai/ha for duncecap larkspur control alone and in combination with chlorsulfuron or metsulfuron at a high elevation site in Wyoming. Aminocyclopyrachlor-containing treatments were compared with 1120 g ai/ha picloram and 63 g ai/ha metsulfuron-methyl. Herbicides were applied to two sites in a randomized complete block design with four replicates each. Herbicides were applied on June 18, 2010 at the first site and June 28, 2011 at the second site. Larkspur mortality, plant species richness, vegetation cover, and grass biomass data were collected 1 YAT. Cover data were used to calculate vegetation diversity and to assess changes in species composition associated with herbicide application. A four parameter log-logistic model was used to evaluate duncecap larkspur mortality, species richness, and cover data in response to aminocyclopyrachlor rate. Aminocyclopyrachlor alone, aminocyclopyrachlor plus chlorsulfuron, and aminocyclopyrachlor plus metsulfuron control of duncecap larkspur increased with increasing rate. Species richness and diversity were reduced by herbicide application. Graminoid biomass was not significantly impacted by herbicide or rate. Aminocyclopyrachlor may be a useful tool for duncecap larkspur control. Addition of chlorsulfuron and metsulfuron to aminocyclopyrachlor increased larkspur control, but had a greater impact on associated vegetation.

Effects of Integrated Downy Brome Management Two Years After Treatment. Heather Elwood*, Corey V. Ransom; Utah State University, Logan, UT (127)

Downy brome infested rangelands are a major concern in the Western United States, including within Dinosaur National Monument where it negatively affects native vegetation, recreation, and grazing. Two sites were selected within Dinosaur National Monument to establish trials evaluating the effect of spring-time seed reduction measures alone (glyphosate at 193 g ai ha^{-1}, clipping at the purple stage, or none) and in combination with fall applied preemergence herbicide treatments. Plots were arranged in a completely randomized design with seed reduction as the whole-plots and fall herbicide treatments as the subplots with four replicates. Preemergence treatments included: an untreated control, imazapic at 70, 105, 140, 175, and 210 g ai ha^{-1}, sulfosulfuron at 70 g ai ha^{-1}, and rimsulfuron at 53 g ai ha^{-1}. Data collected included cover evaluations, density counts, and biomass collection in 2010, 2011, and 2012. Plants were harvested at immaturity (time of clipping) and maturity to determine the effect of whole plot treatments on the number of seeds produced and their viability. Downy brome seed production was not significantly reduced by either method, but germination was reduced by mowing at both sites and by glyphosate at one site. All herbicide treatments reduced downy brome cover 1YAT at both sites. However, 2 YAT only effects from the preemergence herbicide treatments remained significant in reducing downy brome cover at one site; the other site had a significant remnant perennial grass stand which grew competitively with above average rainfall in late 2010 and early 2011.

The Impact of Tall Buttercup (*Ranunculus acris*) on Plant Diversity and Productivity. Hally K. Berg*; Montana State University, Bozeman, MT (128)

Tall buttercup, an invasive perennial forb found in moist fields and sub-irrigated meadows, was listed as a noxious weed in Montana in 2003. Despite its noxious status, little is known about the effect of tall buttercup on species richness and forage production. To investigate the influence of tall buttercup on plant community composition, two study sites were established in July 2012 in sub-irrigated hay meadows near Twin Bridges, Montana. Three 100 m permanent transects were placed at each site spanning from low density to high density of tall buttercup. Foliar cover and biomass were sampled by species at five m intervals along each transect. Data were analyzed using linear regression to determine the relationship between tall buttercup and perennial grasses, grass-like species, forbs, and species richness. Tall buttercup had no impact on perennial grass biomass at either site (P=0.97 and 0.23). At one site, forbs increased by 1.05 g m^{-2} for every gram m^{-2} increase of tall buttercup (P<0.01). Grass-like species decreased at one site by 1.69 g m^{-2} for every gram m^{-2} increase of tall buttercup (P<0.01). However, there was a 1.44 g m^{-2} increase of grass-like species at the other site (P <0.01). Tall buttercup did not influence species richness at either site (P=0.86 and 0.29). Preliminary results suggest that tall buttercup may not have the negative impact on plant communities that was first predicted. Sampling will occur again in 2013 to account for annual variability in plant community composition.

The Use of Herbicides to Reduce Fuel Loads from Weedy Annual Grasses in Central Oregon. Gustavo M. Sbatella*, Sasha Twelker; Oregon State University, Madras, OR (129)

Invasive annual grasses such as downy brome (*Bromus tectorum*), medusahead *(Taeniatherum caput-medusae*), and Ventenata (*Ventenata dubia)* can produce large amounts of fine fuel creating favorable conditions for wild fires. The objective of this study is to assess the effectiveness of imazapic and propoxicarbazone sodium in various application timings and rates in reducing annual grass fuel load production. A study was initiated in the spring of 2012, near South Junction, Oregon, in two sites with a reported invasive annual grass infestation, but contrasting wild fire history. One site burned in the summer of 2011, while no fires were reported in the last 4 years at the other location (unburned). The total biomass at the beginning of the study differed in quantity and composition between sites. Total biomass averaged 929 lbs/a, and 1527 lbs/a, for the burned and unburned site respectively. Meanwhile, litter accounted for 21% of the biomass in the burned site versus 81% in the unburned. The vegetation sampling recorded six months after herbicide applications indicates that the treatment effects differed between locations. At the burned site, litter was reduced 53 percent with imazapic at 6 oz/acre and 42 percent with propoxicarbazone sodium at 1.2 oz/acre with spring applications. In the unburned site, the herbicide application helped control annual weedy grasses; although, the effect on the produced biomass was not significant enough to reduce the production of litter or total biomass. These preliminary results suggest that herbicides can be used as tools to reduce the production of fine fuels, although the magnitude in the reduction is going to be determined by the history of previous wildfires. Herbicides applications are schedule for fall of 2012 and spring of 2013, the impacts on plant composition and biomass production will be continued to be monitored.

Factors Affecting Herbicide Selection and Use in Plant Community Restoration Programs.
Robert A. Masters*[1], Mary B. Halstvedt[2], Louise A. Brinkworth[3], Daniel Chad Cummings[4]; [1]Dow AgroSciences LLC, Indianapolis, IN, [2]Dow AgroSciences LLC, Billings, MT,[3]Dow AgroSciences, Indianapolis, IN, [4]Dow AgroSciences LLC, Perry, OK (130)

An initial step in designing a restoration program is to determine the floristic composition of the desired plant community. A desired plant community should be designed to resist further invasion by undesirable plants and be resilient to major shifts in composition after disturbance (i.e., fire, grazing, drought, etc.). Herbicides are useful and cost effective tools that can selectively control undesirable plants in rangeland restoration programs and be a catalyst that expedite desired vegetation change. Understanding characteristics of the plant community is critical to selecting herbicides that best fit into integrated rangeland restoration programs. Plant community characteristics to consider include the current floristic composition, extent and distribution of undesirable plant infestations, and biology and ecology of important plant species (both desired and undesired). Herbicide characteristics that determine their utility in restoration programs include selectivity, persistence, and mechanism of action. Herbicides are usually selective within certain rates, environmental conditions, and methods of application. The duration of time during which herbicides are active in the plant or soil vary depending on their chemical characteristics and degradation mechanisms. Herbicides registered for use on rangeland in the US include those classified as synthetic auxins, acetolactate synthase inhibitors, photosystem II inhibitors, EPSP synthase inhibitors, and photosystem I electron diverters. Knowledge of herbicide attributes will enable selection of herbicides best suited to meet land management objectives. Assessing the potential impacts of chemical and non-chemical practices on plant community is a critical step in determining the appropriate sequence and combination of vegetation management methods used in rangeland restoration programs. Herbicide benefits are often extended when used as part of integrated management programs and selecting the correct herbicides can facilitate rapid attainment of the desired restored rangeland community.

Paper 131 was withdrawn.

Do Soils Impacted by *Tamarix* spp. Affect the Success of Restoration Projects Through Altered Soil Chemistry and/or Plant-Soil Feedbacks? Erik Lehnhoff, Fabian Menalled*; Montana State University, Bozeman, MT (132)

Tamarix is a relatively new invader in the northern USA, and little is known about *Tamarix* impacts in this area or the potential implications for restoration. This study evaluated the potential impacts of *Tamarix*-mediated soil changes on native plants used for restoration. Soil was collected from The Bighorn River, the Yellowstone River, and the Fort Peck Reservoir, Montana, western USA at paired subsites where *Tamarix* was either present or absent along three water bodies. To evaluate chemical and biological soil effects on plant growth, eight plant species (*Achnatherum hymenoides, Astragalus cicer, Dalea candida, Elymus lanceolatus, Leymus cinereus, Pascopyrum smithii, Ratibida columnifera,* and *Trifolium pretense*) commonly used in restoration projects at *Tamarix*-invaded sites were grown in the collected soil. Plant soil feedbacks were evaluated by growing two species (*Dalea candida* and*Pascopyrum smithii*) in greenhouse soils inoculated with small amounts of the field soils. Germination, emergence, and growth characteristics were compared between *Tamarix* invaded and un-invaded subsites and across water bodies. Seedling emergence and plant relative growth rate, total biomass production, and the allocation of resources to roots and shoots were not negatively affected in field soils or inoculated soils from areas where *Tamarix* was present. In fact, overall, plants emerged earlier and produced more biomass in soils affected by *Tamarix* than in soils from where *Tamarix* was not present. These results indicate that for sites in *Tamarix's* northern range, restoration would not be inhibited by *Tamarix*-induced changes to soil chemistry or microbiota.

Aminopyralid Plus Clopyralid for Mesquite Control: Second Year Research and Individual Plant Treatment Update. Daniel Chad Cummings*[1], Vernon B. Langston[2], Charles Hart[3], Louise A. Brinkworth[4]; [1]Dow AgroSciences LLC, Perry, OK, [2]Dow AgroSciences LLC, The Woodlands, TX, [3]Dow AgroSciences LLC, Stephenville, TX, [4]Dow AgroSciences, Indianapolis, IN (146)

Honey mesquite (*Prosopis glandulosa*) is a native, encroaching, woody legume found in the southwestern US and northern Mexico. Honey mesquite spread and increase in density has been, in part, facilitated by livestock and fire suppression. Chemical control of honey mesquite is most effective when recommended herbicides are applied between 40 and 90 days following axillary bud emergence. For almost three decades, a mixture of triclopyr (0.25 lb ae/A) and clopyralid (0.25 lb ae/A) has been the industry standard for chemical control of honey mesquite. SENDERO*, containing 2.5 lb ae clopyralid olamine salt/Gal + 0.5 ae aminopyralid potassium salt/Gal is a new herbicide for honey mesquite in western rangelands offering a favorable environmental profile and combining the proven efficacy of clopyralid with the strength of aminopyralid. In 9 aerial research trials conducted from 2009 through 2011, aerial applications of SENDERO* at 1.75 pt pr/A (equivalent to 0.5 lb ae clopyralid/ha + 0.1 lb aminopyralid/A) gave 77% control of honey mesquite at two years after application, compared to 60% with the current standard of 0.25 lb ae/A triclopyr + 0.25 lb ae/A clopyralid. A wide spectrum of common undesirable woody species including, black brush, cat claw mimosa, twisted acacia, and locust were also controlled. In 5 research trials conducted in 2011 in TX, foliar individual plant

treatments with SENDERO* at 0.75 %v/v controlled mesquite 17% greater 1 YAT than triclopyr + clopyralid (0.5 + 0.5 % v/v). SENDERO increased control of honey mesquite and significantly reduced variability in control for both aerial and IPT applications compared to older standards. SENDERO* is a new standard herbicide for mesquite control in North America.

Two-year Effects of Aminopyralid on an Invaded Meadow in the Washington Cascades. Timothy B. Harrington*[1], David H. Peter[1], Warren D. Devine[2]; [1]USDA Forest Service, Olympia, WA, [2]University of Washington, Seattle, WA (147)

Four rates of aminopyralid (30, 60, 90, and 120 g ae ha^{-1}) were compared for their ability to reduce abundance of nonnative plant species and favor native species in an invaded Cascade Mountain meadow near Trout Lake, WA. Treatments were applied in two replicated studies (June 2009 and 2010) and two-year changes in foliar cover and species diversity were monitored in each study. Absolute differences in cover between treated and non-treated plots averaged -38% and +28% for dicot and monocot species, respectively, in the second year after treatment. Control averaged 38%, 68%, 90%, and 100% for the non-native dicots, Canada thistle, oxeye daisy, red sorrel, and white clover, and 80% and 96% for the native dicots, common yarrow and woodland buttercup, respectively. Cover of the non-native monocots, Kentucky bluegrass and sheep fescue, averaged 20% and 6% greater, respectively, in treated plots than in non-treated plots. Cover decreased linearly with increasing aminopyralid rate for yarrow (R^2=0.31) and oxeye daisy (R^2=0.56); however, for most species, rate effects were not detectable. Shannon-Wiener diversity index and species richness each had negative linear relationships with aminopyralid rate (R^2=0.25 and 0.89, respectively), predicting up to 31% and 36% reductions in these variables, respectively. Overall control differed little between native (33%) and non-native species (26%; Kentucky bluegrass not included). Aminopyralid shifted the species composition of the meadow community to a lower abundance of nonnative and native dicots and a higher abundance of nonnative monocots. The treatments had no detectable effect on pale blue-eyed grass, a small iris common to the site that is categorized as endangered in Washington.

Invasive Weed Control with Aminocyclopyrachlor in North Dakota. Rodney G. Lym*; North Dakota State University, Fargo, ND (148)

The efficacy of aminocyclopyrachlor (AMCP) has been evaluated on a variety of weed species in North Dakota since 2007. AMCP has provided long-term control of several wide-spread invasive weeds such as leafy spurge, Canada thistle, and spotted knapweed. However, few studies have evaluated the long-term effect of AMCP on not-target species. The purpose of this research was to compare AMCP applied with chlorsulfuron as a DG or with 2,4-D as a LS formulation on broadleaf and grass production in non-cropland.

The experiment was established on June 9, 2011 in an ungrazed non-cropped area in north Fargo. The area had previously been heavily infested with leafy spurge, but the *Aphthona* spp. biological control agents had reduced the weed to a minor component of the vegetation. The area contained a wide variety of broadleaf species, but the major grass species present was Kentucky bluegrass.

AMCP at 1 to 2 oz/A applied with chlorsulfuron or 2,4-D (at 1 to 2 oz/A) provided an average of 81 and 94% leafy spurge control 3 months after treatment (MAT). Control declined to an average of 51% 23 MAT when AMCP was applied with chlorsulfuron, but averaged 72% when applied with 2,4-D. Canada thistle control averaged 98% 3 MAT regardless of AMCP application rate or formulation, but declined rapidly to less than 50% by 23 MAT. Western snowberry (*Symphoricarpos occidentalis* Hook.) height was initially reduced, but gradually recovered with no injury observed by 23 MAT on this native species regardless of treatment. However, Canada goldenrod (*Solidago canadensis* L.) was nearly eliminated and had not returned by the end of the study. Wild licorice (*Glycyrrhiza lepidota* Pursh) was tolerant to AMCP regardless of treatment.

AMCP applied with chlorsulfuron or 2,4-D reduced grass production the year of treatment (2011) even though no grass injury had been observed. Grass biomass averaged 1760 and 1250 lb/A when AMCP was applied with chlorsulfuron or 2,4-D, respectively, compared to 2235 lb/A in the untreated control. Grass production was similar regardless of treatment in 2012 but was much less than in 2011, likely due to drought conditions that occurred in 2012. Broadleaf plant production following AMCP application averaged 270 lb/A in 2011 compared to 1940 lb/A in the untreated control. Similar to the reduced grass production in 2012, broadleaf biomass in the untreated control only averaged 790 lb/A, but was still more than the average biomass in treated plots which again averaged 270 lb/A.

To further evaluate the efficacy of AMCP applied with chlorsulfuron compared to application with 2,4-D a series of experiments were established on leafy spurge, Canada thistle, and spotted knapweed. Long-term leafy spurge control was better when AMCP was applied as a liquid formulation with 2,4-D compared to application with chlorsulfuron as a DG or the standard treatment of picloram plus imazapic, plus 2,4-D. For instance, leafy spurge control averaged 82% with AMCP plus 2,4-D applied at 1 + 7.6 oz /A, respectively, 14 months after treatment (MAT) compared to only 41% with AMCP plus chlorsulfuron at 1 + 0.4 oz/A, respectively. In contrast to the leafy spurge study, Canada and spotted knapweed control from AMCP was excellent whether applied with chlorsulfuron or 2,4-D and averaged 98% 14 MAT.

In summary, AMCP applied with chlorsulfuron or 2,4-D reduced many of the broadleaf species in this study, including leafy spurge, Canada thistle, Canada goldenrod. Western snowberrt growth was reduced the year of treatment, but the species recovered by the year after treatment and wild licorice was very tolerant. Grass production was reduced the year of treatment but not the following growing season. AMCP should maintain long-term control of many broadleaf species but may temporarily reduce grass production.

Effectiveness of Glyphosate Tank Mixtures with Clethodim or Imazapic for Control of Buffelgrass (*Cenchrus ciliaris*). Travis M. Bean*, William B. McCloskey; University of Arizona, Tucson, AZ (149)

Various herbicides have been casually tested for efficacy in controlling invasive buffelgrass, but only glyphosate has been demonstrated to kill mature plants in a single application, though reported rates vary widely. In 2010, we began conducting a series of herbicide trials at two field locations in southern Arizona to improve buffelgrass management in the region. The objectives of this research are to establish effective application rates for glyphosate and to systematically screen herbicides, alone and in combination with glyphosate, with potential for pre emergence activity (imazapic and imazapyr), monocot selectivity (clethodim), and dormant season application (imazapyr). Plant damage and mortality for all trials has increased over a two year time frame, so monitoring and data analysis is ongoing, especially for 2011-2012 herbicide applications. Analysis of current results from glyphosate and imazapic mixtures indicate that mortality of mature buffelgrass plants can be achieved in a single application using an application rate of 2.25 lbs ae ac^{-1} glyphosate, or a 1.5 lbs ae ac^{-1} rate if imazapic is included at a rate of at least 0.0625 lbs ae ac^{-1}. Insufficient data has been obtained for analysis on the effects of imazapic on buffelgrass seedling emergence due to a lack of seedling emergence at both study sites. Current results are inconsistent for glyphosate and clethodim mixtures, showing a significant interaction between herbicide rates for some but not all trials. Summer application of imazapyr resulted in plant mortality in a single application at 1.0 and 1.5 lbs ae ac^{-1}, with severely decreased tiller counts and greenness at the 0.5 lbs ae ac^{-1} rate which may still prove fatal.

Rangeland Weed Control with Aminocyclopyrachlor. Jeff H. Meredith[1], Stephen F. Colbert*[2]; Norman D. McKinley[3], C. William Kral[3] and Keith D. Johnson[3]. [1]DuPont Crop Protection, Memphis, TN, [2]DuPont Crop Protection, Escalon, CA, [3]DuPont Crop Protection, Wilmington, Delaware (150)

DuPont Crop Protection is evaluating aminocyclopyrachlor for weed control in Western United States pasture and rangeland. Aminocyclopyrachlor is characterized by low use rates, favorable mammalian toxicological profile, and a favorable environmental profile. Aminocyclopyrachlor demonstrates both foliar and residual activity on a broad spectrum of broadleaf weeds, vines and brush species.

Data is presented on the control of key broadleaf weed species from trials across in the southern states from 2009 – 2012. Most trials had 3 – 4 replicates, applications made at 20 - 40 PSI and 15 - 30 GPA using backpack or tractor mounted sprayers. The following species were controlled by aminocyclopyrachlor-based product concepts: spotted knapweed (*Centaurea maculosa*) , diffuse knapweed (*Centaurea diffusa*), Russian knapweed (*Acroptilon repens*), Russian thistle (*Salsola* spp.), yellow starthistle (*Centaurea solstitialis*), leafy spurge (*Euphorbia esula*), houndstongue (*Cynoglossum officinale*), Dalmatian toadflax (*Linaria dalmatica*), common sunflower (*Helianthus annuus*), and perennial pepperweed (*Lepidium latifolium*).

Products containing aminocyclopyrachlor for use on range and pasture are not registered for sale or use in the United States. No offer for sale, sale or use of these products is permitted prior to the issuance of the required EPA and state registrations.

The information contained in this presentation is based on the latest to-date technical information available to DuPont, and DuPont reserves the right to update this information at any time.

Efficacy of Indaziflam for Weed Control on Roadsides and Rail in the West. Hans C. Olsen*[1], David Spak[2]; [1]Bayer CropScience, Wildomar, CA, [2]Bayer CropScience, Cary, NC (151)

Indaziflam is a new pre-emergent herbicide registered in the U.S. (tradename Esplanade 200SC) for the control of annual grasses and broadleaf weeds in non-crop areas such as roadsides, industrial sites and railroads. Indaziflam is a cellulose biosynthesis inhibitor (Group 29) which represents a novel mode of action for bareground weed control to help manage herbicide resistance. Indaziflam provides broad-spectrum, residual control of over 75 weed species, including annual grasses, broadleaf weeds and sedges. Research trials were conducted in the western U.S. over the past four years to determine the spectrum of activity of indaziflam and results indicate effective performance of indaziflam tank-mixes on problematic broadleaf weeds such as marestail (*Conyza canadensis*), kochia (*Kochia scoparia*), Russian thistle (*Salsola tragus*) and yellow starthistle (*Centaurea solstitialis*), as well as annual grasses such as annual bromegrass (*Bromus* spp.), wild barley (*Hordeum* spp.), medusahead (*Taeniatherum caputmedusae*) and sprangletop *(Leptochloa* spp.)

Prioritizing Invasive Plant Inventory Targets: San Diego National Wildlife Refuge Inventory Outcomes. Corey V. Ransom*, Kimberly A. Edvarchuk, Heather Elwood; Utah State University, Logan, UT (152)

Invasive species pose a large threat to habitat in the National Wildlife Refuge System. A pilot project involving Utah State University and the US Fish and Wildlife Service was undertaken in 2011 with the goal of evaluating a framework used to assist refuges in conducting inventories and identifying species and areas that are a priority for inventory and subsequent management. Four pilot refuges were selected to represent a diverse array of characteristics including diversity of ecosystems, presence of federally listed species, level of staffing and expertise, level of partner engagement, spatial scale, and presence of other natural resource stressors. Prioritization workshops and subsequent inventories were conducted at three of the refuges in 2011. In 2012, prioritization workshops and inventories were conducted on the San Diego National Wildlife Refuge. San Diego National Wildlife Refuge is one of four refuges within the San Diego National Wildlife Refuge Complex, located in San Diego County, California. The approved refuge acquisition boundary encompasses approximately 52,800 acres and occurs within a highly urbanized area (>3 million people). Currently there are 9,250 acres of non-contiguous lands under management with another 35,000 acres in the refuge approved boundary that are conserved by other agencies or organizations. The refuge is unique in that it has 13 endangered species, eight of which are plants. During workshops, pilot project members met with refuge staff to identify inventory objectives and to prioritize invasive plant species to target and areas to inventory. The refuge provided a list of 109 non-native plant species as potential inventory targets. Because of the difficulty in effectively searching for and accurately recognizing all 109 species and resource constraints, a prioritized list of species was developed. From the working list of the initial 109 species, refuge staff identified 32 species that threaten refuge natural resources. Evaluation of the potential risk that each species poses to biodiversity was used to develop a final list of 21 species for inventory. The list of which units within the refuge would be inventoried was based on: the presence of federally listed species or habitats, health of native vegetation communities, presence of unique plant or wetland communities, past and current habitat restoration sites, and fire history. The McGinty Mountain management unit was given high priority for inventory primarily because it provides critical habitat for several federally listed species and also contained large intact and healthy chaparral vegetation communities. A total of 1,961.6 acres were inventoried by USU crew members in the refuge, representing 21 percent of its 9,235 acres managed lands. Crews were able to conduct inventories in a total of five management units. As expected, management units varied greatly in levels of weed infestation. A total of 4,805 individual infestations or patches were mapped of both targeted and non-targeted species totaling 1,139.98 acres, or approximately 58 percent of the total inventoried area. Of the initial 24 targeted species, crew members located 20 species within the inventoried management areas. The inventory identified 11 species as early detection species. These species were found in small populations across the search areas and should be targeted for eradication.

The data collected in the 2012 inventory of San Diego National Wildlife Refuge provides crucial baseline information that will help the refuge improve their strategic planning, inform future monitoring and increase the efficiency and effectiveness of invasive plant management operations on the refuge.

PROJECT 2: WEEDS OF HORTICULTURAL CROPS

Efficacy of Granular Preemergence Herbicides to Control *Chamaesyce spp*. in Nursery Containers. Kelly M. Young*; University of Arizona, Phoenix, AZ (079)

Spurges in the genus *Chamaescyce* continue to be among the most challenging warm season weeds to manage in nursery containers. Aspects of the plants' biology contribute to this challenge, such as short generation time, small seeds and high fecundity. Poor sanitation practices at nurseries and inconsistent preemergence herbicide applications exacerbate the problem. Prolonged, high summer temperatures may affect the longevity of herbicide efficacy. Comparison of preemergence herbicides to control spurges was conducted at wholesale nursery grow yards in Phoenix, Arizona in the summer and fall of 2012. Granular formulations of dithiopyr at 0.405 lb ai/A; trifluralin + isoxaben at 3 lb ai/A and 0.75 lb ai/A, respectively; trifluralin + isoxaben + oxyfluorfen at 3 lb ai/A, 0.375 lb ai/A, and 0.375 lb ai/A, respectively; dimethenamid + pendimethalin at 1.125 lb ai/A, and 1.5 lb ai/A, respectively; flumioxazin at 0.357 lb ai/A, and oxyfluorfen + prodiamine at 2 lb and 0.75 lb ai/A, respectively were compared to a two-inch coarse wood mulch topdress and an untreated control. Herbicide applications were made on 10 July 2012 using a hand-cranked, broadcast spreader to recently transplanted *Prosopis velutina* in five-gallon containers. Each treatment was replicated five times using a randomized, complete block design. Spurge emergence was counted at 30, 45, 60 and 90 days after treatment and compared. At 90 days after treatment, the oxyfuorfen + prodiamine combination provided the greatest control, followed by fumioxazin, dithiopyr and the dimethenamid + pendimethalin combination, in that order. The two trifluralin combinations and mulch topdress did not perform statistically better than the untreated control by 90 days after treatment.

Preemergence Herbicide Trials in California Bell Peppers. Michelle Le Strange*[1], Richard F. Smith[2]; [1]University of California Cooperative Extension, Tulare, CA, [2]University of California Cooperative Extension, Salinas, CA (080)

Weed control challenges for field grown peppers without plastic mulch continue to be significant in California. Peppers are long-season vegetables that compete weakly with weeds for the first 40 to 60 days following transplanting, while late season weeds can make crop harvest difficult. They are a crop that can be subject to flushes of both winter and summer annual weeds over the course of their growing cycle. Several perennial weeds such as field bindweed and yellow and purple nutsedge are also problematic. In addition, growers are reticent to send weeding crews into fields with heavy weed growth later in the season, since pepper plants become brittle and easily damage. The preemergence herbicides registered for peppers have gaps in the spectrum of weeds that they control and there are very few selective postemergent herbicides that are registered in peppers, and no new herbicides being developed for peppers. As a result of these challenges, weed management is a significant cost of production with growers easily spending up to $400 per acre on herbicide application, mechanical cultivation, and hand hoeing. Since 2004 tandem field studies have been conducted in two of the four major growing regions of California (Central Valley and Central Coast) looking for selective preemergence herbicides suitable for use in transplanted bell pepper production. Application timings include at planting and at layby. At planting applications have looked at pre-transplant, post-transplant over the top, and post-transplant directed spray for some of the herbicides in order to achieve better crop safety. Crop phytotoxicity and weed control ratings, weed counts and bell pepper yields were collected. Pigweeds (prostrate, tumble and redroot), nightshades (black, hairy, and groundcherry), common lambsquarters, common purslane, common groundsel, puncturevine and junglerice were the main weeds tested. Trial results investigating weed control and crop safety of flumioxazin, oxyfluorfen, s-metolachlor, and pendimethalin compared to DCPA and napropamide have led to changes in label registrations for California. Field experiments conducted in 2010, 2011, and 2012 investigated 1x and 2x rates of dimethenamid-p, ethofumesate, and sulfentrazone compared to pendimethalin, and s-metolachlor applied at planting and layby. These trials show that layby applications of dimethenamid–p provide excellent weed control and crop safety with no pepper yield reduction. Where ethofumesate and sulfentrazone contacted the foliage they caused initial phytotoxicity on the leaves, however these symptoms were greatly reduced with time. A 4x application of dimethenamid –p resulted in less phytotoxicity to pepper leaves than a 2x rate of ethofumesate or a 1x rate of sulfentrazone. An application of a 2x rate of dimethenamid-p showed the same pepper phytotoxicity as a 1x application of pendimethalin, both of which diminished as the peppers grew.

Effects of Glyphosate Carryover in Seed Potato Tubers. Pamela Hutchinson*[1], Joel Felix[2], Rick Boydston[3], Brent R. Beutler[1]; [1]University of Idaho, Aberdeen, ID, [2]Oregon State University, Ontario, OR, [3]USDA-ARS, Prosser, WA (081)

Glyphosate on potato foliage can move to developing daughter tubers being grown for seed and affect emergence, growth, and yield of plants growing from those tubers the next year. A study using Ranger Russet was conducted in ID, OR, and WA in 2008-09. In 2008, glyphosate was applied at five rates (1/2, 1/4, 1/8, 1/16, and 1/100 the RR sugar beet rate of 21.5 fl oz/A Roundup PowerMax) at five different timings: when potatoes were 4 to 6 inches tall (SP), at stolon hooking (SH), tuber initiation (TI), or tuber mid-bulking (MB). A nontreated control was included. The greatest foliar injury and U.S. No. 1 and total tuber yield reductions were caused by SH or TI applications compared with injury and yields from SP, MB, or control treatments. Averaged across application times, yields decreased as glyphosate rate increased. In 2009, daughter tubers from 2008 were planted. No underground multiple sprouting was observed. Daughter tuber emergence was lowest when glyphosate was applied to the mother plants at MB even though no injury was observed on those plants. Overall, as glyphosate rate increased, emergence decreased. Daughter tuber yields were affected by emergence and subsequent plant injury displayed during the season. A similar study was conducted in 2011-12 with Russet Burbank including an additional application at vine-kill time (VK), and no 1/2X rate. Tubers harvested from each treatment were planted in a winter grow-out trial and effect on emergence was similar to that of Ranger Russet planted in the spring 2009 trial. However, Russet Burbank daughter tubers had underground multiple sprouting. Daughter tubers were planted spring 2012 at Aberdeen and applications to mother crop the previous year when 4 to 6 inch tall or at VK did not affect emergence from daughter tubers. However, TI and MB applications to the mother crop did affect daughter tuber germination and within these two timing treatments, as glyphosate rate increased germination decreased. As could be expected, tuber yields and quality were lower in the low germination plots compared to the control and other timing treatment plots. Implications are that even though glyphosate drift or miss-application occurring during mid- to late-bulking times may not be noticed on the mother crop, the daughter tubers could be affected. In addition, while Ranger Russet seed was affected by glyphosate applied to the mother crop during MB, Russet Burbank seed was affected by both TI and MB timing treatments. Therefore, potato varieties seemingly respond differently when glyphosate has been encountered by the mother crop. A trial similar to the Russet Burbank has been initiated at Aberdeen with Shepody in 2012 and daughter tuber seed will be planted in the winter grow-out and spring 2013.

Chemigating Pronamide With Split Applications on Lettuce. Jesse Richardson*[1], Barry Tickes[2], Richard Mann[3]; [1]Dow AgroSciences, Hesperia, CA, [2]University of Arizona, Yuma, AZ, [3]Dow AgroSciences, Indianapolis, IN (082)

Sprinkler application of pronamide (Kerb® SC herbicide) through overhead sprinklers has become commonplace in lettuce (*Lactuca sativa*), particularly in the low desert production areas of Arizona and Southern California. This method of application provides more dependable weed control than ground application in that growing region. Studies were conducted in 2008, 2009 and 2012 to determine the feasibility of applying pronamide in two chemigation events, rather than one. In 2008 in a study at Bard, CA, pronamide was chemigated at rates of 0.5, 0.625, and 0.75 lb a.i./acre just prior to lettuce emergence. These three treatments were compared to an identical set of treatments, but with the addition of a second chemigation three days later. The second set of treatments included pronamide at 0.5 + 0.5, 0.625 + 0.375, and 0.75 + 0.25 lb a.i./acre. Adding a second chemigation did not improve control of common purslane (*Portulaca oleracea*) or annual sowthistle (*Sonchus oleraceus*), but it did provide better control of nettleleaf goosefoot (*Chenopodium murale*), particularly at the lower initial pronamide rates. The study was repeated in 2009 at Holtville, CA. In this study, the second chemigation did not improve control of Italian ryegrass (*Lolium perenne*) or shepherd's-purse (*Capsella bursa-pastoris*). A third study was conducted in Yuma, AZ in 2012. In this study, pronamide was applied at 0.5, 0.625, and 0.75 lb a.i./acre just prior to lettuce emergence. The three treatments were compared to pronamide applied at 0.5 + 0.5, 0.625 + 0.625, and 0.75 + 0.75 lb a.i./acre, with the second application three days after the first. Italian ryegrass control was excellent, regardless of the pronamide treatment. Better control of annual sowthistle, littleseed canarygrass (*Phalaris minor*), common purslane, annual bluegrass (*Poa annua*) and nettleleaf goosefoot was achieved with all treatments, when compared to the 0.5 lb a.i./acre rate of pronamide applied once. At the higher pronamide rates, a second application did not improve control of any weed species.

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Weed Control in Grape Vineyards with Flazasulfuron. Dennis J. Tonks*[1], Melvin R. Grove[2]; [1]ISK Biosciences, Kearney, MO, [2]ISK Biosciences, Spring, TX (083)

Mission™ is a new herbicide containing the active ingredient flazasulfuron and is registered for use in grapes for pre- and post-emergence weed control and is being evaluated for use on other crops. In Europe, flazasulfuron has been successfully used for several years in grapes, citrus, and olives. Flazasulfuron can be used to control over 60 grasses and broadleaf weeds. Trials were conducted in 2012 evaluating flazasulfuron performance compared to flumioxazin and rimsulfuron applied to dormant grape vineyards in California. Trials were conducted at 15 locations in the San Joaquin and Napa Valleys and coastal areas of California. Treatments included flazasulfuron at 40 and 50 g ai/ha, flumioxazin at 430 g ai/ha, and rimsulfuron at 70 g ai/ha. Treatments were applied in January or February 2012, prior to bud break in grapes. All treatments were either mixed with glyphosate at the time of application or a separate application was made prior to treatment application to control all existing weeds. Herbicides were applied to both sides of the grape row. Plot sizes varied among trials, and were approximately 2 m wide and ranged from 7.6 to 30 m in length. Generally, weed control was excellent with all treatments up to 120 days after treatment with weed control of all species evaluated were > 90%. Two trials evaluated weeds to 200 days after treatment and control was still > 90% for all herbicides for the limited species evaluated.

Evaluating Mesotrione for Crop Safety and Weed Control Efficacy in Grape and Walnut. Lynn M. Sosnoskie*[1], Bradley D. Hanson[1], Derrick Hammons[2]; [1]University of California - Davis, Davis, CA, [2]Syngenta, Esparto, CA (084)

Currently in CA, there are 26 weed biotypes that have been documented as being resistant to at least one herbicide or herbicide class. Although the majority of known resistances (to the ALS-inhibitors, ACCase-inhibitors, and thiocarbamates) have developed in rice production systems, the most recently confirmed cases are glyphosate-resistant orchard and vineyard weeds. Current recommendations for preventing and managing herbicide resistance in perennial systems advocate rotating chemistries to reduce selection pressure; therefore, the registration of new chemical weed control products is essential in order to provide sufficient diversity with respect to herbicide mode of action. The purpose of these research trials was to evaluate mesotrione, which is not currently registered for use in perennial horticultural crops in CA, for crop safety and weed control efficacy in orchards and vineyards. The studies were conducted in a commercial walnut orchard (experimental rootstock and scion), located in Wheatland, CA, and in table (Thompson seedless) and wine (Merlot) grapes, in Parlier, CA. Initial herbicide applications were made on 21 November, 2012, for walnuts and 21 February, 2012 for grapes. At both sites, herbicide treatments included: a non-treated check; paraquat (0.75 lb ai/A) applied alone; mesotrione (0.09 lb ai/A) applied alone; paraquat plus mesotrione (0.09, 0.19, or 0.38 lb ai/A); paraquat plus mesotrione (0.19 lb ai/A) and simazine (2 lb ai/A) or rimsulfuron (0.06 lb ai/A) or oxyfluorfen (1.25 lb ai/A) or saflufenacil (0.04 lb ai/A); paraquat plus mesotrione (0.09 or 0.19 lb ai/A) applied sequentially; paraquat plus saflufenacil (0.04 lb ai/A), oxyfluorfen (1.25 lb ai/A), penoxsulam/oxyfluorfen (1.5 lb ai/A) or indaziflam (0.085 lb ai/A); and flumioxazin (0.32 lb ai/A) plus glufosinate (0.86 lb ai/A). Sequential treatments were applied on 23 March, 2012 (walnuts) and 9 May, 2012 (grapes). Crop safety and weed control evaluations were made at monthly intervals after the trials were established. No crop injury was observed at either site. In the walnut trial, burclover, redstem filaree and ryegrass species were the most regularly occurring weeds across all observation periods. In Parlier, redstem filaree, spotted spurge, horseweed and hairy fleabane were the most commonly observed species. Paraquat plus mesotrione (all rates), without the inclusion of an additional tank mix partner, provided between 50 and 81% weed control 3 to 4 months after treatment (MAT) across both sites; the addition of simazine, rimsulfuron or oxyfluorfen increased overall weed control to 76 to 98%. The use of sequential applications of paraquat plus mesotrione extended the duration of total weed control in both systems. With respect to weed control at 4 to 5 MAT, all but one of the mesotrione treatments were statistically similar (P>0.05) to an industry standard of flumioxazin plus glufosinate. Observed weed control in the grape studies was likely affected by the differential activity of the evaluated herbicides against individual weed species, namely spotted spurge, horseweed and hairy fleabane. In general, the mesotrione treatments were relatively ineffective at reducing spotted spurge densities, although they were statistically better than the flumioxazin plus glufosinate standard for controlling horseweed and fleabane.

Herbicide Evaluation for Dahlia in Western Washington. Yushan Duan*[1], Timothy W. Miller[2], Carl R. Libbey[2]; [1]Washington State University, Pullman, WA, [2]Washington State University, Mount Vernon, WA (085)

Dahlia is an ornamental crop whose value for cut flowers and tuber production is as much as $100,000 per acre. Dahlia is currently produced about 75 acres in 20 counties in Washington State. It is a poor competitor with weeds due to the generally slow early-season growth and shallow root system. Due to its high value and small acreage, there are few herbicide currently registered for use in dahlia and growers rely on cultivation and hand weed control to keep production field free of weeds. Therefore, nine herbicides including two registered products (EPTC and trifluralin) were evaluated for efficacy and crop safety in three dahlia cultivars ('Parkland Rave', 'Audrey Grace' and 'Javier G') over two years at Washington State University Northwestern Research and Extension Center, Mount Vernon, WA. In 2011, weed control at 6 weeks after treatment (WAT) was over 90% with diuron (4 lbs ai/A) and pendimethalin (2 lbs ai/A), and over 75% for mesotrione (0.2 lbs ai/A), flumioxazin (0.1 lbs ai/A) and EPTC (5.7 lbs ai/A). In 2012, all herbicides except napropamide (4 lbs ai/A) were giving over 90% weed control at about 4 WAT. Flower number, stem length or tuber yield did not differ significantly among treatments in either year. However, dahlia treated with pendimethalin produced significantly more flower buds in the second year. No crop injury was observed and all tested herbicides appeared to be safe in these three dahlia cultivars.

The Effect of Combined Solarization and Destabilized Green Waste Composting on Weed Seed Mortality and Soil Biology. Ruth M. Dahlquist[1], Christopher W. Simmons.[2], Dee Ann Kroeker[1], K.M. Hernandez[1], S.T. Betts.[1], J.T. Claypool[2], L.K. Jabusch[2], Megan N. Marshall[3], Mean S. VanderGheynst[2], James J. Stapleton[4]* [1]Department of Biology, Fresno Pacific University, Fresno, CA; [2]Department of BioAg Engineering, University of California, Davis, CA; [3]Department of BioAg Engineering, Pennsylvania State University, University Park, PA; [4]Statewide IPM Program, UC Kearney Agricultural Center, Parlier, CA (086)

Soil solarization can be useful as a pre-plant treatment to eliminate weed propagative structures in soil without using fumigants or herbicides. With the goal of making solarization-based soil treatments more effective, predictable and flexible, we tested mortality of *Brassica nigra* (black mustard) seeds in field soil amended with mature green waste compost activated with wheat bran, as compared to non-amended field soil. The soils were solarized in Parlier, CA for 22 days in July 2011 and 15 days in July 2012. Mortality of seeds buried in compost-amended soil was significantly higher than non-amended soil both years. Additional laboratory and field studies showed that amended soil resulted in temperatures 2-4 ^{o}C higher than in soil alone, and that ~85% of total organic carbon in amended soil was exhausted within 22 days of heating. Bacterial community structure in solarized soil was measured by 16s rDNA sequencing.

Community structure changed based on soil amendment and solarization. Also, communities varied with soil depth, indicating possible enrichment of thermophiles and other niche-specific taxa.

What's The Fit For Roundup Ready Alfalfa? Robert G. Wilson*; University of Nebraska-Lincoln, Scottsbluff, NE (087)

Experiments were conducted at Scottsbluff, Nebraska during 2011 and 2012 to examine various aspects of Roundup Ready Alfalfa 'DeKalb 41-18RR' production when the crop was grown under irrigation. Two of the experiments were initiated in 2011 and forage production was examined a year following establishment in 2012. Three other experiments were initiated in 2012 to examine enhanced forage production, establishment of mixtures of perennial grass and alfalfa, and herbicide-resistant weed management. Alfalfa density declined 60% from the spring of 2011 (16 plants/sq. ft.) to the spring of 2012 (6 plants/sq. ft.) due to self thinning, winter kill or disease. Establishment of alfalfa in 2011 with no weed suppression resulted in less forage production in the same area the following year, even though weeds were suppressed in 2012. Control of weeds in the year (2012) of establishment at Scottsbluff with glyphosate resulted in a 20% increase in alfalfa density 5 months after planting and a 10% increase in the relative feed value (RFV) of forage. In the untreated, the first cutting of forage contained 8% alfalfa and 92% weeds while treatment with glyphosate or biomoxynil changed the composition to 84% alfalfa and 15% weeds. Orchardgrass, tall fescue and meadow fescue could be successfully established in Roundup Ready alfalfa by applying glyphosate at the three trifoliate alfalfa growth stage to reduce weed competition and then seeding grasses the following day. Seeding perennial grasses following the first alfalfa cutting resulted in poor grass establishment, in addition failure to control weeds in seedling alfalfa reduced perennial grass density. During the year of establishment forage production (3 cuttings) utilizing Roundup Ready alfalfa could be increased 0.6 tons/acre (12% moisture) over that achieved by only treating with glyphosate (3.4 tons/acre) when Mustang Max (0.018 lb/acre) and Nachurs foliar fertilizer (1.5 qt/acre) were applied to 4 inch tall alfalfa before the first cutting and after the first and second cuttings (4.0 tons/acre). Adding preplant P-K-S fertilizer before seeding, glyphosate for weed control, Mustang Max, Nachurs and Headline SC at 1.125 lb/acre to 4 inch tall alfalfa before the first cutting and after the first and second cuttings resulted in total production of 4.3 tons/acre (3 cuttings) during the year of establishment. Roundup Ready alfalfa offers the producer the advantage of suppressing weeds with glyphosate without crop injury. For producers with perennial and annual weed problems this technology offers unique advantages.

Dry Bean Tolerance to Flumioxazin. Robert G. Wilson*; University of Nebraska-Lincoln, Scottsbluff, NE (088)

Flumioxazin is a promising herbicide for preemergence hairy nightshade and palmer amaranth control in dry beans. During the 2008 growing season some of the treated acres suffered a degree of crop injury while weed control was excellent. Studies were initiated at Mitchell, Nebraska to examine the influence of the amount of corn residue, flumioxazin rate, time of herbicide application and dry bean market class on the extent of crop injury and weed efficacy. Three levels of corn stover were established two weeks before dry bean planting; 90% corn residue (no-till); one discing, 50% corn residue; and two discings, 25% corn residue. Flumioxazin was applied at 0.0469 (1X) or 0.1406 (3X) kg/ha either 7 days before planting, at planting, 4 days after planting, and at the time of dry bean cracking. Six different market classes: Great Northern, black, small red, light red kidney, yellow, and pinto were planted in each plot and all treatments were replicated four times. Early season dry bean injury was influenced by amount of corn residue, time and rate of flumioxazin application and dry bean market class. When averaged over all treatments crop injury increased from 4 to 16% as flumioxazin rate increased from 1X to 3X. Crop injury was lowest with 90% corn residue coverage in no-till and greatest with 25% residue coverage with two discings. Crop response was least when flumioxazin was applied 7 days before planting (5%) or at planting (9%), and then increased to 19% when applied 4 days after planting and 28% at cracking. Flumioxazin applied 4 days after planting causes the greatest injury to blacks > Great Northern > small red > yellow, and the least to light red kidney and pinto market classes. The results of this experiment indicate that dry bean injury from flumioxazin is minimal when the herbicide is applied 7 days before planting, in no-till crop production and to pinto and light red kidney market classes.

Rotational Crop Response to Fomesafen Soil Residues one Year after Application. Joel Felix*; Oregon State University, Ontario, OR (089)

A field study was conducted in 2012 at the Malheur Experiment Station, Ontario, OR to evaluate the response of several rotational crops to soil residues of fomesafen applied in 2011 to control weeds in potato. Fomesafen was applied prior to potato emergence at 280 or 560 g ai ha^{-1} alone or at 280 g ai ha^{-1}tank-mixed with *S*-metolachlor plus pendimethalin at 1,420 and 1,060 g ai ha^{-1}, respectively. A grower standard of *S*-metolachlor 1,420 g ai ha^{-1} plus pendimethalin 1,060 g ai ha^{-1} was included. No injury was observed on winter wheat var. ‘Stephens’ and spring wheat var. ‘Alturas’ planted 179 and 293 days after herbicide application, respectively. Similarly, pinto bean var. ‘Windbreaker’ was not injured by fomesafen soil residues when planted 360 days after herbicide application. However, spring barley var. ‘Millennium’ planted 293 days after herbicide application was injured 48 to 72% by fomesafen soil residues and the grain yield was reduced 19% compared to the grower standard. Also, sugar beet hybrid ‘27RR20’ planted 324 days after herbicide application was injured 13 to 95% across fomesafen containing treatments. Residues from fomesafen applied at 560 g ai h^{-1} injured sugar beet the most and reduced beet root yield and estimated recoverable sugar by 35% and 41%, respectively, compared to the grower standard. Soil residues from fomesafen at 280 g ai ha^{-1} did not injure rotational dry bulb onion var. ‘Vaquero’ planted 296 days after herbicide application. However, residues from 560 g ai ha^{-1} caused 92% onion injury and the U.S. no. 1 bulb yield was reduced 60% compared to the grower standard. Sweet corn var. ‘Golden Bantam’ was injured 40 to 92% by fomesafen soil residues compared to the grower standard. The results suggested that winter- and spring wheat, direct-seeded bulb onion, as well as pinto bean could be planted safely at 179 and 293, 296, 360 days, respectively, following application of fomesafen 280 g ai ha^{-1} to control weeds in potato.

Meadowfoam Seed Meal Effects on Weed and Soil Microbial Communities. Suphannika Intanon*, Andrew Hulting, Carol Mallory-Smith; Oregon State University, Corvallis, OR (090)

Meadowfoam (*Limnanthus alba* Hartw. *ex* Benth) seed meal, a by-product of meadowfoam oil extraction, has glucosinolate degradation compounds that are similar to those from Brassicaceae. The compounds are reported to be herbicidal. Two field studies were conducted to evaluate the application of meadowfoam seed meal for weed control in lettuce and the effect of meadowfoam seed meal on soil microbial activity. Meadowfoam seed meal was applied either as 2.86 kg m^{-2} on day 0 or as 1.43 kg m^{-2} on day 0 followed by 1.43 kg m^{-2} on day 7. To account for the fertilizer effect of the seed meal, urea was used as a nitrogen source and applied either as 16.8 g m^{-2} on day 0 or as 8.4 g m^{-2} on day 0 followed by 8.4 g m^{-2} on day 7. Meadowfoam seed meal treatments suppressed weed emergence and growth. Emergence suppression was greater than 94% on spiny sowthistle and 70% on Japanease millet in meadowfoam seed meal treatments compared to untreated control. Meadowfoam seed meal appeared to be organic source of nitrogen and sulfur. The carbon inputs from meadowfoam seed meal increased the gross metabolic activity of the mixed microbial population. The microbial enzyme activity varied with amended materials and sampling times. The split rate application of meadowfoam seed meal provided weed control similar to the full rate application but caused more lettuce injury. Thus, both fertilizer and bioherbicide effects were found with the use of meadowfoam seed meal.

Dithiopyr: New Developments for Post Emergent Crabgrass Control in the Western and Southern U.S. Vanelle F. Peterson*[1], James M. Breuninger[2], Daniel D. Loughner[3], Anita L. Alexander[4], Mike D. Lees[5], James T. Brosnan[6], Gregory K. Breeden[6], Barry Brecke[7], Ramon Leon[8], Scott McElroy[9], Michael Flessner[9]; [1]Dow AgroSciences, Mulino, OR, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Lawrenceville, NJ, [4]Dow AgroSciences, Lawrenceville, GA, [5]Dow AgroSciences, Granite Bay, CA, [6]University of Tennessee, Knoxville, TN, [7]University of Florida, Milton, FL, [8]University of Florida, Jay, FL, [9]Auburn University, Auburn, AL (122)

Dithiopyr (Dimension® 2EW) is a member of the pyridinecarboxylic acid family of herbicides and controls annual grasses, especially crabgrass (*Digitaria spp.*), and several small-seeded annual broadleaf weeds in established lawns, commercial sod farms, non-cropland and industrial sites, ornamental turf, and container, field-grown, and landscape ornamentals. The current label allows for use on crabgrass at early post emergence: *"Early postemergence applications of this product will control crabgrass only if applied prior to the fifth leaf (first tiller) stage of growth…. The addition of a nonionic surfactant at 0.5% by volume (2 qt per 100 gallons of spray) may improve early postemergence control."* Research was conducted from 2010 through 2012 in CA, FL, AL, and TN to establish the potential for post emergent control of crabgrass past the fifth leaf stage and the need for a surfactant with those applications. Experiments were designed as randomized complete blocks with 4 replications per treatment. Broadcast applications were made with a CO_2 backpack sprayer at 80 or 86 GPA on 5 by 10 ft plots. At 4 sites in CA in 2010 and 2011, dithiopyr at 0.5 lbs ai/A provided excellent crabgrass control (93%) 6 to 10 weeks after post emergent applications to 1 to 3 tiller crabgrass in bermudagrass turf. In 2012, all sites were bermudagrass (*Cynodon dactylon*) or a bermudagrass and fescue (*Fescue spp*.) mix (CA) Treatments were dithiopyr at 0.5 lb ai/A with and without 0.25% v/v non-ionic surfactant, MSMA at 2 lb ai/A with 0.25% v/v non-ionic surfactant, and quinclorac at 0.75 lb ai/A (as Drive XLR8) with 1.5 pints product/A crop oil concentrate. Applications were made on crabgrass (*Digitaris adscendens* in AL, and *D. ischaemum* in CA, TN and FL) before tillering, 1 to 2 tiller or 3 to 5 tiller. Percent visual cover and control evaluations of crabgrass were made at 3 to 5, 6 to 10 and 11 to 14 weeks after each application timing. Results from sites were combined and analyzed using general linear mixed model techniques and Tukey's mean comparison test (P=0.05). At 11 to 14 weeks after application, control of crabgrass was excellent with dithiopyr applied with or without a non-ionic surfactant before tillering (97% for both treatments) and 1 to 2 tiller (85 or 87%). Quinclorac and MSMA gave 50% control or less at these 2 timings. At the 3 to 5 tiller stage crabgrass control with dithiopyr with a surfactant (58%) was better than without the surfactant (37%), quinclorac (31%) or MSMA (30%). A surfactant was not necessary when dithiopyr was applied before tillering or 1 to 2 tiller stages. Dithiopyr, labeled for selective use in all major turf grass species, gave superior post emergence control of crabgrass than quinclorac or MSMA, which have limited tolerance in key turf grass species. New label wording is being considered for the Dimension 2EW label to expand the window for post emergent crabgrass control in bermudagrass and turfgrasses.

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Performance and Efficacy of Amicarbazone and Methiozolin for Poa annua Management in Desert Turfgrasses. Kai Umeda*[1], David Kopec[2]; [1]University of Arizona Cooperative Extension, Phoenix, AZ, [2]University of Arizona, Tucson, AZ (123)

Amicarbazone at 0.18 and 0.22 lb a.i./A applied in the fall of 2010 initially gave 88 to 90% control, respectively, of *P. annua* at 2 months after sequential applications. During spring bermudagrass transition, the treated *P. annua* recovered and control decreased to only 73%. Amicarbazone did not injure perennial ryegrass. During the fall of 2011, amicarbazone at 0.13 or 0.18 lb a.i./A was applied at four different timings after overseeding and then followed with a sequential application at 2 weeks after the initial application. All treatments were applied with a backpack CO_2 sprayer equipped with a hand-held boom with three flat fan nozzles. Following sequential applications at 2 to 4 months after overseeding during November 2011 into January 2012, perennial ryegrass was severely injured as high as 56% by amicarbazone at 0.18 lb a.i./A where the sprays in the plots were started and ended. Timings of sequential applications following overseeding provided only as high as 62% control with amicarbazone at 0.18 lb a.i./A. Another identical experiment was initiated but only a single application was made after which severe perennial ryegrass phytotoxicity was observed. At the front and back parts of the sprayed plots, 20 and 30% injury was caused by amicarbazone at 0.13 and 0.18 lb a.i./A, respectively. A third experiment investigated the safety of amicarbazone on perennial ryegrass with and without nonionic surfactant. Amicarbazone at 0.09 and 0.13 lb a.i./A without a surfactant caused less injury at the front and back part of the sprayed plots. Amicarbazone at 0.13 lb a.i./A with a surfactant gave *P. annua* control that approached an acceptable level at 82% compared to 62% without surfactant

Methiozolin at 0.5 lb a.i./A was most efficacious with four applications applied at 10-day intervals during November to December 2011. *P. annua* control was more effective and complete with only few plants recovering and regrowing. *P. annua* that was controlled did not create voids in the green's surface as bentgrass filled in gradually. The *P. annua* control process was gradual from chlorosis to eventual elimination. Spring applications initiated in February or March did not satisfactorily give acceptable control at less than 85% control. During December applications, *P. annua* did not exhibit any symptoms until weeks after the fourth application of methiozolin. Spring applications exhibited chlorotic symptoms following the third application at 10-day intervals. Bentgrass was relatively safe and only showed slight discoloration.

New Approaches to Manage Difficult to Control Turfgrass Weeds in Hawaii. Kai Umeda*[1], Joseph DeFrank[2], Orville Baldos[2], Scott Lukas[2], Craig Okazaki[2]; [1]University of Arizona Cooperative Extension, Phoenix, AZ, [2]University of Hawaii, Honolulu, HI (124)

Results of five separate field experiments on golf course and municipal athletic field turfgrasses demonstrated efficacy of postemergence herbicides against goosegrass (*Eleusine indica*), kyllinga (*Kyllinga brevifolia*), dallisgrass (*Paspalum dilatatum*), hilograss (*Paspalum conjugatum*), and carpetgrass (*Axonopus compressus*). Experiment 1 showed that the pre-mix product thiencarbazone + foramsulfuron + halosulfuron (Tribute Total) with methylated seed oil applied sequentially in August followed again in September gave acceptable control of goosegrass for about 1 month. Slight bermudagrass turf injury was observed. Experiment 2 on an adjacent soccer field included Tribute Total at 0.121 lb a.i./A applied twice gave very good control of kyllinga. Similarly, 2 applications of sulfentrazone + metsulfuron-methyl (Blindside) at 0.413 lb a.i./A controlled kyllinga. On a baseball field infested with dallisgrass, Experiment 3 compared Tribute Total tank-mixes, and the addition of metribuzin with methylated seed oil and ammonium sulfate visually enhanced efficacy over the addition of non-ionic surfactant for dallisgrass control. Imazamox at 0.045 and 0.06 lb a.i./A reduced dallisgrass following sequential applications in September and October in another experiment. The final experiment compared the efficacy and safety of postemergence herbicides with and without broadcast spreading of salt, NaCl at 1000 lb/A on seashore paspalum (*P. vaginatum*) and bermudagrass on a golf course green and surrounding collar area. Tribute Total, foramsulfuron, trifloxysulfuron, and thiencarbazone + iodosulfuron + dicamba (Celsius) applied alone or in combination with salt reduced hilograss population. Tribute Total and Blindside with salt gave acceptable reduction of carpetgrass. Tribute Total, Blindside, Celsius, and trifloxysulfuron alone or with salt controlled green kyllinga. The application of salt alone did not cause injury to the seashore paspalum compared to reducing bermudagrass nearly 50% for 2 to 3 months after treating. Tribute Total, foramsulfuron, Celsius, and trifloxysulfuron caused marginally acceptable chlorosis of the seashore paspalum.

Advances in Control of Diuron Resistant Annual Bluegrass (Poa annua) in Cool Season Grasses Grown for Seed. Daniel W. Curtis*, Andrew Hulting, Carol Mallory-Smith, Kyle C. Roerig; Oregon State University, Corvallis, OR (125)

Cool season grasses grown for seed are swathed into windrows, allowed to dry and then threshed with a combine equipped with a pick-up header. Weed seeds present in the crop are inherently harvested along with the crop seed in this production system. Oregon seed certification allows contamination of only 0.3% annual bluegrass (Poa annua) seed by weight. Many seed companies have a zero tolerance. Thus, annual bluegrass seed contamination in cool season grass seed production is a major production factor to growers. Diuron has been used to control annual bluegrass which has led to many diuron resistant populations of annual bluegrass. Field experiments were conducted from 2009-2012 to examine weed control efficacy and crop tolerance of grasses grown for seed to pyroxasulfone and flumioxazin. Early January, 2009, treatments of pyroxasulfone applied at 100 g ai/ha and flumioxazin applied at 112 g ai/ha to an established stand of perennial ryegrass with diuron resistant annual bluegrass resulted in control of 90% or greater with pyroxasulfone and 48% with the flumioxazin. Yields were not different than the untreated control. A study initiated in the fall of 2009 documented crop safety and diuron resistant annual bluegrass control with V-10206 (pyroxasulfone) and flumioxazin. V-

10206 was applied at 59, 119 and 239 g/ha preemergence to diuron resistant annual bluegrass. The diuron resistant annual bluegrass was controlled 90% or greater at all three rates. In this study, a flumioxazin treatment was applied at 70 g/ha and controlled 83% of the diuron resistant annual bluegrass. Yields were not affected by these treatments. Two studies were conducted during the 2010-2011 growing season, one in established perennial ryegrass and one in established tall fescue, with four rates of V-10233, a combination of flumioxazin and pyroxasulfone. V-10233 was applied preemergence to diuron resistant annual bluegrass at 106, 160, 213 and 319 g/ha. In the perennial ryegrass study, diuron resistant annual bluegrass was controlled 90% or greater with the three higher rates of V-10233. In the tall fescue study, V-10233 controlled the diuron resistant annual bluegrass 90% at the lowest rate and 100% at the higher three rates. These studies indicate V-10233 controls annual bluegrass with adequate crop safety in cool season grass seed production.

PROJECT 3: WEEDS OF AGRONOMIC CROPS

Fertility of Wheat x Jointed Goatgrass (Aegilops cylindrica Host.) First Generation Backcross Progenies. Craig Beil*[1], Philip Westra[2], Pat Byrne[1]; [1]Colorado State University, Fort Collins, CO, [2]Colorado State University, Ft. Collins, CO (091)

Interest in the deregulation of transgenic wheat cultivars has led to increased concerns regarding introgression of novel genes from wheat to jointed goatgrass. Field trials were conducted in Colorado during the 2010-11 and 2011-12 growing seasons and supplemented with greenhouse trials to determine backcrossing rates of wheat x jointed goatgrass first generation backcross (BC_1) plants. Backcrossing rates in the field were determined with germination studies of spikes collected from 14 BC_1 plants in 2011 and 6 BC_1 plants in 2012. Pollination of BC_1 plants with jointed goatgrass led to the production of 43 BC_2 plants from the 2010-11 growing season and 1 BC_2 plant from the 2011-12 growing season. Mean BC_1 backcrossing rates for the 2010-11 and 2011-12 growing seasons were estimated at 0.648% and 0.024%, respectively. Self-fertility of BC_1 plants was estimated using two different methods: a single bagged spike method (17 plants) and a whole bagged plant self-pollination method (37 plants) resulting in self-fertility of rates of 0.0% and 0.004%, respectively. Given the low self-fertility rate of BC_1 plants in our trials, the progeny from field BC_1 plants are most likely the result of a backcrossing event and not a self-pollination event. These results demonstrate the first direct account of a mean backcrossing rate of BC_1 plants pollinated by jointed goatgrass under field conditions. Determining the best management practices of transgenic cultivars will be necessary to minimize gene introgression from wheat to jointed goatgrass.

Investigating the Mechanism of Glyphosate Resistance in Nineteen Giant Ragweed Accessions. Christopher R. Van Horn*[1], Philip Westra[2]; [1]Colorado State University, Fort Collins, CO, [2]Colorado State University, Ft. Collins, CO (092)

In the wake of glyphosate resistant crops we have seen a boom in the number of glyphosate resistant weeds. This is partly due to the overuse of glyphosate as part of poor weed management strategies that fail to address long-term weed control. In order to implement the best strategies to manage glyphosate resistant weeds, it is important that we understand the mechanism of resistance. Glyphosate resistance in giant ragweed (*Ambrosia trifida*) was first discovered in 2004 and we still do not know the mechanism of this resistance today. Glyphosate is a nonselective herbicide that targets and inhibits the enzyme 5-enolpyruvalshikimate-3-phosphate synthase (EPSPS), preventing the synthesis of essential aromatic amino acids. We have used twenty different populations of giant ragweed throughout the midwest United States and southern Ontario, Canada to investigate the mechanism of glyphosate resistance. From these twenty accessions, we have characterized three phenotypic responses to glyphosate treatment: susceptible, resistant slow response, and resistant rapid necrosis. Observational data suggests that light is a necessary component to stimulate the rapid necrosis response. Sequence analysis showed no nucleotide mutation at the Proline-106 target site region across all populations. Analysis of EPSPS protein level using western blotting suggested no evidence of increased EPSPS in either glyphosate resistant or susceptible populations. Shikimate data suggests a translocation-based resistance mechanism may be involved. These initial results provide a much needed framework for the future of giant ragweed glyphosate resistance research.

Weed Control in California Rice with Imazosulfuron plus Thiobencarb (League MVPTM). Patrick A. Clay*[1], Tom Dewitt[2], John Pawlak[3], Frank Carey[4]; [1]Valent U.S.A. Corporation, Maricopa, AZ, [2]Valent U.S.A. Corporation, Fresno, CA, [3]Valent U.S.A. Corporation, Lansing, MI, [4]Valent U.S.A. Corporation, Olive Branch, MS (093)

Imazosulfuron plus thiobencarb is registered for use in water seeded rice systems (U.S. EPA). The combination product is formulated as a 10.43 percent granular (0.43% imazosulfuron plus 10% thiobencarb) and will be sold in California water seeded rice as League™ MVP (CA registration pending at time of publication). *League MVP* was evaluated as a foundation herbicide treatment from 2010 through 2012 at rates of 30 and 35 lbs product/A. *League MVP* was compared with clomazone (Cerano®), and thiobencarb (Bolero® UltraMax) for management of early season weeds. *League MVP* and *Bolero UltraMax* were evaluated for preemergence and early postemergence weed control when applied at the 2 to leaf stage of water seeded rice. *Cerano* was evaluated as a preemergence treatment applied at planting of water seeded rice.

Averaged across studies, *League MVP* provided control of *Leptochloa fascicularis* (sprangletop) equal to *Bolero UltraMax* and *Cerano*. Control *Echinochloa* spp.(early and late watergrass) was equal for *League MVP* and *Bolero UltraMax* with control numerically greater than *Cerano*. Control of *Scirpus mucronatus* (ricefield bulrush) and *Cyperus difformis* (smallflower umbrellaplant) was greatest with *League MVP* compared with *Bolero UltraMax* and *Cerano*. Broadleaf weed species/aquatics *Ammannia* spp. (redstems), and *Bacopa spp* (waterhyssops) were controlled similarly with *League MVP*and *Bolero UltraMax* with control greater than *Cerono*. Control of *Heteranthera limos* (ducksalad) was greatest when *League MVP* was applied at 35 lbs product/A.

Efficacy of Penoxsulam and Oxyfluorfen on Problematic Weed Species in Tree Nuts. Deb Shatley*[1], Richard Mann[2], James Mueller[3], Byron B. Sleugh[4], Jesse Richardson[5]; [1]Dow AgroSciences, Lincoln, CA, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Brentwood, CA, [4]Dow AgroSciences, West Des Moines, IA, [5]Dow AgroSciences, Hesperia, CA (094)

Pindar™GT (penoxsulam + Oxyfluorfen) is a broad-spectrum tree nut herbicide for the control of many winter annual weeds in almonds, walnuts, pistachios and pecans. Pindar GT is a 4.04 lb ai/gallon suspension concentrate (SC) formulation premix containing 10 g of penoxsulam + 476 g of oxyfluorfen/liter. Pindar GT provides both pre-emergence and post-emergence control of glyphosate resistant and susceptible fleabane (*Conyza bonariensis*) and horseweed (*Conyza canadenisis*), as well as control of other high anxiety weeds including malva (*Malva* spp), filaree (*Erodium* spp) and willowherb (*Epilobium* spp). Pindar GT at 3.0 pints/acre will provide up to 6 months residual weed control of many key annual winter weeds when applied during the winter dormant period from October to February, providing equivalent or better weed control than standards.

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Effects of pH on Pyroxsulam Adsorption and Desorption in Inland Pacific Northwest Silt Loam Soils. Alan J. Raeder*[1], Ian C. Burke[1], Joseph P. Yenish[2], Roger E. Gast[3]; [1]Washington State University, Pullman, WA, [2]Dow AgroSciences, Billings, MT, [3]Dow AgroSciences, Indianapolis, IN (096)

Pyroxsulam is used primarily for postemergence control of annual grass weeds in winter and spring wheat. When applied in the spring to winter or spring wheat, pyroxsulam residues can cause injury to lentil grown the following year in the inland Pacific Northwest (PNW) – the phenomena is not observed anywhere else in the world. Soil characteristics, such as organic matter (OM), pH, cation exchange capacity (CEC), and clay content, along with environmental conditions are considered to be largely responsible for the adsorption and desorption of herbicides to soils. In this study, the adsorption and desorption of pyroxsulam to and from seventeen inland PNW silt loam soils with varying levels of OM, pH, CEC, and clay content were evaluated. The analysis was carried out using a batch equilibration method and a 1:1 soil: solution ratio. Duplicate test samples were dosed with 7.5 ng ^{14}C-pyroxsulam g^{-1} soil, placed on a rotating shaker, and evaluated by removing triplicate aliquots after 4, 4.5, 18, 39, and 61 hours of shaking. A multiple regression analysis revealed that OM, pH, and clay content were significant predictors of adsorption with pH being the most significant soil characteristic. The desorption of pyroxsulam was only influenced by OM. Pyroxsulam carryover appears to be affected by both pH and OM. Further work addressing the effect of temperature on the degradation should be sufficient to model the fate of pyroxsulam in inland PNW soils and predict carryover situations.

Corn Response to Nitrogen Rates and Timing of Weed Control. Gregory J. Endres*, Blaine G. Schatz, Michael Ostlie; NDSU, Carrington, ND (097)

A field study commenced in 2009 at NDSU Research Extension Centers in Carrington and Minot to examine the combination of soil nitrogen (N) and timing of initial weed control that provides the highest economic return for corn grain production in central North Dakota. Experimental design was a randomized complete block with split-plot arrangement and four replicates. Targeted N levels (main plot) at 0- to 24-inch soil depth were 50, 100 and 150 lb/A. Weed management treatments (split plot) for the glyphosate-resistant corn included a weedy check, soil-applied herbicides at corn planting (PPI or PRE), early POST = control targeted at 2- to 6-inch weed height, and late POST = control targeted at 8- to 12-inch weed height. Additional POST herbicides (primarily glyphosate) were applied as required to maintain weed control during the growing season. Common weeds in the study included green and yellow foxtail, wild buckwheat, common lambsquarters, and prostrate and redroot pigweed. Currently, five site-years of data have been generated: Carrington, 2009-10 and 2012, and Minot, 2009 and 2011. Across weed control treatments and site-years, corn yield averaged 82, 99, and 100 bu/A with 50, 100, and 150 lb soil N/A, respectively. Across soil N levels and site-years, corn yield averaged 117 bu/A with initial weed control at planting or early POST, 99 bu/A with late POST control, and 41 bu/A with the untreated check. Average corn yield with the combination of factors was highest (127 bu/A) with the high soil N level and initial weed control at time of corn planting. However, the highest economic return is associated with the medium soil N level and early POST glyphosate with yield at 125 bu/A. NDSU currently recommends using a soil-applied herbicide with a mode-of-action differing from glyphosate to manage glyphosate-resistant weeds and to reduce risk of yield loss from early season weed competition.

Broadleaf Weed Control in Field Corn with Preemergence Followed by Sequential Postemergence Herbicides. Richard N. Arnold*, Margaret M. West, Kevin A. Lombard; New Mexico State University ASC, Farmington, NM (098)

Research plots were established on May 10, 2012, at New Mexico State University's Agricultural Science Center at Farmington, New Mexico, to evaluate the response of field corn (var. Pioneer PO636HR) and annual broadleaf weeds to preemergence followed by sequential postemergence herbicides. Soil type was a Wall sandy loam with a pH of 7.8 and an organic matter content of less than 0.3%. The experimental design was a randomized complete block with three replications. Individual plots were four, 30 in rows 30 ft long. On May 18, field corn was planted with flexi-planters equipped with disk openers. Preemergence treatments were applied on May 9 and were immediately incorporated with approximately 0.75 in of sprinkler applied water. Sequential postemergence treatments were applied on June 12 when field corn was in the 4^{th} leaf stage with weed heights averaging approximately 1 to 3 inch. All sequential postemergence treatments were applied with a single or combined application of either a crop oil concentrate, or sprayable ammonium sulfate at 1% or 5 lbs/A. All treatments were applied with a compressed air backpack sprayer equipped with 11004 nozzles calibrated to deliver 30 gal/A at 35 psi. Preemergence treatments were evaluated on June 12 and preemergence followed by sequential postemergence treatments were evaluated on July 12. All preemergence and preemergence followed by sequential postemergence treatments gave excellent control of redroot and prostrate pigweed, black nightshade, and common lambsquarters except the weedy check. Preemergence applications of pyroxasulfone and saflufenacil and at 1.3, 0.6, oz ai/A gave poor control of Russian thistle (*Salsola iberica Sennen & Pau*). The addition of diflufenzopyr plus dicamba to pyroxasulfone and saflufenacil applied as a sequential postemergence treatment at 1.5 oz ai/A increased Russian thistle (*Salsola iberica Sennen & Pau*) control approximately 20 to 50%.

Sheep Fescue (Festuca ovina L.) Response to Herbicides and Environment. Shawn P. Wetterau*, Ian C. Burke; Washington State University, Pullman, WA (099)

Following Conservation Reserve Program contract expiration, conversion back to crop production using direct seeding methods and herbicides can be problematic when sheep fescue is present. Greenhouse studies were conducted to evaluate herbicides for sheep fescue management in combination with fertility inputs. Both studies were arranged in a randomized complete block design with a split-plot treatment arrangement and four replications. The main plots for the first study were two levels of fertility (0 and 135 kg ha^{-1} of nitrogen) and sub-plots were 21 different herbicides. The main plots of the second study were five levels of fertility (0, 34, 67, 101, and 135 kg ha^{-1} nitrogen) and sub-plots consisting of two herbicides (glyphosate and imazamox) with 4 levels each (0.75X, 1.0X, 1.25X, and 1.5X of the labeled rates (glyphosate 1X rate - 2.2 kg ai ha^{-1}; imazamox 1X rate - 0.035 kg ai ha^{-1}). In the first study there was a positive interaction with fertility and herbicide for four of the twenty one herbicides, for the four herbicides sheep fescue control increased as fertility increased from the 0 kg-N to the 135 kg-N rates. In the second study imazamox failed to control sheep fescue. Averaged across levels of fertility, control with glyphosate was 33% at the 0.75X rate, 53% at the 1X rate, 65% at the 1.25X rate, and 77% at the 1.5X rate. While herbicide, rate and timing of application are major factors for control of sheep fescue, fertilizer application appears to increase control for certain herbicides.

Glyphosate-Resistant Kochia Control in Corn-Sugarbeet Rotations. Jared C. Unverzagt*[1], Andrew R. Kniss[1], Robert G. Wilson[2]; [1]University of Wyoming, Laramie, WY, [2]University of Nebraska-Lincoln, Scottsbluff, NE (100)

Glyphosate-resistant sugarbeet growers rely heavily on glyphosate to control kochia, because conventional sugarbeet herbicides provide limited kochia control. Field studies were conducted near Lingle, WY and Scottsbluff, NE in 2012 to investigate kochia control in corn to mitigate glyphosate-resistant kochia density in a corn-sugarbeet rotation. Corn was planted in 76-cm rows on May, 8 2012 at Lingle, and 56-cm rows on May, 7 2012 at Scottsbluff. PRE herbicides treatments were evaluated before POST herbicide application to document PRE herbicide efficacy of kochia at Lingle. All POST herbicide treatments were applied with and without glyphosate. Sites were analyzed separately due to differences in herbicide performance at each site. POST only treatments provided similar or greater kochia control with the addition of glyphosate at both sites with the exception of tembotrione plus bromoxynil at Scottsbluff. At Scottsbluff, dicamba plus diflufenzopyr and tembotrione plus bromoxynil provided the greatest kochia control (>92%) among treatments not containing glyphosate. At Lingle, dicamba plus diflufenzopyr, fluroxypyr plus bromoxynil, and dicamba plus rimsulfuron provided the greatest kochia control (>90%) among treatments not containing glyphosate.

Integrated Herbicide Programs for Weed Management in Glyphosate-Resistant Sugar Beet. Vipan Kumar*[1], Prashant Jha[1], Nicholas A. Reichard[1], Mandeep K. Riar[1], Jaya R. KC[2]; [1]Montana State University, Huntley, MT, [2]Montana State Universtiy, Huntley, MT (101)

Overreliance on glyphosate has led to evolution of glyphosate-resistant (GR) weeds, including kochia in north central and northwestern United States. There is a need for development of integrated herbicide tools to prevent occurrence of GR weeds in GR sugar beet. A field experiment was conducted at the MSU Southern Agricultural Research Center, Huntley, MT, in 2012, to evaluate herbicide programs in conjunction with glyphosate for weed control in GR sugar beet. The experiment was conducted in a randomized complete block design with 4 replications. Herbicides were applied with a hand-held boom calibrated to deliver 94 L ha^{-1} at 276 kPa. Pre-plant (PPI) and preemergence (PRE) herbicides were applied prior to and at sugar beet planting, respectively. POST herbicides were applied at 4- to 6- and/or 8- to 10-leaf stages of sugar beet. Kochia, redroot pigweed, and common lambsquarters were the target weed species in the study. Data on visual control was recorded at 1, 3 and 7 wks after last application (WAA), and sugar beet root and sucrose yields were recorded at harvest. PRE ethofumesate (4.2 kg/ha) followed by POST glyphosate (1.26 kg/ha) tank-mixed with phenmedipham + desmedipham (0.672 kg/ha) at 4- to 6-leaf stage of sugar beet and a sequential POST glyphosate (0.84 kg ae/ha) at 8- to 10-leaf stage of sugar beet provided complete control of kochia 7 WAA, and was superior to all other treatments. PPI of s-ethyl dipropylthiocarbamate (2.24 kg/ha) and s-ethyl cyclohexylethylthiocarbamate (2.8 kg/ha) followed by a single POST glyphosate (1.26 kg ae/ha) at 4- to 6-leaf stage of sugar beet provided < 80% control of kochia. Tank-mixing dimethenamid-P, s-metolachlor, acetochlor, or clopyralid with the 8- to 10-leaf sequential glyphosate treatment did not further improve kochia control, which averaged 82 to 87% at 7 WAA. For redroot pigweed, addition of ethofumesate PRE improved control (from < 90 to 100%) obtained from POST glyphosate alone or tank-mixed with phenmedipham + desmedipham at 4- to 6-leaf stage followed by a sequential glyphosate at 8- to 10-leaf stage of sugar beet. Redroot pigweed control after a second application of glyphosate alone or tank-mixed with dimethenamid, s-metolachlor, acetochlor, or clopyralid averaged 91 to 100% 7 WAA. Addition of ethofumesate PRE to the sequential glyphosate POST program improved root and sucrose yields by 49 and 36%, respectively. In conclusion, ethofumesate applied PRE and use of tank mixtures with sequential POST glyphosate applications at 4- to 6-leaf followed by 8- to 10-leaf stages of sugar beet could potentially reduce the risk of weed control failures in GR sugar beet.

Sainfoin (*Onobrychis viciifolia*) Tolerance to Postemergence Herbicides. Ryan E. Rapp*[1], Andrew R. Kniss[2], Jared C. Unverzagt[2]; [1]Monsanto Company, Scott, MS, [2]University of Wyoming, Laramie, WY (102)

Sainfoin has increased in popularity in the Rocky Mountain Region because of its drought tolerance, feed value, and safety for grazing. Sainfoin requires effective broad-spectrum weed control for successful establishment and stand longevity; however, few herbicides are registered for postemergence weed control in the crop. Field studies were conducted in seedling and established sainfoin at the Research and Extension Center near Powell, Wyoming to evaluate sainfoin tolerance to postemergence herbicides. Glyphosate, imazamox, and imazethapyr were applied at a range of rates in both spring and fall. In seedling sainfoin, dry matter yields were not affected by spring applications of imazamox (P=0.14) or imazethapyr (P=0.42) at rates up to 0.07 and 0.14 kg ai/ha, respectively. Spring application of glyphosate at 0.16 kg ae/ha to seedling sainfoin reduced dry matter yield by 18%. A typical field use rate of glyphosate (840 g ae/ha) reduced seedling sainfoin dry matter yield by 53% when applied in spring. Similar results were observed in established sainfoin. Dry matter yield was not reduced by either fall or spring applications of imazamox or imazethapyr at any rate. Glyphosate applied at 0.16 kg ae/ha to established sainfoin in the spring reduced yield by 12%. Contrary to many anecdotal reports, these results indicate that glyphosate has the potential to severely injure sainfoin, and therefore, should not be applied to the actively growing crop. Imazamox and imazethapyr showed excellent crop safety in sainfoin at all application timings, even at twice the rate commonly used in other legume crops.

What's Old is New Again: Fiber and Oilseed Flax Production in the Willamette Valley of Oregon? Andrew G. Hulting*, Kyle C. Roerig, Daniel W. Curtis, Carol Mallory-Smith; Oregon State University, Corvallis, OR (103)

Efforts to diversify the grass grown for seed-small grain dominated cropping systems of western Oregon with alternative broadleaf crops are ongoing. Historically, flax (*Linum usitatissimum*) grown for both seed and fiber was an important rotational crop in the Willamette Valley of Oregon. There has been renewed interest on the part of private industry in producing flax for both seed and fiber in the region. One of the challenges with producing flax is reevaluating best management agronomic practices for improved flax varieties. Weed management, among other unknowns such as planting date, soil fertility management and harvest methods, in flax is often cited as a concern by growers. Therefore, a study that quantified the impacts of planting date, flax variety and chemical weed management treatments on flax biomass and seed yield was completed in 2011-2012 near Corvallis, Oregon. Two varieties of flax, 'Linore' and 'Agatha', were planted at both a fall timing in November and at a spring timing in April. PPI, PRE and POST herbicide treatments were applied prior to and following each flax planting date. Flax injury ratings were completed over the duration of the growing season and biomass and seed yield quantified at harvest in August 2012. Fall planting of both varieties resulted in greater biomass and seed yield than did spring planting. For the fall planted study, the mean seed yield averaged across herbicides treatments was 2112 kg/ha for Linore and 1225 kg/ha for Agatha. Conversely, Agatha produced slightly higher biomass (7710 kg/ha) than did Linore (7195 kg/ha) averaged across herbicide treatments in the fall planted study. Effects of herbicide treatments on flax injury, biomass and seed yield were similar regardless of flax variety or planting date. PPI trifluralin applications at 0.84 kg/ha resulted in early season crop injury (20-30%) that lessened over the duration of the growing season and did not impact biomass or seed yield compared to an untreated control. Similar results were noted with PRE applications of *s*-metolachlor applied at 1.60 kg/ha. PRE applications of pendimethalin (1.59 kg/ha) or mesotrione (0.11 kg/ha) resulted in no crop injury. POST applications of fluroxypyr-bromoxynil at 0.36 kg/ha resulted in excessive flax injury (greater than 50%) and reduced flax biomass and seed yield compared to the untreated control and other POST applications including mesotrione (0.11 kg/ha), bromoxynil-MCPA (0.39 kg/ha) and clopyralid (0.28 kg/ha). The experiment is being repeated during 2012-13 and this agronomic and weed management information will be evaluated by growers and industry to determine whether or not flax production has a role to play in crop diversification strategies in western Oregon.

Use of Maleic Hydrazide for Volunteer Chicory Management in Spring Wheat. Don W. Morishita*, Donald L. Shouse, Andy Nagy; University of Idaho, Kimberly, ID (104)

Chicory (*Cichorium intybus*) is a simple perennial that is being considered as an alternate crop in southern Idaho. One of the drawbacks to growing chicory is that it can be a volunteer problem the following year. Efforts to control volunteer chicory in wheat or field corn the year after a chicory crop have not been very successful. Previous field studies have shown that clopyralid and fluroxypyr used in combination or in tank mixtures with 2,4-D, or thifensulfuron + tribenuron were the most effective. Early season volunteer chicory control was best at about 80% with these combinations, but later in the season control would be less than 25%. Depending on the volunteer chicory stand, grain yields could be severely reduced. Maleic hydrazide is used as a sucker inhibitor in tobacco, potato sprout inhibitor and reduces volunteer potato populations. In potato, maleic hydrazide is applied at 2 weeks before potato vine desiccation to reduce volunteer potato. In fall 2010, a small strip trial was conducted at the University of Idaho Research and Extension Center near Kimberly, Idaho to determine if maleic hydrazide could potentially reduce chicory shoot re-growth the year after harvesting chicory roots. The results appeared to be promising so a replicated field study was initiated to determine: 1) if maleic hydrazide would reduce volunteer chicory emergence and 2) when used in combination with herbicides applied postemergence, improve volunteer chicory control in spring wheat. Chicory was planted May 17, 2011 at 100,000 seed/A and grown under sprinkler irrigation. Experimental design for the volunteer chicory study was a randomized complete block with four replications. Individual plots were 2.23 m by 9.1 m. Soil type was a Porteneuf Silt Loam (26.4 % sand, 65 % silt, and 5.6 % clay) with a pH of 8.1, 1.60 % organic matter, and CEC of 14-meq/100 g soil. Maleic hydrazide (MH) was applied at 2.52 and 3.36 kg ai/ha on two dates, September 21 and 28, which was 4 and 3 weeks before chicory harvest, respectively with a CO_2-pressurized bicycle-wheel sprayer calibrated to deliver 140 l/ha using 8001 flat fan nozzles at 138 kpa and 4.8 km/h. The chicory was harvested October 24, 2011. 'Alturus' spring wheat was planted April 4, 2012, at a rate of 112 kg/ha. Volunteer chicory control herbicides were applied broadcast on May 25 with a CO_2-pressurized bicycle-wheel sprayer calibrated to deliver 140 l/ha using 8001 flat fan nozzles at 138 kpa and 4.8 km/h. Chicory shoot emergence was monitored in each plot on a weekly basis from May 1 until July 5 (after head emergence). Crop injury and weed control was evaluated visually 17 and 35 days after the herbicide application (DAA) on June 11 and 29, 2012. Wheat was harvested mechanically on August 9. Volunteer chicory stand counts in the treatments that did not receive MH, but were sprayed with clopyralid + fluroxypyr or clopyralid + 2,4-D averaged 2.2 volunteer chicory shoots/m^2 on July 5 compared to the untreated control, which averaged 1.5 shoots/m^2. There was no difference in cumulative volunteer chicory shoots between maleic hydrazide rates applied nor whether it was applied 3 or 4 weeks before harvest. The average cumulative chicory shoot density on July 5 was 0.9 shoots/m^2. Interestingly, the addition of clopyralid + fluroxypyr or clopyralid + 2,4-D as a sequential herbicide application to the maleic hydrazide did not reduce chicory shoot emergence any more than maleic hydrazide alone. However, the addition of the herbicide treatments to the maleic hydrazide apparently reduced the competitiveness of the chicory shoots. Grain yield with the herbicides averaged 6,321 kg/ha compared to 5,245 kg/ha with maleic hydrazide alone.

Effect of Wheat Population on Wheat Yield and Yield Parameters: A Case for Increasing Planting Rates. Rachel Unger*, Misha R. Manuchehri, Ian C. Burke, Mark E. Swanson; Washington State University, Pullman, WA (114)

Seeding rate can be an effective tool for increasing crop competitiveness. However, growers in eastern Washington are reluctant to increase seeding rates because of potential yield reduction and increased diseases. A field study was conducted in 2011 and 2012 at four locations in eastern Washington to determine the effect of winter wheat populations on wheat yield and yield parameters. Each field site represented a different rainfall zone (irrigated, low, intermediate, and high) and included planting populations of 50, 75, 100, and 125% of the typical planting density for each rainfall zone. Wheat populations were counted in the spring to determine actual planting population. Whole plant samples were collected prior to mechanical harvest to determine kernels per head, kernel weight, heads per plant, and harvest index. Yield was not affected by increased planting density above the typical planting density, but yield was reduced when the typical planting density was decreased by 50%. Increased planting population above 50% of the typical planting population decreased kernel weight. Heads per plant increased as planting population decreased with the highest head counts per plant observed in the lowest plant population. Harvest index increased as planting density decreased below 125% of the typical planting density. Growers can increase winter wheat seeding rates up to 125% of the typical seeding rat in four precipitation zones in eastern Washington without decreasing yield. Increased seeding rate may lead to increased crop competitiveness against predominant weed species in each zone.

Management of *Avena fatua* L., *R. Dentatu* L., *Helianthus annuus* L., *Triticum aestivum* L. and *Zea mays* L. by Exploiting *Carica papaya* L. Allelopathy, as Bio-Herbicide. Tauseef Anwar*; PMAS Arid Agriculture University, Rawalpindi, Pakistan (115)

This study was conducted to investigate the allelopathic effect of *Carica papaya* leaf powder on seed and seedling of weeds, wild oat (*Avena fatua* L.) and toothed dock (*Rumex dentatus* L.) and associated crops, sunflower (*Helianthus annuus* L.), wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.) on filter paper and soil in Weed Management Laboratory, Department of Plant and Environmental Protection, National Agriculture Research centre, Islamabad. *C. papaya* leaf powder significantly decreased the germination and subsequent growth of weeds *A. fatua* and *R. dentatus.* The radical and plumule growth of Z. *mays* and *H. annuus* decreased when *C. papaya* was applied to direct seeds while remained unaffected when applied to the seedlings. The leaf powder showed no effect on wheat seed germination, radical and plumule growth. It is suggested that *C. papaya* leaf powder can be used as a bio-herbicide.

Discovery of Glyphosate Resistant Palmer Amaranth in Arizona. William B. McCloskey*[1], Lydia M. Brown[2]; [1]University of Arizona, Tucson, AZ, [2]University of Arizona, Maricopa, AZ (116)

Glyphosate-resistant Palmer amaranth was discovered in Buckeye, AZ in July 2012 after three 1.5 lb ae/A glyphosate applications failed to control Palmer amaranth plants. Seed was collected from two populations of Palmer amaranth, *Amaranthus Palmerii*, in Buckeye and Glendale, AZ in western Maricopa County suspected of being resistant to glyphosate due to control failures. For comparison, seed was also collected from a known glyphosate susceptible Palmer amaranth population at the University Of Arizona Maricopa Agricultural Center (MAC). Seeds of each biotype were planted in 4 inch pots, plants were grown to the 4 true-leaf growth stage in a greenhouse, sprayed with various rates of glyphosate using a CO_2 pressurized backpack sprayer calibrated to deliver 10 GPA. Phytotoxicity was visually estimated to confirm glyphosate resistance; in some experiments main-stem node number and plant height were also measured. In the first experiment, the Buckeye biotype showed little response to slight stunting at glyphosate rates of 0.375, 0.75, 1.5 and 3.0 lb ae glyphosate/A. In contrast the Glendale and Maricopa biotypes were killed by rates of 0.375 and 0.75 lb ae glyphosate/A. In the second experiment, glyphosate rates from 0.0089 to 0.356 lb ae/A, 14 days after treatment (DAT) resulted in phytotoxicity ratings of 3.5 to 9.9 for the Maricopa biotype and 0.25 to 9.9 for the Glendale biotype (0 to 10 scale with 10 representing death). In contrast, the phytotoxic response to increasing glyphosate rate from 2.67 to 9 lb ae/A 14 DAT was 3.5 to 6.6 for the Buckeye biotype. The Buckeye plants were severely stunted and chlorotic for a period of two weeks after treatment but eventually recovered, resumed growth and began flowering in the greenhouse. Many glyphosate resistant Palmer Amaranth populations in the southeastern U.S. are resistant to pyrithiobac-sodium in addition to glyphosate. Thus, the Buckeye, AZ Palmer amaranth population was also tested for tolerance to pyrithiobac-Na and compared to two other Palmer amaranth populations; the population from MAC which has been sprayed with pyrithiobac-Na in the past and a population from Sahuarita, AZ that is thought to have never been treated with an ALS inhibitor herbicide. Preliminary results indicated that the Sahuarita population is sensitive to pyrithiobac-Na (phytotoxicity rating of 8 at 0.0892 lb ai/A 9 DAT) compared to the Buckeye population (phytotoxicity rating of 2 at 0. 892 lb ai/A 9 DAT). The Maricopa population which has been treated with pyrithiobac-Na in the past had a phytotoxicity rating of 5 at 0. 892 lb ai/A 9 DAT and showed an intermediate response over a rate range of 0.00044 to 1.78 lb ai/A. In conclusion, the Maricopa and Glendale biotypes collected in 2012 were susceptible to glyphosate but the Buckeye biotype was resistant to glyphosate. The Buckeye biotype also appears to be tolerant to pyrithiobac-Na in preliminary experiments. The management of glyphosate resistant Palmer amaranth in western Maricopa County will be a serious challenge to cotton producers locally while producers in the rest of the state are at risk of importing the resistance gene.

Evaluating the Interaction Between Herbicide and Fertilizer Application Timing to Improve Italian Ryegrass Control, Grain Quality, and Yield in Oklahoma Wheat Production. Steven R. Calhoun*; Oklahoma State University, Ninnekah, OK (117)

Controlling Italian ryegrass (*Lolium Multiflorum*) is a serious problem for Oklahoma winter wheat (*Triticum aestivum* L.) producers to face. Italian ryegrass when not controlled reduces crop yields and overall grain quality due to high levels of inert material (dockage). The objective of this experiment was to study the influence of the rate of fall and spring applied nitrogen (N) fertilizer and Italian ryegrass removal timing on yield and nitrogen uptake of winter wheat. Italian ryegrass was controlled with Axial xl (Pinoxaden) four times, three in the fall and once in the spring. Tissue samples collect during the 2011-2012 growing season showed an increase in wheat biomass weights when ryegrass populations were controlled. Good growing conditions early in the season allowed wheat biomass to develop and out compete the ryegrass. Adequate soil fertility combined with proper weed control timing showed an increase in yields. The application of N fertilizer to weed free plots resulted in high grain yields and quality by eliminating ryegrass interference. Yields in the weedy plots were slightly lower than the weed free plots that received the same amount of nitrogen. The results found in the study can be used to better manage herbicide and nitrogen inputs for maximum weed control, grain quality, yield, and economic return.

Weed Control with Postemergence Herbicide Combinations in Dry Bean. Andrew R. Kniss, Louise Lorent*, David A. Claypool; University of Wyoming, Laramie, WY (118)

Inadequate soil moisture or poor soil incorporation at the time of preplant-incorporated (PPI) herbicide application can result in early weed escapes. In dry beans, this is of major concern as post-emergence (POST) herbicides options are limited and early weed pressure can decrease crop yield and quality. POST herbicide combinations may offer producers an efficacious remedial option in case of poor weed control from PPI herbicides. A field study was conducted in 2012 to compare tank mixtures of five POST herbicides. All pairwise combinations of imazamox, bentazon, fluthiacet-methyl, halosulfuron and fomesafen at rates of 35, 1120, 6, 35 and 280 g ai ha^{-1}, respectively, were applied when beans were at the 3 trifoliolate growth stage.

All treatments included COC at 1% volume/volume. Redroot pigweed, common lambsquarters and hairy nightshade control was evaluated 63 days after spraying. Bentazon plus either fluthiacet-methyl or fomesafen provided the greatest common lambsquarters control (88%) but were among the worst treatments for redroot pigweed control (≤37%). In general, treatments containing imazamox provided the greatest redroot pigweed control (≥93%) except for imazamox plus fomesafen which provided only 77% control. Hairy nightshade control exceeded 90% with all treatments except halosulfuron plus either fluthiacet-methyl, bentazon or fomesafen. Halosulfuron plus fluthiacet-methyl was not statistically different than the non-treated check for the control of common lambsquarters and hairy nightshade.

Dry Bean Response to Preemergence Flumioxazin. Andrew R. Kniss*, David A. Claypool; University of Wyoming, Laramie, WY (119)

Field studies were conducted each year between 2009 and 2012 to evaluate flumioxazin safety in dry edible beans. Treatments included flumioxazin (56 g/ha) PRE in combination with pendimethalin (795 g/ha) PRE, ethalfluralin (840 g/ha) PRE or trifluralin (560 g/ha) PPI. Flumioxazin treatments were compared to nontreated and handweeded controls, as well as standard herbicide treatments of ethalfluralin plus EPTC PPI and imazamox plus bentazon POST. Soil at the sites ranged from 42 to 56% sand, 13 to 21% clay, 1.1 to 1.8% organic matter, and pH 7.8 to 8.0 depending on the year. Dry bean stand was counted in 10 feet of row 14 days after dry bean planting. Twenty feet of row from each plot was harvested at crop maturity to calculate dry bean yield. Treatments containing flumioxazin reduced dry bean stand by 24 to 68% compared with treatments not containing flumioxazin. Stand reduction from flumioxazin was more pronounced in years where precipitation was high following dry bean planting. Flumioxazin treatments caused dry bean yield loss averaging 27% over 4 years.

Dry Bean Response to Preemergence Sulfentrazone Plus S-Metolachlor. David A. Claypool*, Andrew R. Kniss; University of Wyoming, Laramie, WY (120)

A field study was conducted at the Sustainable Agriculture Research and Extension Center near Lingle, Wyoming, in 2012 to evaluate dry bean response to pre-emergence sulfentrazone plus s-metolachlor. Great Northern ('Orion') and pinto beans ('Othello') were planted in 30-inch rows at a rate of 60,000 seeds/A on May 30. Soils at the site were Haverson and McCook loams (42% sand, 41% silt, 17% clay, 1.4% organic matter, pH 8.0, CEC 14.9). Herbicide treatments were applied with either a CO_2-pressurized knapsack sprayer or a tractor-mounted sprayer delivering 16.8 gallons of total volume per acre at 30 psi with TeeJet 11002FFDG nozzles. Treatments included a weedy check and a weed-free (hand weeded) check. Herbicide treatments consisted of: four rates of sulfentrazone plus s-metolachlor (0.071 + 0.64, 0.11 + 0.98, 0.16 + 1.48, and 0.22 + 1.97 lbs ai/A), sulfentrazone (0.11 lbs ai/A), s-metolachlor (0.98 lbs ai/A), dimethenamid-P (0.98 lbs ai/A), and imazamox plus bentazon (0.031 + 0.5 lbs ai/A). All herbicides were applied pre-emergence on May 31 except imazamox plus bentazon which was applied post-emergence on June 18. Plots were 10 feet wide by 30 feet long and arranged in a randomized complete block design with 4 replicates. Visual crop injury evaluations were made on June 12 and 20. Weed control was visually evaluated on July 12 and August 22. Weeds evaluated were common lambsquarters, redroot pigweed, hairy nightshade and green foxtail. Bean yields were determined from 20 feet of row per plot harvested on September 11. Crop injury rates were similar for both pinto and great northern varieties. Injury rates on June 12 increased with rate of sulfentrazone plus s-metolachlor and ranged from 3 to 26% and 5 to 21% for pinto and great northerns, respectively. Other treatments were rated at less than 5% injury except for dimethenamid-P which had 10 and 16% for pinto and great northerns, respectively. Crop injury rates observed at the June 20 evaluation were approximately half the rates observed on June 12. The combination of sulfentrazone plus s-metolachlor (0.11 + 0.98 lbs ai/A) improved the spectrum of weed control compared to either compound alone at equivalent rates. On August 22, sulfentrazone (0.11 lbs ai/A) provided 70 and 0% control of hairy nightshade and green foxtail, respectively, compared to 98% control of each species for sulfentrazone plus s-metolachlor. S-metolachlor alone (0.98 lbs ai/A) provided 46 and 45% control of common lambsquarters and hairy nightshade, respectively, compared to 99 and 90% control for sulfentrazone plus s-metolachlor. Weed control of sulfentrazone plus s-metolachlor on August 22 increased with rate applied. Rates were not significantly different and ranged from 98 to 99% for common lambsquarters, 96 to 99% for redroot pigweed, 76 to 99% for hairy nightshade, and 88 to 99% for green foxtail. August 22 weed control from dimethenamid-P and imazamox plus bentazon were: 91 and 78% for common lambsquarters, 99 and 98% for redroot pigweed, 93 and 90% for hairy nightshade, and 99 and 66% for green foxtail, respectively. Weedy checks had no harvestable yield. Weed-free check yields were 738 and 1096 lbs/A for pinto and great northerns, respectively. Pinto yields for all sulfentrazone plus s-metolachlor rates and the imazamox plus bentazon treatment were not significantly different and ranged from 1289 lbs/A (0.22 + 1.97 lbs ai/A) to 1671 lbs/A (0.16 + 1.48 lbs ai/A). Pinto yields for other treatments were: sulfentrazone, 878 lbs/A; s-metolachlor, 721 lbs/A; dimethenamid-P, 1004 lbs/A; and imazamox plus bentazon, 1316 lbs/A. Great Northern yields increased with rate of sulfentrazone plus s-metolachlor and ranged from 1348 to 1891 lbs/A; the three highest rates were not significantly different. Great Northern yields for other treatments were: sulfentrazone, 869 lbs/A; s-metolachlor, 420 lbs/A; dimethenamid-P, 1100 lbs/A, and imazamox plus bentazon, 599 lbs/A.

Cross Spectrum Efficacy of Pyroxsulam on Grasses and Broadleaf Weeds in California and Arizona Cereals. Byron B. Sleugh*[1], Jesse Richardson[2], Deb Shatley[3], Roger E. Gast[4]; [1]Dow AgroSciences, West Des Moines, IA, [2]Dow AgroSciences, Hesperia, CA,[3]Dow AgroSciences, Lincoln, CA, [4]Dow AgroSciences, Indianapolis, IN (121)

Pyroxsulam is an effective herbicide for the control of key grass weeds and a wide range of broadleaf weeds in winter and spring wheat, including Durum. Pyroxsulam containing herbicides have been used successfully in cereal crops for several years in Canada (Simplicity™) and the Great Plains (PowerFlex™, PowerFlex™ HL, and GoldSky™). Field studies were conducted in 2012 with pyroxsulam in the Sacramento and San Joaquin Valleys in California, and Yuma, Arizona. The objective of these studies was to determine the efficacy of pyroxsulam on grasses and broadleaf weeds including annual ryegrass (*Lolium multiflorium*), perennial ryegrass (*Lolium perrene*), wild oat (*Avena fatua*), Lesser canarygrass (*Phalaris minor*), common chickweed (*Stellaria media*), coast fiddleneck (*Amsinckia intermedia*), shepherd's purse (*Capsella bursa-pastoris*) and others. All treatments were applied post emergence and included pyroxsulam (Simplicity,15 g a.i. ha^{-1}), mesosulfuron (Osprey,15 g a.i. ha^{-1}), and pinoxaden (Axial XL, 60 g a.i. ha^{-1}), and fenoxaprop (Puma,93 g 60 g a.i. ha^{-1}). All treatments provided excellent control of wild oat for the duration of the study. Pyroxsulam and mesosulfuron had greater efficacy compared to pinoxaden and fenoxaprop on most of the weeds evaluated. Pyroxsulam at 15 g ai ha^{-1} provided excellent control of key grass and broadleaf weeds including wild oat, Italian ryegrass, wild mustard, common chickweed, California burclover and coast fiddleneck. Pyroxsulam possesses cross spectrum (grasses and broadleaf) efficacy on weeds in California and Arizona cereals and could be a useful tool to manage weeds in these cropping systems.

Management of Multiple Resistant Italian Ryegrass in Winter Wheat with Pyroxasulfone. Kyle C. Roerig*, Daniel W. Curtis, Andrew Hulting, Carol Mallory-Smith; Oregon State University, Corvallis, OR (141)

Italian ryegrass *(Lolium perenne* ssp. *multiflorum)* resistant to multiple herbicide modes of action has become prevalent in winter wheat fields in several areas of western Oregon. Italian ryegrass can severely impact winter wheat yields. Pyroxasulfone is a new herbicide which controls Italian ryegrass. In a trial conducted in a commercial winter wheat field planted October 16, 2011, pyroxasulfone applied at 89 and 104 g ai/ha October 25, 2011, provided 80% or better control of multiple resistant Italian ryegrass. This application provided better control than the same rates applied November 4, 2011. Control of Italian ryegrass with the later pyroxasulfone application was 45-50% which was similar to 55% control provided by flufenacet-metribuzin applied at 477 g ai/ha October 25, 2011. Timely application of pyroxasulfone is important to maximize control. A post emergence application of pyroxsulam applied November 4, 2011, provided 80% control 56 days after treatment, but only 20% at the end of the season and the increased competition severely impacted winter wheat yield. In a trial initiated during the fall of 2012, pyroxasulfone applied at 89, 104 and 119 g ai/ha is providing 99% or better control of Italian ryegrass. Registration of pyroxasulfone for use in winter wheat may occur in 2013 or 2014. Resistance to currently registered herbicides suggests that Italian ryegrass may develop resistance to pyroxasulfone as well. Better resistance management techniques will be required to prevent Italian ryegrass from developing resistance to pyroxasulfone.

Does Pyroxsulam Provide Effective Control of Persian Darnel, Green Foxtail, and Yellow Foxtail? Joseph P. Yenish*[1], Patricia L. Prasifka[2], Neil A. Spomer[3], Kevin D. Johnson[4], Roger E. Gast[3]; [1]Dow AgroSciences, Billings, MT, [2]Dow AgroSciences, West Fargo, ND, [3]Dow AgroSciences, Indianapolis, IN, [4]Dow AgroSciences, Danville, IL (142)

In portions of eastern Montana and western North Dakota, Persian darnel (Lolium persicum) is an annual grass species of concern in cereal production. Currently, pyroxsulam product labels do not list Persian darnel as either controlled or suppressed, but commercial experience has shown potential for good to excellent control. Moreover, pyroxsulam products are labeled for control of the related species, Italian ryegrass. Green and yellow foxtail are troublesome weeds across Montana, North Dakota, South Dakota and Minnesota. Pyroxsulam product labels list control and suppression for yellow and green foxtail, respectively. The level, range, and consistency of green foxtail control with pyroxsulam have not been well established across a variety of field and climate conditions. Six replicated Persian darnel control trials were conducted in 2011 and 2012 in Montana. Mean control of Persian darnel with 15 g pyroxsulam/ha applied to up to 4-leaf growth stage was 86% evaluated six weeks after treatment (WAT). Pyroxsulam at the same rate provided an average of 89% yellow foxtail control 4 WAT in twenty-one replicated trials conducted from 2006 through 2012. Pyroxsulam at 15 g ai/ha provided an average of 74% green foxtail control 6 WAT in trials conducted from 2006 through 2012. Over a wide range of locations and environmental conditions, pyroxsulam provided good to excellent control of Persian darnel and yellow foxtail and suppression of green foxtail when applied at the 1 to 4 leaf stage of growth.

Performance of Thiencarbazone-methyl + Pyrasulfotole + Bromoxynil in Wheat in the Northern Plains. Steven R. King*[1], Dean W. Maruska[2], Kevin B. Thorsness[3], Michael C. Smith[4], George S. Simkins[5], Charles P. Hicks[6], Mark A. Wrucke[7]; [1]Bayer CropScience, Huntley, MT, [2]Bayer CropScience, Warren, MN, [3]Bayer CropScience, Fargo, ND, [4]Bayer CropScience, Sabin, MN, [5]Bayer CropScience, Vadnais Heights, MN, [6]Bayer CropScience, Fort Collins, CO, [7]Bayer CropScience, Farmington, MN (143)

Huskie Complete™ herbicide is a new postemergence grass and broadleaf herbicide that has been developed by Bayer CropScience for use in spring, durum, and winter wheat. Huskie Complete has a favorable ecological, ecotoxicological, and environmental profile with low acute mammalian toxicity and no genotoxic, mutagenic or oncogenic properties noted. Huskie Complete is a pre-formulated mixture containing the novel active ingredients, thiencarbazone-methyl and pyrasulfotole, with bromoxynil and the highly effective herbicide safener, mefenpyr-diethyl. This unique combination of active ingredients provides consistent broad spectrum grass and broadleaf weed control with excellent crop tolerance. Rapid microbial degradation is the primary degradation pathway for thiencarbazone-methyl and pyrasulfotole in the soil environment and there is no soil activity of bromoxynil. Therefore, Huskie Complete has an excellent crop rotation profile, allowing re-cropping to the major crops grown in the northern cereal production area.

Huskie Complete is specially formulated as a liquid for easy handling and optimized for grass and broadleaf weed control. Apply Huskie Complete at 13.7 fl oz/A after the cereal crop has emerged and up to jointing. Grass weeds should be treated with Huskie Complete between the 1 leaf and 2 tiller stage of growth and broadleaf weeds should be treated between the 1 - 8 leaf stages of growth depending on weed species.

Huskie Complete is labeled on 72 different grass and broadleaf weed species with many of them common in the northern cereal production area of the United States. Huskie Complete provides excellent control of key grass and broadleaf weeds such as ACC-ase resistant and susceptible wild oat and green foxtail, yellow foxtail, barnyardgrass, kochia, pigweed sp., wild buckwheat, common lambsquarters, mustard sp., Russian thistle, field pennycress, prickly lettuce, common waterhemp, white cockle, and nightshade sp. Excellent control of sulfonylurea resistant weeds such as kochia, prickly lettuce and Russian thistle biotypes has been confirmed with Huskie Complete in field trials. Bromus species and foxtail barley can be effectively controlled or suppressed with a tankmix of 0.2 oz/A of Olympus. Huskie Complete has been tested on spring, durum, and winter wheat varieties and crop tolerance was excellent on all varieties tested. Broad spectrum weed control across a wide range of grass and broadleaf weeds, excellent crop safety, and very favorable toxicological, ecotoxicological, and environmental properties make Huskie Complete a valuable and easy to use tool for cereal grain producers.

Effect of Droplet Size on Weed Control with Dicamba and Glyphosate Tank-Mixtures Applied with Commercial Sprayers. Brian L. Olson*[1], Christopher D. Kamienski[2], Joe

Sandbrink[3], Kirk Remund[3], Jeff N. Travers[3]; [1]Monsanto Company, Colby, KS,[2]Monsanto Company, Washington, IL, [3]Monsanto Company, St. Louis, MO (144)

Strategies to reduce off target movement of herbicides include the use of spray tips and drift reducing agents that reduce physical drift by altering droplet size, usually by creating larger droplets and/or minimizing fine spray droplets. However, larger spray droplets may have a negative effect on weed control if the droplet size does not allow for proper herbicide coverage, uptake and translocation. In 2012, field trials were conducted at 13 locations across the United States. Treatments included the following spray tips: TurboTeeJet® Wide Angle Flat Spray Tip (TT), AIXR TeeJet® Air Induction XR Flat Spray Tip (AIXR) and the Turbo TeeJet® Induction Flat Spray Tip (TTI). All spray solutions contained glyphosate (1120 g ae/ha), dicamba (560 g ae/ha) and Interlock (290 g ai/ha). Applications were made with sprayers equipped with spray booms ranging in size from 7.62 - 30.48 m. Sprayer travel speed ranged from 10.5 – 19.3 km/h, while operating pressure ranged from 207 – 345 kPa. The application volume was 94 – 187 L/ha. Treatments were applied postemergence (POST) to corn before the V5 growth stage or fallow fields with weed heights ranging from 10 – 50 cm. Weed control ratings were taken 7 to 10 days after treatment (DAT) and 16 to 23 DAT. Average weed control ratings for the final evaluation, across all species, locations, and rating dates was 96.9, 96.7, and 96.5% for the TT, AIXR, and TTI treatments, respectively. There were no significant differences across the three nozzles within individual weed species, which included velvetleaf (*Abutilon theophrasti*) Palmer amaranth (*Amaranthus palmeri*), waterhemp (*Amaranthus tuberculatus syn. rudis*), glyphosate-resistant (GR) waterhemp (*Amaranthus tuberculatus syn. rudis*), common ragweed (*Ambrosia artemisiifolia*), common lambsquarters (*Chenopodium album*), kochia (*Kochia scoparia*), and large crabgrass (*Digitaria sanguinalis*). These results suggest that drift reducing nozzles should provide good weed control potential when applying dicamba plus glyphosate mixtures.

Paper 145 was withdrawn

Why I Cannot Use Tillage To Control Weeds. Robert N. Klein*; University of Nebraska, North Platte, NE (153)

The most limiting resource to crop production in Nebraska is water. In 2007 Nebraska replaced California as the number one state with the most irrigated acres. Nebraska currently has 8.5 million acres under irrigation. Reducing the amount of water needed for these irrigated acres, increasing water use efficiency, and using the limited water available for dryland crop production are top priorities. Also, we need to protect the soil from wind and water erosion and maintain or even improve soil quality, which is accomplished with maintaining good crop residue levels. Evaporation accounts for 35% of the crop water use when irrigating twice a week with corn being grown on bare soil. The evaporation component of crop water use in growing irrigated corn can be reduced to 15% if the corn is grown on soil with a good level of crop residue and irrigated once a week. In addition, one has the soil water loss with each tillage or cultivation operation. The loss varies with soil type, soil water, type of tillage or cultivation, depth of tillage or cultivation and amount of crop residue remaining after the operation. The range is usually one-third to two-thirds inch of soil water loss for each operation and averages about one-half inch or about five to six bushels of corn. No-till systems increase water infiltration which permits applying more water when irrigating which increases water use efficiency and also more rainfall moves into the soil.

Kochia Management Without Glyphosate in Montana. Prashant Jha*, Vipan Kumar, Nicholas A. Reichard; Montana State University, Huntley, MT (154)

We have recently (2012) confirmed the presence of glyphosate-resistant kochia in Montana. The two suspected kochia populations in fallow fields from northern Montana in 2012 were tested (whole plant bioassay) and found to be 8- to 10-fold more resistant to glyphosate compared to a known susceptible biotype. We are currently investigating other cases of suspected glyphosate-resistant kochia populations from MT. There is a need for development of alternative (non-glyphosate) herbicide programs for control of glyphosate-resistant kochia in wheat-fallow systems. Field experiments were conducted at the MSU Southern Agricultural Research Center, Huntley, MT, in 2011 and 2012, to evaluate herbicide options for kochia control in spring fallow and in wheat stubble (post-harvest). Herbicides were applied with a hand-held boom calibrated to deliver 94 L ha^{-1} at 276 kPa. Except the post-harvest treatments, all POST treatments were applied to 8- to 10-cm tall kochia plants. Experiments were conducted in a randomized complete block design with 4 replications. Kochia control with PRE applications of dicamba (0.56 kg ae/ha) and sulfentrazone (0.210 kg ai/ha) averaged 92% compared with 82 and 71% control from KIH 485 (0.175 kg ai/ha) and flumioxazin (0.07 kg ai/ha), respectively, 6 wk after application. Among POST herbicide programs, fluroxypyr + bromoxynil at 0.361 kg/ha, pyrosulfutole + bromoxynil at 0.109 kg/ha, carfentrazone-ethyl + 2, 4-D at 1.716 kg/ha, and paraquat (0.84 kg ai/ha) plus linuron (0.84 kg ai/ha) provided effective control of kochia, which averaged 96% 21 DAA. Kochia control from POST applications of diflufenzopyr + dicamba at 0.024 kg/ha, saflufenacil (0.025 kg/ha) plus 2,4-D ester (0.282 kg/ha), diflufenzopyr + dicamba at 0.024 kg/ha along with 2,4-D (0.183 kg/ha) averaged 84%. Glyphosate at 1.26 kg ae/ha provided 82% control of kochia (population was susceptible to glyphosate) 21 DAA. Among the post-harvest (wheat stubble) herbicide programs, paraquat (0.42 kg ai/ha) plus linuron (0.84 kg ai/ha) and paraquat (0.42 ka ai/ha) plus metribuzin were the best treatments with 95% average kochia control 25 DAA. Kochia control in wheat stubble with diflufenzopyr + dicamba plus 2,4-D LV4 was 70%, which was higher than the control (55%) obtained from dicamba plus 2,4-D LV4. In conclusion, these non-glyphosate based post-harvest, early spring residual, and alternative POST burndown herbicide programs could be utilized to manage glyphosate-resistant kochia in no-till wheat-fallow systems. However, potential injury to wheat crop from these soil residual herbicides especially under dry conditions of Montana needs further investigation.

Glyphosate-Resistant Kochia on the Canadian Prairies. Robert E. Blackshaw*[1], Hugh J. Beckie[2], Ryan Low[3], Linda M. Hall[3]; [1]Agriculture and Agri-Food Canada, Lethbridge, AB, [2]Agriculture and Agri-Food Canada, Saskatoon, SK, [3]University of Alberta, Edmonton, AB (155)

Kochia is one of the most abundant and economically important weeds on the Canadian prairies; 3rd most abundant in southern Alberta and overall 10th most abundant in this region. A report of poor kochia control with glyphosate was investigated in three chemfallow fields (each farmed by a different grower) in Alberta during the summer of 2011. Suspected kochia plants were collected, grown to maturity in the greenhouse, and mature seed collected. Subsequent greenhouse dose-response experiments determined that these three kochia populations were indeed resistant to glyphosate; exhibiting a resistance factor ranging from 4 to 6 based on shoot biomass (GR_{50} ratios) and 5 to 7 based on survival response (LD_{50} ratios). A 2012 field confirmation dose-response experiment documented a similar resistance factor of 6 (GR_{50} ratios). Since this initial investigation an additional eight kochia populations have been confirmed to be glyphosate-resistant and several other populations collected during the summer of 2012 from both Alberta and Saskatchewan are being evaluated. Further herbicide resistance screening of the elevan confirmed glyphosate-resistant kochia populations found that all populations are Group 2 (thifensulfuron/tribenuron) resistant but Group 4 (dicamba) susceptible. A chemfallow experiment was conducted at Lethbridge, Alberta in 2012 to identify alternative herbicides for control of Group 2/Group 9 (glyphosate) resistant kochia. In a chemfallow situation (no crop competition), 2,4-D ester, bromoxynil, and bromoxynil/MCPA only provided a low level of growth suppression and would not be suitable for this purpose. In contrast, excellent kochia control was attained with fluroxypyr, dicamba, dicamba/diflufenzopyr, sulfentrazone, and MCPA/diclhlorprop/mecoprop-P. These findings will be utilized to provide growers with initial advice on effective alternative herbicides and future research will be conducted to develop integrated strategies for longer-term management of glyphosate-resistant kochia.

Prevalence of Glyphosate-resistant Kochia in Kansas and Effectiveness of Alternative Management Practices. Amar S. Godar*[1], Phillip W. Stahlman[2]; [1]Kansas State University, Manhattan, KS, [2]Kansas State Univ., Hays, KS (156)

Cases of kochia (*Kochia scoparia*) control failure with glyphosate increased dramatically in western Kansas in the years following confirmed presence of four glyphosate-resistant (GR) populations in 2007. The objectives of this online survey were to estimate the impact of GR kochia in western Kansas and gather information on growers' response to the problem. Fifty two crop consultants from 46 western Kansas counties participated in this survey representing approximately 420,000 ha of cropland. Within the entire area surveyed, 67% fields were infested with kochia in 2011-2012, of which nearly half were GR populations. Survey respondents reported the average use rate of glyphosate increased from 0.8 kg ae/ha before 2007 to 1.2 kg ae/ha in 2011-2012. Similarly, glyphosate use frequency increased from 2.1 applications per season to 3 applications in fallow and 2.7 applications per season in GR crops in 2011-2012. Absolute dependency on glyphosate for weed control in GR crops decreased from 49 to 14% during the survey years. One-third of respondents reported inconsistent results with alternative kochia control practices other than tillage. Results suggest that GR kochia currently infests nearly one-third of the cropland in western Kansas. During the years of survey, growers increased both the use rate and frequency of glyphosate applications; however, continued failure of such practices decreased sole dependency on glyphosate. Owing to the extended germination period of kochia, overlapping preemergence and postemergence residual herbicides will help maximize control. Such practices, in most instances, will add considerable cost to the previous practice of using glyphosate alone.

Preemergence Dicamba Dose Response Curves For Kochia Control Followed by Paraquat Tank Mixes. Randall S. Currie*[1], Curtis R. Thompson[2], Phillip W. Stahlman[3]; [1]Kansas State Univ., Garden City, KS, [2]Kansas State Univ., Manhattan, KS, [3]Kansas State Univ., Hays, KS (157)

In 2010, in response to an emerging threat of glyhposate-resistant kochia, a regional task force tested 9 preemergence and 14 postemergence non-glyphosate herbicide tank mixes for kochia control at 6 to 9 locations. (Stahlman et al., 2010, Proc. WSSA) None of these tank mixes consistently provided 100% control of kochia but preemergent applications of dicamba provided the best and most consistent preemergence control. However, it was unclear what dicamba rate would provide the optimal level and duration of kochia control. Among the postemergence applications, paraquat and atrazine tank mixes provided the highest and most consistent level of control. Therefore, it was the objective of this study to measure the dose response relationship of several preemergence dicamba rates, followed by postemergence tank mixes of paraquat and atrazine. Within the first week of March, a split plot experiment with, 0, 0.25, 0.5, 0.75 and 1 lb /A of dicamba as the main plot, was established. During May, the main plot treatments began to fail. Subplots of paraquat and atrazine at 0.75 and 1 lb/A were then applied. To reduce the possible interference of grassy weeds, 2 lb/A of S-metolachlor was included. This Experiment was conducted at Garden City, Hays and Tribune Kansas. To expand the inference to a wheat-fallow- wheat rotation, at the Tribune location, an additional set of subplots were included - a tank mix of paraquat+ metribuzin at 0.75 and 0.5 lbs./A. Control 30 DAT (Days After Treatment) ranged from 100% to 94% with 1 lb/A dicamba across all locations. At this rate, control declined to 94% to 83%, across all locations 60 DAT. With 0.5 lb/A dicamba, control 60 DAT declined to 85% to 70% across all locations. At all but the Garden City location, a logistic model explained the dose response relationship with R-squares greater than 0.90 at all rating dates from 33 to 94 DAT. At the Garden City location, this was true until 47 DAT. However, from 68 to 110 DAT the rate of control at the Garden City location was best described by simple linear models with R-square values greater than 0.90 at all rating dates. At all rating dates, the rate of diminishing returns was observed with 0.5 lb/A dicamba. At this rate, control declined linearly with time at all three locations with R-squares ranging from 0.90 to 0.97. The slopes of these lines predicted from 0.56% to 0.86% decline in control per day during the first 60 days. At the Tribune and Hays locations, tank mixes with paraquat and atrazine or metribuzin augmented control of dicamba treated plots elevating control from 93% to 100% through 88 DAT. Record heat and drought at application at Garden City, coupled with beginning kochia populations of greater than 250 plants/square inch, made coverage of postemergence treatments poor and lead to atypically poor control, compared to previous work. There was substantial kochia mortality in the control plots due to drought and remaining plants were stunted and failed to reach a height of 12 inches at the end of the growing season. This limits the utility of the later season post treatments at this location. All locations support the early March application of 0.5 lb. /A of dicamba for early season preemergence control of kochia. However, additional postemergence treatments are still needed. At two of the three locations, preemergence dicamba treatments followed by postemergence applications of paraquat and atrazine or metribuzin, provided excellent season long control.

Management of Glyphosate Resistant Kochia in Fallow using Isoxaflutole, Pyrasulfotole and Tembotrione based programs. Charles P. Hicks*[1], Greg Hudec[2], Jim Bloomberg[3]; [1]Bayer CropScience, Fort Collins, CO, [2]Bayer CropScience, Manhatten, KS, [3]Bayer CropScience, Raleigh, NC (158)

Glyphosate resistant Kochia (*Kochia scoparia* L.) is rapidly spreading across the high plains region. Confirmed resistance in Colorado, Kansas, Nebraska and Montana necessitate alternative herbicide programs for kochia management in fallow cropping systems. Field studies were initiated at 8 locations in Kansas, Nebraska, Colorado and Wyoming to determine the effectiveness of both PRE applied and POST programs. Test sites in Kansas and one site in Colorado had confirmed glyphosate resistant kochia while other locations were considered susceptible populations.

Several herbicide programs resulted in excellent control of Kochia under extremely hot and dry conditions. Corvus Herbicide (isoxaflutole plus thiencarbazone-methyl) applied PRE with either atrazine or metribuzin averaged 95% kochia control across locations. Laudis herbicide (tembotrione) applied POST with atrazine plus banvel or Starane NXT (fluroxypyr + bromoxynil) averaged 90%+ control of Kochia. Huskie herbicide (pyrasulfotole + bromoxynil) plus atrazine or Starane were also very effective POST treatments. Based on results from these trials, there appears to be several very effective options for control of glyphosate resistant kochia across the high plains.

Glyphosate-Resistant Kochia: Herbicide Solutions for a Growing Problem. Brad Lindenmayer*[1], Pete Forster[2], Les Glasgow[3], Philip Westra[4], Phillip W. Stahlman[5]; [1]Syngenta Crop Protection, Fort Collins, CO, [2]Syngenat Crop Protection, Eaton, CO, [3]Syngnta Crop Protection, Greensboro, NC, [4]Colorado State University, Ft. Collins, CO, [5]Kansas State Univ., Hays, KS (159)

The evolution of glyphosate resistance (GR) in weed populations is a serious problem increasing production costs and changing production practices for farmers around the world. GR populations of *Kochia scoparia* have recently been identified across the US Great Plains, posing a significant threat. A collaborative study between Syngenta, Colorado State University, and Kansas State University was conducted with the objective of identifying herbicide solutions to control GR kochia in both corn and soybean cropping-systems. Of the 14 treatments evaluated, generally treatments that combined HPPD and PS-II or PS-I and PS-II herbicides pre-plant were most effective. Postemergence applications provided little additional control, indicating the importance of early-season control. When applied to 4-8 cm kochia, Lumax® EZ (2,700 g ai ha^{-1}) + AAtrex® (1,120 g ai ha^{-1}) + Gramoxone® SL (700 g ai ha^{-1}) followed by Status® (196 g ai ha^{-1}) + AAtrex (560 g ai ha^{-1}) + Touchdown Total® (1,170 g ae ha^{-1}) was the most effective treatment in corn, while Boundary® (2,190 g ai ha^{-1}) + Gramoxone SL (700 g ai ha^{-1}) followed by Callisto® (105 g ai ha^{-1}) + Touchdown Total (1,170 g ae ha^{-1}) was the most effective treatment in soybeans across all Syngenta trials. Earlier application (1-2 cm kochia) in the university trials resulted in excellent control from all treatments, indicating the importance of treating smaller plants. Results from this study suggest that there are viable options available for GR kochia control and that early-season control is paramount; achieved through a program combining a burndown and residual pre-plant herbicide application followed by a postemergence application to control any subsequent weed flushes.

PROJECT 4: TEACHING AND TECHNOLOGY TRANSFER

Editor's Note: Data Management Workshops and discussions were conducted in this section but no abstracts were submitted; titles are listed below for information and to document that there was a Project 4 session at the annual meeting.

Efficient Weed Research Management with ARM 9. Steve Gylling*, Gylling Data Management, Inc., Brookings, South Dakota.

Trial Reporting Capabilities of ARM 9. Steve Gylling*, Gylling Data Management, Inc., Brookings, South Dakota.

Field data collection: proven methodology. Kelly Young, University of Arizona, Phoenix, AZ.

PROJECT 5: BASIC BIOLOGY AND ECOLOGY

Evolution and Spread of Glyphosate Resistance in Horseweed and Hairy Fleabane in California Orchards and Vineyard. Marie Jasieniuk*[1], Miki Okada[1], Bradley D. Hanson[1], Kurt J. Hembree[2], Anil Shrestha[3], Steven D. Wright[4]; [1]University of California - Davis, Davis, CA, [2]University of California Cooperative Extension Fresno County, Fresno, CA, [3]California State University - Fresno, Fresno, CA, [4]University of California Cooperative Extension Tulare and Kings Counties, Tulare, CA (105)

Recent increases in glyphosate use in perennial crops of California are hypothesized to have led to an increase in selection and evolution of glyphosate resistance in horseweed (*Conyza canadensis*) and hairy fleabane (*C. bonariensis*) populations. We investigated the geographical distribution of glyphosate resistance and the genetic diversity and structure of populations of the two species across and surrounding the Central Valley to assess the evolutionary origins and spread of resistance. Frequencies of resistant individuals were higher in horseweed populations of the southern Central Valley than the northern, but were more uniformly high in hairy fleabane populations. Analyses of population genetic diversity and structure indicated multiple independent origins of resistance in the Central Valley for both species. Approximate Bayesian Computation analyses of resistant horseweed genotypes revealed expansion after glyphosate use began in agriculture but many years before it was detected. Substantially greater frequencies of resistant individuals in hairy fleabane than horseweed in the northern Central Valley suggests a species difference in the rate of evolution of glyphosate resistance in the common environment to be investigated in future studies.

A Growing Degree Day Model for Phenological Development of Hairy Fleabane (Conyza bonariensis). Anil Shrestha*[1], Bradley D. Hanson[2], Kurt J. Hembree[3], Marie Jasieniuk[2], Steven D. Wright[4]; [1]California State University - Fresno, Fresno, CA, [2]University of California - Davis,

Davis, CA, [3]University of California Cooperative Extension Fresno County, Fresno, CA, [4]University of California Cooperative Extension Tulare and Kings Counties, Tulare, CA (106)

This study compared the phenological development of five glyphosate-resistant (GR) and five glyphosate-susceptible (GS) populations of hairy fleabane plants grown from seeds collected from various parts of the central valley of California. Potted plants were grown in full sun in spring/summer of 2010 and 2011. Time taken by each plant to reach the rosette, bolting, appearance of first bud, appearance of first open flower, and appearance of first seed set were recorded and was converted into growing degree days (GDDs) using a base temperature of 4.2 C. The rate of phenological development was similar between the GR and GS populations. Resistance to glyphosate did not affect the rate of phenological development of the GR and GS hairy fleabane plants. The phenological development of these hairy fleabane populations was hence described by a common GDD model.

Effect of Height and Seeding Rate on Spring Wheat - Wild Oat (Avena fatua) Interaction. Zachariah Miller, Luther Talbert, Fabian Menalled*; Montana State University, Bozeman, MT (107)

Increasing crop competitive ability through seeding rate and crop size provides a mean to diversify weed management. However, few studies have assessed the integrated effects of these two practices and the evidence for linking taller varieties with improved weed management are confounded by inter-variety morphological differences. A field experiment was conducted near Bozeman, MT to investigate the impacts of seeding rate and height of three hard red spring wheat varieties on crop-wild oat interactions. Within each variety, crop height (tall or semi-dwarf) was determined by one to two genes. Spring wheat was planted at high (337 plants m^{-2}) or (202 plants m^{-2}) low seeding rates into wild oat-infested or weed-free plots. Each treatment was replicated four times in a completely randomized design. Data were collected on grain yield, weed density, biomass, and seed production. Effects of wild oat on spring wheat yields depended on an interaction between crop height and seeding rate. At low seeding rates, semi-dwarf lines had greater yields than tall lines in weed-free controls but yields were similar in weedy plots. At high seeding rates, weeds-free yields and weed impacts on yields were similar between tall and semi-dwarf lines. While increasing seeding rate decreased weed per capita biomass, canopy height did not impact weed growth. Both seeding rate and crop height had independent effects on weed seed production. Increasing seeding rate and crop height reduced weed seed production by approximately 30% and 20%, respectively. Increasing seeding rate had the largest and most consistent effects on weed growth and seed production and taller wheat lines may be useful as part of a long-term integrated wild oat management program that should be used in combination with high seeding rates.

Eco-Efficiency of Herbicide Treatments in Conventional and Glyphosate-Resistant Sugarbeet Production. Carl W. Coburn*, Andrew R. Kniss; University of Wyoming, Laramie, WY (108)

Rapid adoption of glyphosate-resistant sugarbeet has largely displaced conventional sugarbeet production. Eco-efficiency analysis allows comparison of production systems by quantifying output per unit of input. A meta-analysis was conducted to compare the eco-efficiency of herbicide treatments in conventional and glyphosate-resistant sugarbeet production. Using herbicide treatment and yield data from eight studies located in various growing regions, a partial eco-efficiency analysis was performed on conventional and glyphosate-resistant herbicide programs. Environmental impact was determined using the risk quotient (RQ) method for two aquatic indicator species commonly assessed for herbicide risk. Exposure was quantified using the tier 1 risk assessment model Generic Estimated Environmental Concentration (GENEEC), and effect was quantified using herbicide toxicity data. Treatment yield was divided by the calculated RQ to determine eco-efficiency of herbicide treatments. Greater values of eco-efficiency indicate lower environmental impact per unit of sugar production. Statistical comparisons of eco-efficiency were made using paired t-tests. Average estimated exposure levels for all herbicide treatments were below 0.06 ppm and average RQ for all treatments were below the EPA recommended level of concern. Glyphosate treatments resulted in significantly higher eco-efficiency values compared to standard and micro-rate treatments with or without a PRE for both indicator species. The eco-efficiency of 2-3 applications of glyphosate was 170 times greater than that of micro-rate treatments. Differences in eco-efficiency were largely driven by active ingredient toxicity and sugarbeet yield. Future work will include terrestrial indicators in the analysis.

The Evaluation of Simulated 2,4-D and Dicamba Drift on Winter Canola in Oklahoma. Samantha K. Ambrose*, Chad B. Godsey, Sarah Lancaster; Oklahoma State University, Stillwater, OK (109)

Winter canola (*Brassica napus*) is a valuable rotational crop for wheat (*Triticum* spp.) producers in the southern plains and provides opportunity to improve control of some winter annual grass weed species; however, unintentional drift of herbicides in winter wheat and pastures may cause damage to winter canola, causing lower yields and decreased crop quality. This study was conducted to determine the effect of simulated 2,4-D and dicamba drift on winter canola seed yield, 100-seed weight, and seed oil content when applied at various vegetative and reproductive growth stages. 2,4-D ester and dicamba were applied at 0.5, 2.5, 5, 10, and 20% of the recommended use rates for pasture maintenance at either the 4-6 leaf stage (late-October), early flowering (mid-March), or early pod set (April). Canola yield when dicamba was applied at the 4-6 leaf stage and early bloom stage was greater than or equal to 100% of the control yield. Yield increased with increasing dicamba rates at early bloom, then peaked when dicamba was applied at 5% before decreasing slightly at the 10 and 20% rates. Dicamba rates at the early pod set application timing were near or equal to 100% of the control yield. No difference was observed between 10 and 20% dicamba rates at 4-6 leaf or early pod set application timings. There were no trends observed in seed oil content or 100-seed weight for dicamba treatments. Canola yield decreased with increasing 2,4-D rates at 4-6 leaf and early bloom application timings. 2,4-D rates of 10 and 20% at the 4-6 leaf application timing resulted in complete crop loss. No trend was observed at early pod set for 2,4-D application rates; however, yield loss of 24% was observed at the 5% 2,4-D application rate. Seed oil content decreased with increasing 2,4-D application rates when applied at the 4-6 leaf and early bloom application timings. Seed oil content during the early pod set application timing was near or equal to the control percentages for each 2,4-D application rate. All 2,4-D application rates at each application timing resulted in a 100-seed weight near or greater than the control 100-seed weight average. The 4-6 leaf application timing resulted in a 100-seed weight decrease with increasing 2,4-D application rates. At the early bloom application timing, 100-seed weight increased with increasing 2,4-D application rates until the 10% 2,4-D application rate, then decreased at the 20% application rate. This study shows that 2,4-D has greater effects on canola yield, seed weight, and oil content than dicamba at simulated drift rates.

Using Climate Modeling to Project Development of Bromus tectorum in the Pacific Northwest. Nevin Lawrence*[1], Ian C. Burke[1], John Abatzoglou[2], Daniel A. Ball[3]; [1]Washington State University, Pullman, WA, [2]University of Idaho, Moscow, ID, [3]Oregon State University, Pendleton, OR (110)

Growers in the PNW are likely to see shifts in agroclimatic zones and will need to adapt practices as climate changes. Increasing mean annual temperatures, increasing spring precipitation, and decreasing summer precipitation have been observed in the Pacific Northwest (PNW) over the last 50 years. Changes in the PNW climate over the next century are projected to outpace recent trends. To aid in grower adaptation, better knowledge of weed response to climate change is needed. Downy brome, a weed species distributed throughout the PNW, was selected to model physiological and ecological response to climate change. A previously published downy brome development model identified 1,000 growing degree days (GDD) as a relevant development threshold for the PNW. Utilizing 14 climate models that adequately captured the historical characteristics of the PNW climate, the calendar date at which 1000 GDD was reached from 1950-2005 was compared to the projected mean calendar date from 2031-2060. Projected date that 1,000 GDD was reached occurred 10-30 days earlier in the year. The interaction of earlier downy brome development and increased spring moisture may interfere with ability of growers to make timely applications of spring applied herbicides under future climate projections. Further refinement of the downy brome development model could improve the accuracy and usefulness of future climate projections. Field studies are currently ongoing to incorporate greater spatial resolution of downy brome phenotypic variation.

Evaluating Tree Response to Aminocyclopyrachlor Ground Application. Curtis M. Hildebrandt*[1], Philip Westra[2]; [1]Colorado State University, Fort Collins, CO, [2]Colorado State University, Ft. Collins, CO (111)

The auxinic compound, Aminocyclopyrachlor (AMCP), is a pyrimidine carboxylic acid herbicide used to control broadleaf weeds and woody species. Research has shown that AMCP has a high soil residual activity. In addition, the water soluble nature of the herbicide makes the potential mobility and bioavailability of AMCP to non-target species relatively high. An increasing awareness of AMCP's effects on desirable tree species, such as white pine, creates the need for research regarding the herbicide's activity on different tree species throughout the United States. Field plots were established at the ARDEC facility north of Fort Collins, CO to look at the effect of ground applications of AMCP near honey locust and green ash trees. Applications were made at 210 g ai ha^{-1} underneath the drip line of the target trees. Field plots were also established at Annex Reservoir #8 five minutes north of Fort Collins, as well as near Mead, CO and both sites were treated at the 210 g ai ha^{-1} rate at varying distances from the target trees to evaluate the herbicide's activity on cottonwood and willow. Preliminary results from spring and summer applications in the 2012 growing season indicate that honey locust is sensitive to the herbicide application, while green ash did not exhibit any injury symptoms. Late summer applications next to the cottonwoods and willows have not yet shown injury symptoms.

A greenhouse dose response study, including nine different regionally important tree species, is being conducted this coming spring.

Impact of Cover Crop Termination Through Sheep Grazing on Weed Community Structure. Sean McKenzie, Hayes Goosey, Kevin O'Neill, Fabian Menalled*; Montana State University, Bozeman, MT (112)

Targeted sheep grazing of cover crops could potentially benefit agriculture as it may provide farmers an alternative to using machinery while enhancing nutrient cycling, soil conservation, and pest management. Because grazing represents an ecological filter of plant communities, it is important to understand its potential impacts on weed community structure before implementation on agroecosystems. We compared the effects of sheep grazing and mowing for cover crop termination on plant community structure at the Towne's Harvest Organic Farm near Bozeman, MT. Metrics included plant diversity, weed biomass, and cover crop biomass. In six 10 m X 15 m plots, we seeded a cover crop consisting of buckwheat (*Fagopyrum esculentum* Moench), beet (*Beta vulgaris* L.), sweetclover [*Melilotus officianalis* (L.) Lam.], and pea (*Pisum sativum* L.), allowed it to grow to peak biomass, collected samples at peak biomass, and terminated half of the plots with sheep grazing and half with tractor mowing. We collected similar measurements one month after terminating the cover crop. We failed to detect any significant difference in plant biomass and diversity between mowed and grazed plots both prior to and after cover crop termination. Our results suggest that farmers integrating sheep grazing may not encounter deleterious changes in weed communities.

Regional and Whole Plant EPSPS Gene Amplification in Glyphosate Resistant Kochia. Philip Westra*[1], Andrew Wiersma[1], Jan Leach[1], A.S.N. Reddy[1], Phillip W. Stahlman[2]; [1]Colorado State University, Ft. Collins, CO, [2]Kansas State Univ., Hays, KS (113)

Glyphosate-resistant *Kochia scoparia* in the central Great Plains of the U.S. threatens hard won advances in reduced tillage based on glyphosate control of weeds. To monitor and assess resistance, *K. scoparia* accessions were collected from fields with putative glyphosate resistance in KS, CO, ND, SD, and Alberta, Canada. Whole plant glyphosate dose response and shikimate assays were used to confirm resistance and assess levels of resistance. PCR, quantitative PCR, sequencing, and immunoblotting were used to determine the mechanism responsible for resistance. Sequence of the *EPSPS* binding site proline confirmed that amino acid substitution at that residue was not responsible for glyphosate resistance. Estimates of *EPSPS* gene copy number revealed increased copy number in all glyphosate-resistant individuals with the increase ranging from 3 to 9 *EPSPS* copies relative to a reference *ALS* gene. Glyphosate-resistant kochia with increased *EPSPS* copy numbers also had consistently reduced shikimate levels in leaf disks treated with 100 µM glyphosate. *EPSPS* copy number was linearly correlated to *EPSPS* transcript abundance, and EPSPS enzyme accumulation was consistently elevated in resistant plants with increased copy number. Based on these finding, we see that the geographic range infested with glyphosate-resistant *K. scoparia* is expanding, and that use of increased glyphosate rates will likely select for higher levels of resistance. These results are consistent with a model attributing increased EPSPS expression as a mechanism for glyphosate resistance in *K. scoparia*. We suggest that lower level increases in EPSPS expression (as compared to *Amaranthus palmeri*) is sufficient for field-level glyphosate resistance. RNA-seq and basic transcriptome assembly of glyphosate-susceptible and -resistant *K. scoparia* is in progress and should lead to a better understanding of factors contributing to resistance. Kochia transcriptome data generated on an Illumina 2000 sequencer has been obtained and is being assembled using bioinformatics to determine genetic differences between susceptible and resistant kochia.

EDUCATION & REGULATORY SECTION

Organizing plant photographs using Adobe Lightroom. Robert F. Norris*; University of California, Davis, CA (133)

Lightroom® is a photographic database manager that has the ability to search for, and locate, photographs of plants. The software is widely used by professional photographers to manage photographic files and to perform routine file manipulation. It is not necessary to know the location of the files. A combination of appropriate keywording and metadata tagging permits searching for plant photographs by family, genus, Latin binomial or by common name. Additionally, it is feasible to search by plant attributes such as whether or not the plant is a weed, or whether the photograph is of seeds, seedlings, leaves, fruits, or shows spines. The photographs can also be filtered by habitat/ecosystem. Camera metadata allows for searching by time of acquisition, camera and/or lens used, and by location and altitude when using global positioning system enabled cameras. The key to plant searches is using the metadata fields of 'title' for the common name, 'caption' for the Latin binomial, and 'label' for the genus. The keywording system is hierarchical. Under the system described, the main keyword categories include location, habitat/ecosystem, altitude, and plants. The main keyword 'plants' is sub-divided into categories including dicotyledon families, monocotyledon families, gymnosperm families, non-flowering plants, growth stages/forms, and type of plant. Each sub-category is further divided to permit actual lists of families, growth forms, or plant types. Using a database with over 60,000 photographic files it is feasible to locate any appropriately tagged photograph within a few seconds.

A Generalized Framework for Teaching and Interpreting Plant Invasion and Management. Brian A. Mealor*; University of Wyoming, Laramie, WY (134)

Many hypotheses offer potential explanations for why some plant species proliferate and cause ecological impacts and management challenges upon introduction into a new region. Most of these hypotheses focus on a single mechanism for the superior performance of invasive plants in new systems: release from natural enemies, novel chemical weapons, empty niche, resource fluctuation, and others. To a lesser extent do hypotheses address interacting mechanisms which may contribute to invasion success: evolution of increased competitive ability and interrelated causes of plant invasion hypotheses. Through several years of teaching invasive plant ecology and management to upper class undergraduates and graduate students, it became apparent that some students were overlooking how each of the separate hypotheses for invasion success could potentially occur simultaneously in one scenario – in essence focusing on the components of the system but not grasping the dynamics of the system as a whole. To better illustrate potential interactions in the invasion process, I developed a causal loop systems diagram which encapsulates major hypotheses of invasion. By facilitating students' ability to view plant invasion and dominance from a systems perspective, the link between ecological theory and weed management becomes clearer and potential leverage points for managing invasive weeds become evident.

Does Acidic AMS Replacement Adjuvants Condition Water? Rich Zollinger*, Kirk Howatt; North Dakota State University, Fargo, ND (135)

Studies were conducted in 2009 through 2011 in North Dakota, Nebraska, Kansas, and Illinois to evaluate phytotoxicity from glyphosate (no adjuvant formulation) applied with commercial acidic ammonium sulfate replacement (AAR) adjuvants in distilled water and water with 1000 ppm hardness. Commercial AAR adjuvants were compared to ammonium sulfate (AMS) plus nonionic surfactant (NIS). Most AAR adjuvants contain monocarbamide dihydrogen sulfate (MCDS) which is a compound of sulfuric acid complexed with urea and can reduce spray water pH to approximately 2.0. The low pH is below the pKa of most herbicides and causes herbicides to have a neutral charge which reduces binding with antagonistic cations in hard water. AMADS (1-aminomethanamide dihydrogen tetraoxosulfate) at not less than 1% v/v provided similar herbicide enhancement as AMS plus NIS in distilled and hard water. In the absence of hard water, some commercial AAR adjuvants enhanced glyphosate phytotoxicity similar to AMS plus NIS; however, in hard water glyphosate phytotoxicity was less. Generally, the rate of 1% v/v was required for commercial AAR adjuvants to equal the same herbicide enhancement as AMS plus NIS. The AMADS concentration in commercial AAR adjuvants may be diluted with other ingredients in the formulations. Lowering spray solution pH did not increase glyphosate activity in hard water. Sulfate in AMS and AMADS can condition hard water which may then allow the ammonium to enhance herbicide activity. AMADS applied at no less than 1% v/v or AMADS contained in some commercial AAR adjuvants provide the minimum water conditioning from $SO_4^=$ similar to AMS. Hard water that is sufficiently conditioned with $SO_4^=$ may allow urea in AMADS to enhance and optimize herbicide phytotoxicity similar to AMS.

Paper 136 was withdrawn

Prospects for Biofuel Feedstock Crops in California. Steve Kaffka*[1], Nick George[2], Santiago Burcaram[3]; [1]UC Davis, Davis, CA, [2]California Biomass Collaborative, Davie, CA, [3]California Biomass Collaborative, Davis, CA (137)

ABSTRACT

Biomass use for energy and related bio-products is affected in the US by both federal and state level regulatory programs. The Renewable Fuel Standard (RFS2) is a federal policy mandating types and amounts of biofuels to be used in the US market, including California. The Low Carbon Fuel Standard (LCFS) is a state policy that avoids direct mandates, but requires that the average Carbon Intensity (CI) of transportation fuels in the state decline by 10 % by 2020. To achieve these domestic biofuel production goals, USDA projects that most feedstocks will be

produced in the Midwestern and southeastern states, and little to none in the western US. However, California's LCFS and its Alternative Renewable Fuel and Vehicle Technology Investment Program (AB 118) provide incentives and subsidies for the development of new biofuel production businesses in California. The prospects of adopting purpose grown bioenergy crops in California have been investigated using a cropping systems optimization model localized for different regions of the state, and linked to crop production research and simulation modeling for new crops. Applied research and model results, together with crop simulation, indicate that a number of regions and crops could support crop production for biofuel feedstocks under reasonable price assumptions. As an example, production of winter annual oilseed crops like canola, Camelina, and other new oilseed crops in diverse locations in California will be discussed. Since most new canola cultivars are herbicide tolerant, if oilseed crops are grown to help meet state alternative fuel mandates and accommodate desires for new green in-state businesses, jobs and production, the use of herbicide-tolerant canola may become more widespread.

Agronomic Aspects of Growing Switchgrass and other Cellulosic Biofuel Crops in California. Robert Hutmacher*[1], Daniel Putnam[2], Steven D. Wright[3], Gabriel Pedroso[2], Christopher DeBen[2], Steve Kaffka[2], Gerardo Banuelos[4]; [1]UC Davis, Five Points, CA, [2]UC Davis, Davis, CA, [3]University of California Cooperative Extension Tulare and Kings Counties, Tulare, CA, [4]University of California Cooperative Extension Tulare Co., Tulare, CA (138)

Switchgrass (*Panicum virgatum)* is one of a number of perennial crop and annual crop species under investigation as feedstock for various types of biofuel production plans. As a warm-season perennial grass, many of the production issues experienced with switchgrass likely apply to a number of other species. Two different ecotypes of switchgrass are widely available in commercial germplasm, and they are described generally as lowland types and upland types. Lowland type characteristics can be generalized as being taller, coarser and more vigorous with higher biomass potential when compared with most of the upland types. Genetic backgrounds of the lowland types are more linked to environments with warmer winter weather and more growing season rainfall than some of the more common upland types. An important characteristic of the switchgrass varieties evaluated in California studies in recent years affecting management decisions is slow early seedling growth and plant establishment. In semi-arid production areas such as California, this can make attention to upper soil profile water availability an all-important practice for good stand establishment. Since in many cases an established switchgrass field could be kept for many years, weak switchgrass early growth also makes attention to early weed control vital to acceptable stand establishment. In the San Joaquin Valley studies, all tested switchgrass varieties were winter dormant, with some varietal differences in timing of dormancy. Biomass production with this warm-season grass is strongly dependent on warmer temperatures and water availability, with little biomass production between November and early to mid-March or later under San Joaquin Valley conditions. In studies conducted to date with one moderate yield potential variety, a two-cuts per year harvest approach has consistently outyielded one-cut and three-cuts per year approaches. Total plant water use and responses to nitrogen fertilizer rate will also be discussed. Due to the fact that perennial crop production for biofuels could in some situations compete for land with annual crops also grown for biofuel, some production issues noted for switchgrass in studies at the University of California West Side Research and Extension Center will be compared with management issues noted with sweet sorghum.

Weed Control Research and Challenges in California Biofuel Crops. Steven D. Wright*[1], Kurt J. Hembree[2], Robert Hutmacher[3], Daniel Putnam[4], Gerardo Banuelos[5], Gabriel Pedroso[4]; [1]University of California Cooperative Extension Tulare and Kings Counties, Tulare, CA,[2]University of California Cooperative Extension Fresno County, Fresno, CA, [3]UC Davis, Five Points, CA, [4]UC Davis, Davis, CA, [5]University of California Cooperative Extension Tulare Co., Tulare, CA (139)

Native grassland species such as switchgrass (*Panicum virgatum*), can be impaired by weed populations during establishment. This presents a substantial challenge for growers of perennial bioenergy crops. Previous work in southwestern Wisconsin has demonstrated that 2,4-D amine gave good control in switchgrass. A field experiment was conducted in the southern San Joaquin Valley on August 9th, 2007 to evaluate herbicides weeds in switchgrass. Herbicides included dicamba (0.25 lbs ai/A), 2,4-D amine (0.5 lbs ai/A), bromoxynil (0.25 lbs ai/A), dimethenamid-p (0.84 lbs ai/A), carfentrazone (0.03 lbs ai/A), cloransulam (0.005 lbs ai/A), and pyraflufen (0.03 lbs ai/A). Herbicides were applied with a CO_2 backpack sprayer. Results indicated that at 6 DAT carfentrazone at the 0.03 lbs ai/A demonstrated significantly better control (>100%) of all weeds present: London rocket, shepherd's-purse, lambsquarter, prostrate and redroot pigweed. Injury was 20 % but disappeared by 14 DAT. At 14 DAT, 2, 4-D amine without a tank mix gave very minor injury, however; gave excellent control (>90 %) of London rocket and shepherd's-purse. The 2, 4-D amine tanked -mixed with either dicamba or bromoxynil gave minor to no injury and gave good control (>75%) to all weeds present. There was no control of barnyardgrass by any of these herbicides evaluated. This study showed that 2,4-D amine can be effective with or without a tank mix from the herbicides tested with minor to no injury. The most rapid weed control was obtained with carfentrazone at the 0.03 lbs ai/A. In addition to herbicide management, pre-irrigating to generate the first weed flush and then control weeds with herbicides or tillage, before planting switchgrass would ensure a uniform stand. Pendimethalin was applied in the fall to control winter grasses. Once established no further herbicides were applied.

Currently in California, more growers are experimenting with other biofuel crops such as camelina, sorghum, safflower, and canola. Canola is by far one of the most popular biofuels grown in Canada and U.S. There are glyphosate resistant varieties, however; there is limited acreage in California. Nevertheless, with glyphosate resistant cultivars several herbicide applications which may pose a common resistance problem to growers. We are currently developing sorghum for biofuel. Variety studies are ongoing because of lodging adoption has been slow. Treated seed protected allowing for metolachlor herbicide is not yet available, however, 2,4-D amine, dicamba, and pendimethalin herbicides are. Nevertheless, California needs more research in the biofuel crop industry. Regardless of the biofuel crop, establishment success is important to the long-term success and a critical component of its success is an aggressive weed control strategy.

Risk Assessment of the Potential for Biofuel Crops to Become Weedy Invaders in California. Joseph M. DiTomaso*; University of California, Davis, CA (140)

The expected production of biomass-derived liquid fuels in the US will require cultivation of millions of acres of bioenergy crops, of which the leading candidates include perennial grasses such as switchgrass (*Panicum virgatum*), giant miscanthus (*Miscanthus* x *giganteus*), napier or elephantgrass (*Pennisetum purpureum*), and particularly giant reed (*Arundo donax*). None of these grasses are not native to the western US, though switchgrass is native to other areas of the US. Because they grow rapidly and produce high levels of biomass, they generally possess many of the same qualities as other invasive perennial grasses, and in fact, both giant reed and napiergrass are considered highly invasive in certain parts of the country. To evaluate the potential invasibility of these species, a variety of evaluations and experiments need to be conducted. For example, risk analysis and climate matching models, as well as greenhouse and field evaluations on environmental tolerance and competitive ability need to be establilshed. For both switchgrass and miscanthus, we concluded that dryland regions of the western US are not suitable to vigorous establishment and invasion. However, riparian areas appear to be far more likely to support populations of both species. Napiergrass is a tropical species and is unlikely to survive in much of the western US. In contrast, giant reed is already well established as an invasive species in some states and is listed as a noxious weed in California and Texas. With effective prevention, monitoring and mitigation practices in place throughout the development, growth, harvest, transport, and storage processes, it should be possible to minimize or eliminate the movement of seeds and/or vegetative propagules to sensitive habitats.

DISCUSSION SESSIONS

Project 1 Discussion Session: Weeds of Range and Natural Areas

Moderator: Todd Neel, National Park Service, Marblemount, WA

Topic 1: *Is it Time to Redifine Invasive Species in Light of Climate Change and Assisted Migration?*

1. By the executive order (February 3, 1999, #13112, Invasive Species) – all assisted migrations by definition may potentially create an invasive species.

Native species suggested through conservation or genetic modification, what threat do they pose:

a. Torrey pines in Florida - highly endangered non reproducing population in its native range, extinction is likely in the next 50 – 100 years or less. Being out planted in Mississippi and elsewhere in the south (see attached article).
    a. Is this a potentially invasive species, by definition and by reality?
    b. Does it have the potential to ecologically change the environments that it is being planted in?
    c. How is it being monitored or planting being controlled?
    d. Scientific, ecological the philosophical perspective; is this a good thing?
    e. OR like animals should these species be maintained in plant zoos which are botanical gardens, and seed repositories?
b. American chestnut – genetically enhanced with blight resistance from Chinese chestnut (origin of chestnut blight)
    a. Is a genetically modified version of a native species potentially an invasive species?
    b. Is the definition of invasive independent of GMO?
    c. Since there is small but growing population of native chestnut, and American chestnut is an early seral species historically controlled by regular burning of eastern forests, what controls should be placed on this population?
c. White bark pine - under threat by climate change and indirectly through climate change and changes in the range of native bark beetles and the expansion of blister rust with warmer annual temperatures at higher elevation – if moved (assisted migration) could this pose a threat as an invasive species like Monterey Pine (below)?

Native species that have already proved invasive through "migration:"

a. Monterey Pine (*Pinus radiata*): Limited native range under threat by climate change, insects and diseases. However, has proven highly invasive when introduced outside its native range in California. Also highly invasive in some places where it has been introduced around the world, New Zealand, South Africa.
    a. Same questions above with the addition of horticulture cultivars with much broader ecological amplitude are already reproducing in wildland environments.

b. Would this be an invasive species if planted outside its range for the purpose of preservation of the species?

Discussion 1 Notes – 13March2013

- Is it ethical to replant endangered tree species for proactive conservation?
- Can a native be invasive? Definitions vary.
- In response to predicted climate change….
  - Torreya invasive potential?
  - *In situ* conservation vs. *ex situ* conservation??
  - Maintaining genetic diversity in conserved populations. GMVP concept (DC C-not completely sure on this one.)
- Will habitats move based on climate change?
- How will systems change due to global warming?
- *Ventenata dubia* is actually listed as rare in Europe.
- *Ex situ* conservation in Hawaii – germplasm banking
  - Some reclamation into suitable habitat which may not currently have the species.
- What results from the "no action" alternative and what does that mean.
- Why is the species not moving by itself?
- Australian example – discovery of species perceived to be extent. Reproduced trees clonally for conservation purposes.
- We should be skeptical about bioclimatic envelopes as predictors for conservation or invasion – selection occurs at extremes.
- Jodie Holt – Rare localized species versus species integrated in the environment
  - Habitat conservation plans may be more system based approach
  - Planting into lawns, etc. may not be ecologically appropriate
  - What time frame do we use for reference?
- Kew Gardens creates genetic material banks for preservation – may be main source for maintaining species in Botanic Zoos
- Human manipulation of native populations to help them survive? Whether it enhances its resistance to exotic diseases or native enemies is an important point.
  - Can we create a native "invasive" species with this type of manipulation?
  - Or is there a difference between biotechnology and traditional breeding?
    - Is out-breeding depression a concern?
    - Local site collected seed vs. adapted mixes (NPS is very restrictive on which ones to use)
  - What is the driver/impetus for restoration?
  - In transplant projects – should we intentionally leave enemies behind?
  - Restoration folks are considering genetics more and more
    - Concept varies from organization to organization
- Should we change the definition of invasion (original question)? NO is the consensus of the group
  - Does policy restrict our options to do this successfully if necessary?
- Native vs. non-native discussion is often driven by economics

- Cost and time is a limiting factor
- Availability of seed is always an issue
- Are we shifting from one weed problem to another?
  - Example Crested wheatgrass – historical perspective?
- Steering committee definitions for invasive species
  - Revisit – IPSM Beck et al. 2008

Topic 2: *How Will New Bio-pesticides Potentiall Impact Weed Management Efforts Across the Western United States?*

Bio-pesticides: New cheatgrass bacteria (ACK 55), cheatgrass fungus *Pyrenophora semeniperda (*black finger of death and others). Do we know enough and are existing biological control agent regulatory controls and registration processes sufficient to understand the potential ecological effects on a landscape scale, and the potential effects on native species of amplifying and distributing these types of bio-pesticides?

a. What can we learn from the mistakes of historical biocontrol (*Rhinocyllus conicus* on native thistles, *Cactoblastis cactorum* on native prickly pear, etc.), and is the current registration process sufficient to avoid these mistakes with fungi and bacteria?
b. What testing or monitoring should be in place to determine native and ecologically native?
c. What steps, controls need to be in place for biopesticies to provide a margin of safety for the environment?
d. What procedures should be in place when moving microorganisms over large areas and into ecologically dissimilar landscapes (should we place the same concerns /limits on genetic material as we do in moving native plant species – i.e. is a strain of bacteria or fungus from Montana the same genetically as the same species found in Utah? Should there be different strains for different regions? Do we know enough to adequately answer these questions?)

Discussion 2 Notes - 13March2013

- How much do we know about these species and what effect might they have on the native species?
- How specific are these organisms? Host specificity varies across agents, locations, etc.
- We don't know a lot about those soil organisms and how they may interact with soil ecology in general; we tend to focus on their effects on the target organism and not their role in the soil ecosystem.
- If we introduce an organism into a new environment, there is a possibility of three outcomes: neutral, competitive, facilitation
- Mycorrhizal associations, obligate vs. not; most natives are obligate, but many non-natives are not, still end up taking advantage of organisms. (Hawaii example)
- Safety – human safety… not as many chemistries to deal with fungi if they infect humans; some can be very dangerous if they infect humans

- We're not winning the battle against BROTE with herbicides, so this approach for widespread control doesn't seem to hold much potential either
- Is there a screening process for these biological agents?
- Many of these are fairly ubiquitous , so why are they not having much effect naturally
    - Choose most virulent strains
    - High inoculation rates?
- Do we expect these organisms to stay around long? Do they persist in the environment?
- Outside organizations will want to voice their opinions on this, especially if large amounts of an organism are going to be spread everywhere.
- Would such products undergo regulation by EPA like herbicides would?
    - Probably not as stringent and not APHIS – regulated
- Once you introduce an organism like this in the ecosystem, can we get rid of it?
- Since there are endemic populations of many of these?
    - Biopesticide vs. Biological control agent? How do you know when the line is crossed and what does this mean for regulation?
    - Biopesticides for tree crops and tomatoes can serve as examples; these types of things are being done in other disciplines, but just because they are does that make it okay?
    - Jill Schroeder plans to bring the questions to contacts in EPA
- Jill Schroeder Response email:

From: Wozniak, Chris [mailto:wozniak.chris@epa.gov]
Sent: Monday, March 18, 2013 9:32 AM
To: Schroeder, Jill
Cc: Borges, Shannon
Subject: RE: question about biopesticide risk assessment and definitions

Hi Jill,

Sounds like an interesting discussion! I'll answer these questions based upon my knowledge of bioherbicides and am copying a colleague who works more closely with microbial agents so she can chime in and correct where needed.

1- They wanted to know more about how the risk assessment for biopesticides differs from chemical pesticides (I know it is less stringent but was not sure about what was assessed).

   A weighty question for sure, but basically we in BPPD need to deal with many of the same issues (animal and plant toxicity, environmental persistence, non-target effects, product characterization) as those assessing chemical pesticides, however, we also deal with the reproductive capacity of the microbe since it is assumed it is likely to reproduce in the environment and possibly spread. Hence, pathogenicity tests are also part of the data submission. One must show clearance of the organism from the test animal (rat or mouse) following oral and likely intraperitoneal administration. Skin and eye irritation or toxicity/pathogenicity tests may also be required. Although all data requirements listed in 40CFR 158.2140 and 2150 must be fulfilled, some may be satisfied by data waivers where appropriate. For example, if an organism does not grow at human or avian body temperatures, it may be possible to ask for a waiver for certain toxicity/pathogenicity tests. This is something that is normally done at a pre-registration meeting between the registrant / applicant and the staff here in BPPD.

Since Pyrenophora is a known plant pathogen, non-target plant impacts will be a key consideration in the risk assessment. That is, what is the host range?

2- They also wanted to know how EPA defines a biopesticide versus a biological control agent – the black fingers of death being the example. It is applied to control the cheatgrass but also persists for some time after inoculation so is it a biopesticide or biocontrol agent? The group was under the impression that it had been submitted to the agency for registration as a biopesticide.

FIFRA and 40 CFR have definitions for biopesticides and biological control agents. We do not register or regulate what some term classical biocontrol agents like ladybird beetles, lacewings, etc… We do regulate microbial agents such as algae, bacteria, fungi, viruses and protozoa. Pyrenophora would definitively fall under our purview if used to control weeds.

If you look at our website you can see examples of other mycoherbicides like those intended for control of citrus strangler vine: http://www.epa.gov/pesticides/chem_search/reg_actions/reregistration/red_PC-111301_15-Feb-06.pdf

And dyer'swoad: http://www.epa.gov/opp00001/chem_search/reg_actions/registration/fs_PC-006489_01-Jun-02.pdf and http://www.epa.gov/pesticides/chem_search/reg_actions/registration/decision_PC-006489_1-Jun-02.pdf .

Let me know if this answers your questions. Hope we can touch base next time you are in town!

Cheers,
Chris

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Project 2 Discussion Section: Weeds of Horticultural Crops

Moderator: Lynn M. Sosnoskie, University of California – Davis, Davis, CA

Topic: *Who? Where? When? What? How are growers getting the information they need?*

This topic was inspired by the most recent requests for applications for the United States Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA) Agriculture and Food Research Initiative (AFRI) grant program. Integrated AFRI programs are expected to allocate one-third of their funds for non-research related projects (for example, extension outreach) and then measure the subsequent impact. Impact can only occur if growers take research-generated recommendations and apply them in real-world settings. Currently, there is a significant amount of weed management/crop production information available to producers; the sources of this material are varied and may include: university research and extension personnel; federal, state and local government agencies; agribusiness; agriculture media; internet sources; and other farmers. Additionally, the information may be transmitted between the sources and the growers in numerous ways, such as: one-on-one visits; organized meetings (via university/extension, agribusiness and commodity commissions); traditional media (e.g. bulletins, circulars and articles); internet and social media; and word of mouth. Considering that stakeholders are a diverse collective (e.g. age, gender, crop and cropping system preferences, education and ideologies), are we able to optimally deliver information to all constituents?

Important points of discussion included:

Does the traditional, linear continuum of extension/education (e.g. universities /specialists to farm advisors/county agents to growers/PCAs) effectively service a sophisticated and electronically connected clientele?

Does the wealth of 'nameless' and easily available information diminish the role of extension? How does extension go about 'branding' their information to ensure quality and credit?

How do research and extension personnel account for their output that is disseminated using modern media (e.g. 'hits' to a blog, 'retweets' using Twitter, 'likes' on a Facebook page)? Will universities accept these "statistics" when it comes time to review performance and issue promotions?

How important are electronic tools and social media for extension? Are blogs the modern day newsletters and bulletins? Can you accurately disseminate information, via Twitter, in 140 characters or less or is the medium simply a portal to lead interested parties to more details at another source? Do we have any choice but to adapt to these technologies (and the technologies that eventually replace them)?

With the loss of extension positions/contraction of personnel (because of ongoing budget concerns), are universities losing the one-on-one connections with growers? What about industry, are they assuming some of the roles of extension? Does this create a conflict of interest?

Does the growing dependency on electronically available information disconnect farmers from observing and understanding their farms and their farms' needs?

How do you measure the ultimate impact of extension? Have these metrics been fully defined? Can you be successful by simple raising awareness, or do you need to demonstrate some sort of physical change in programs and practices?

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Project 3 Discussion Section: Weeds of Agronomic Crops

Moderator: Joe Armstrong, Dow AgroSciences, Davenport, IA

Topic: *Herbicide-Tolerant Cropping Systems – How Can Academia and Industry Work Together for Successful Stewardship?*

Discussion session report not available.

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Project 4 Discussion Section: Teaching and Technology Transfer

Moderator: Kelly Young, University of Arizona, Phoenix, AZ.

Topic: *Field Data Collection: Proven Methodology.*

The discussion session for the Teaching and Technology track was held Wednesday afternoon, March 13 from 4:00 pm – 5:15 pm. Approximately 15 people were in attendance. Kelly Young chaired the session, Ryan Rapp co-chaired and Byron Sleugh was elected chair for 2015.

The discussion session followed immediately after a two-part presentation by Steve Gylling on the use of ARM 9 for research management and trial reporting. The intention of this discussion session was to provide advice on reliable and valid field data collection techniques so that solid data can be entered into statistical analysis programs, such as ARM.

The discussion began with a quick survey of who uses electronic, handheld devices to input data in the field. Tablet computers, such as ipads are used for data collection, taking photos, mapping, counting and the direct input of data into analysis programs. Many apps are free or very inexpensive and are constantly being developed and released. A number of features, such as a slide rule, can be used to streamline data entry in the field and minimize input errors.

Benefits of using tablets in the field are direct input of data into spreadsheets. The data can by synced via the cloud to a desktop computer, loaded with more powerful data analysis software. Downfalls of using tablets include high price, fragility, the high level of variability in features and functionality between tablets, screen visibility in bright sunlight and the lack of functional applications to help in the field. For example, ARM only works with Windows based tablets (not iPADS).

To follow up on comments made in the ARM 9 sessions, the discussion turned to significance levels researchers use in weed science. As students, many researchers learned to use 5% as the highest acceptable probability that the results are due to chance, but much higher levels can be used when conducting applied research. It was pointed out that a grower may accept a 50% probability that a treatment significantly increases yields, whereas an industry researcher my only accept a 1% level when investigating the safety of a product. The outcome of this discussion was that we should not necessarily default to a 5% level, but we should take into account the goal of the research, the audience you will reach with the results, and the level of risk you are willing to take.

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Project 5 Discussion Session: Basic Biology and Ecology

Moderator: Sarah Ward, Colorado State University, Ft. Collins, CO

Topic: *Research for Improved Weed Seedbank Management: Current Developments and Future Needs.*

Disscussion section report not available.

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Chair-elect 2014:
?

WESTERN SOCIETY OFWEED SCIENCE NET WORTH REPORT

April 1, 2012 through March 31, 2013

ASSETS	
Cash and Bank Accounts	
Checking	48,601.87
Money Market	79,455.02
TOTAL Cash and Bank Accounts	128,056.89
Other Assets	
Asset (Weeds of the West unsold inventory)	110,884.95
TOTAL Other Assets	110,884.95
Investments	
RBC Dain Rauscher Acnt	224,262.31
TOTAL Investments	224,262.31
TOTAL ASSETS	463,204.15
TOTAL LIABILITIES	0
OVERALL TOTAL	463,204.15

WSWS CASH FLOW REPORT

April 1, 2011 through March 31, 2012

INFLOWS	
Annual Meeting Income	$66,505.00
Bio Control Of Invasives Book	$169.02
California Weeds Books	$1,446.00
DVD Weed ID	$199.90
EBIPM Course	$2,110.00
Interest Inc	$162.99
Invasive Plants Book	$247.53
Noxious Weed Shortcourse	$2,250.00
Renewal Membership	$2,179.55
Royalty For Proceedings Or RPR	$780.00
Student Travel Account	$1,772.00
Sustaining Member Dues	$11,050.00
Weeds Of The West	$50,393.60
Weed Control in Natural Areas	$3,435.00
TOTAL INFLOWS	$142,700.59
OUTFLOWS	
Annual Meeting Expense	$26,807.55
Book Handling Fee	$539.50
California Weeds Books	$1,195.75
CAST Annual Dues	$1,500.00
Director Of Science Policy	$8,832.00
Insurance	$500.00
Merchant Account	$4,108.33
Noxious Weed Shortcourse	$16,199.59
Postage	$14.07
Service Contract	$23,000.00
Stipend	$1,500.00
Student Travel Account	$3,000.00
Supplies	$1,137.66
Tax Preparation	$446.38
TAXES	$403.00
Travel To Summer Meeting	$3,634.99
Travel To WSWS Meeting	$1,209.60
Web Site Transactions	$2,500.00
Weed Control in Natural Areas	$2,969.19
Weeds of the West	$60,720.34
TOTAL OUTFLOWS	$160,217.95
OVERALL TOTAL	($17,517.36)

WSWS 2013 FELLOW AWARDS

Fellows of the Society are members who have given meritorious service in weed science, and who are elected by two-thirds majority of the Board of Directors.

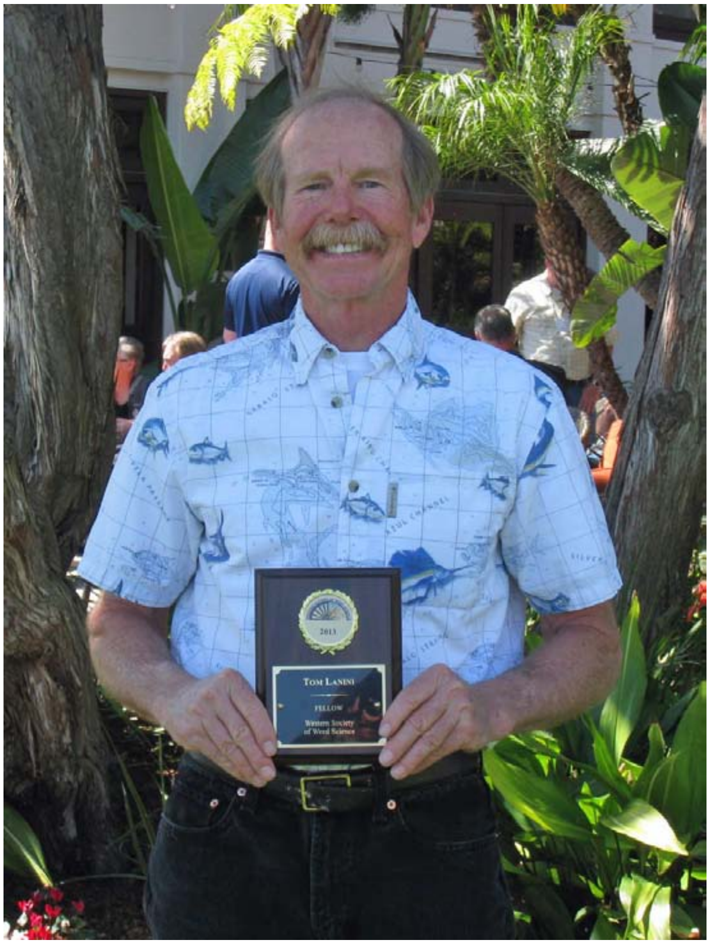
Tim Miller

Dr. Tim Miller is an Associate Professor of Weed Science at the Northwestern Washington Research and Extension Center (WSU) in Mount Vernon, WA. Tim was an Extension support scientist at the University of Idaho from 1992-1997 and Extension Agent in Idaho from 1988-1992. He was also a Chemical Officer in the U.S. Army from 1981-1985.

His main areas of interest and expertise are integrated weed management in specialty and horticultural crops, but he also works with invasive and aquatic plant management. In addition to his service to the WSWS, Tim has been an active member of WSSA, the Washington State Weed Association, Washington State Noxious Weed Control Board, Oregon Society of Weed Science, Alaska Committee for Noxious and Invasive Plant Management, and the Idaho Weed Management Association. Tim has conducted over 550 weed control trials on specialty and horticultural crops, non-crop sites, and aquatics. He has delivered nearly 500 presentations on weed management or weed identification in the last 14 years, authored or co-authored 13 journal articles, 4 book chapters, and 50 extension bulletins. Tim has served as a major professor for 3 MS graduate students, and has served on the graduate committee for one PhD student. Tim also participates regularly in the Master Gardener program and is an instructor for the WSWS Noxious Weed Short Course.

Dr. Miller has served on numerous committees, judged graduate student papers and posters, served on local arrangements committees, and has represented WSWS at WSSA meetings. He has served on the WSWS Board of Directors and served as Chair of the Education and Regulatory Section, the Horticultural Crops section, and the Teaching and Technology Transfer sections. In addition, he chaired a very successful WSWS Knotweed Symposium in 2007. He has authored or co-authored 32 papers or posters at WSWS annual conferences since 1995 and submitted 59 WSWS Project Reports. For his numerous contributions and service to WSWS, Dr. Miller was selected for the WSWS Presidential Award of Merit in 2007 and 2012. Tim is well regarded by weed science and other colleagues throughout the Western United States, and has initiated a number of cooperative research projects with significant importance to PNW horticultural crops. Tim has established solid working relationships with industry representatives, in addition to academic colleagues and northwest specialty crop producers.

Tom Lanini



Dr. Tom Lanini serves as an Extension Weed Ecologist at UC-Davis. Tom spent three years at Penn State University (1983-86) and 27 years as an Extension Weed Ecologist at UC-Davis. Dr. Lanini will be retiring from his UC-Davis position in 2013.

Tom has been very active and provided significant service to the WSWS by serving on numerous committees, including local arrangements, graduate student paper judging, and chaired the horticultural crops section. He served as local arrangement chair for the WSWS in 2006. He has also served on numerous committees for the Weed Science Society of America and was chair of the local arrangements committee for WSSA in 2002. Dr. Lanini is a regular reviewer for Weed Technology and Weed Science journals.

Dr. Lanini's primary responsibilities are in the area of vegetable crop production, but he has extended his expertise into a broad range of other areas including weed control in wildlands, aquatic, forestry, alfalfa, orchard and specialty crops, and non-crop areas. He is also considered an expert on dodder management, precision weed management, and organic methods of weed control. Tom has delivered more than 600 extension presentations, published over 50 peer-reviewed manuscripts, and over 280 extension papers, proceedings, and reports. In 1993, he spent his sabbatical leave at the USDA-ARS Aquatic Weed Control Lab in Florida, gaining experience in aquatic weed control. In 2004-2005, he spent a sabbatical in Chile expanding his expertise in the area of agronomic crops. Some of Dr. Lanini's major contributions to agriculture in the western United States include his educational program centered on the development of low input and cultural weed management strategies, understanding weed biology, and weed/crop interactions and thresholds.

He has served on the steering, program, and collegiate committee for the California Weed Science Society, served on the board of directors, and received the Award of Excellence from the California Weed Science Society. Dr. Lanini served as mentor to several other extension weed scientists at UC-Davis. Tom has also trained 11 graduate students at the Master and PhD level in ecology, plant pest protection, and vegetable crops graduate groups.

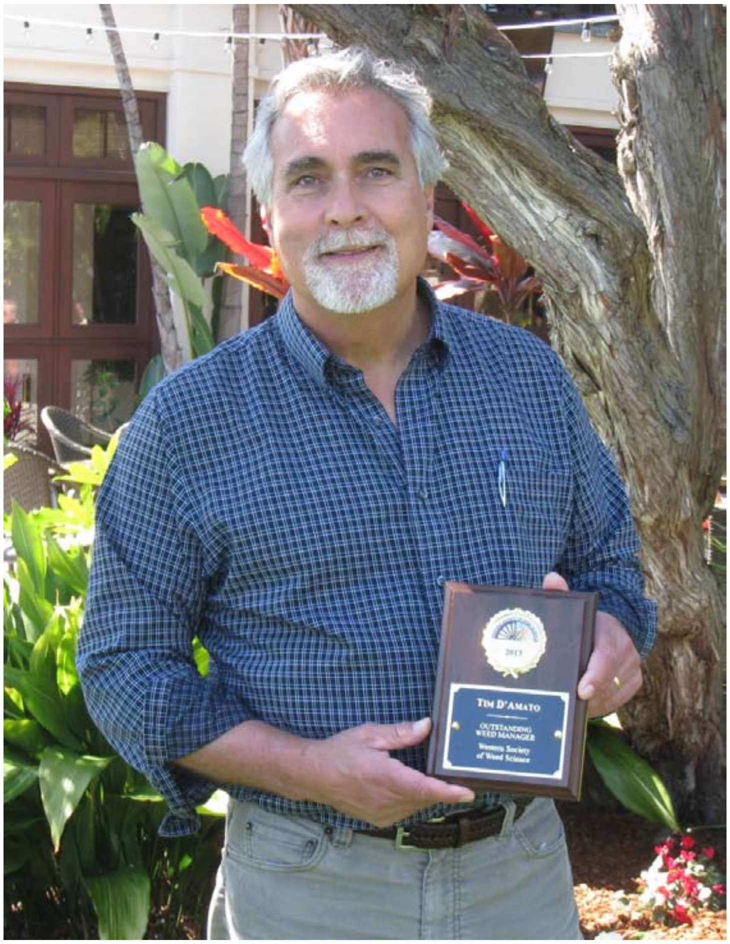
**WSWS 2013 OUTSTANDING WEED SCIENTIST, PRIVATE SECTOR –
Mary Halstvedt**

Mary has a thirty one year career with Dow AgroSciences and started as a sales representative but moved into research and technical service within 4 years. Mary authors and develops informational newsletters and training programs that are so valuable that Dow continues to support these informational tools. Mary has co-authored over 30 papers and posters at the WSWS. Mary coordinates research initiatives with Universities and provides land managers with need to know information. Mary awarded a “2012 Agrow Award for “Best Innovation in NonCrop” at an announcement in London to an audience of about 400 people classed as “movers and shakers” in crop protection. Mary works to develop practical solutions to weed issues on small acres, large ranches or publicly-owned land. Mary has made significant contributions to develop and implement effective and economical weed management strategies in prairie and rangeland systems in the western United States.

WSWS 2013 OUTSTANDING WEED SCIENTIST, EARLY CAREER – Jane Mangold

Jane is a Weed Specialist and assistant professor of Integrated Invasive Plant management at Montana State University. Jane's primary responsibility is her Extension work focusing on integrated, multi-disciplinary approaches to invasive plant management in range, wild land and agricultural systems. Dr. Mangold develops an impressive array of face-to-face, off-campus programs throughout Montana and the region with state-of-the-art technology reaching thousands of participants. One land manager referring to Jane's workshop "It was the best program I have ever attended in my 25 years as a weed manager". Jane has published more than 15 refereed journal articles, contributed chapters to three books, co-authored 21 extension publications, written 18 publications for the popular press and continues to edit a bi-annual Integrated Pest Management bulletin and a monthly Weed Post. Dr. Mangold is an associate editor for Rangeland Ecology and Management and serves as a reviewer for seven scientific journals. On a personal level, one of Jane nominators said Jane emits a "kind and considerate approach to life".

WSWS 2013 WEED MANAGER AWARD – Tim D'Amato

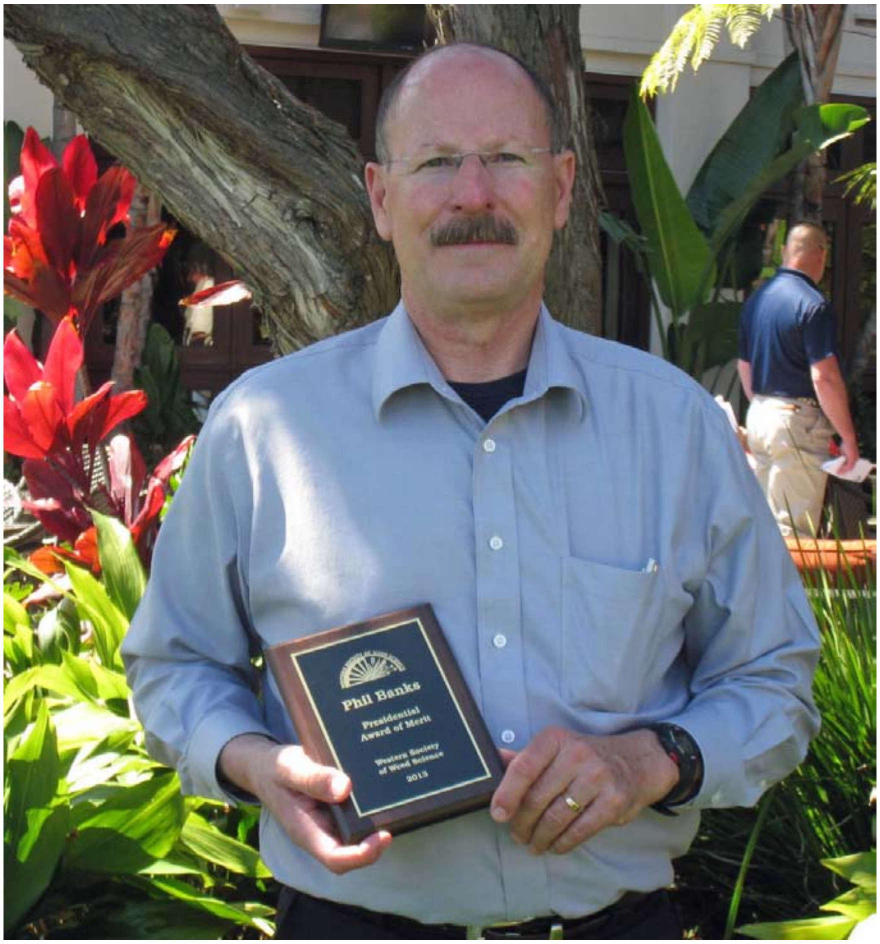


Tim started his weed science career in the 1980s working as a research technician in sugar beet weed management with Dr. Ed Schweitzer of the ARS in Fort Collins. Tim worked with Phil in his weed science program for 15 years after which he became Boulder County Weed Manager. Tim transferred to Larimer County in 2007 as weed coordinator. The move to Larimer County, home of CSU, dramatically increased the number of collaborative projects CSU personnel conduct with Tim and his crew. Tim and his team assembled a group of workers to combat the numerous noxious weeds that were some of the first plants to grow back after the High Park Fire of 2012. Tim's current supervisor says he operates on a highly professional level, taking action to create needed solutions, make contacts and ensures the mission of the weed district is maintained. Tim is always ready with a funny quip and keeps things light no matter the situation – he is easy going and ensures a fun day whether in the field or an all day meeting. Tim is a long-time member of the WSWS and regularly presents research posters and papers at our annual meeting. He encourages his team to become active in the WSWS and brings his employees to annual meetings. A supporting letter from George Beck says "Tim runs one of the best county weed management programs in Colorado."

WSWS 2013 PROFESSIONAL STAFF AWARD – Joan Campbell

Joan has been part of the weed science program at the University of Idaho for over 31 years. Joan has taught the introductory weed science course at UI for over 25 years and her evaluation scores exceed the departmental and college averages. Joan assists Donn in teaching weed biology, herbicide fate and mode of action courses. When Donn accepted a position as Director of the Idaho Agricultural Experiment Station, Joan stepped up to the overall management of the weed science program maintaining an active small grain cropping research program. Joan works long hours and weekends and you may find her in her office after 6:00 pm or at the research farm on Saturday. Joan set up the first web site for the WSWS, served as Proceedings editor and Progress report co-author. She has been awarded the WSWS Presidential Award and is a WSWS fellow. Joan has presented 23 papers and authored 125 Research Progress Reports. Joan's supporting letters emphasize how well she conducts research, trains graduate students and new research associates. To quote one of her supporting letter nominators "she was always there working with me not just giving instructions".

WSWS 2013 PRESIDENTIAL AWARD OF MERIT – Phil Banks



President Kai Umeda presented Phil Banks with the Presidential Award of Merit for his cheerful, ever present, and meticulous service to the WSWS.

WSWS 2013 STUDENT SCHOLARSHIP RECIPIENTS

Our committee received nine scholarship application packages. These young people are talented and our committee wished we had nine scholarships to offer. Three individuals were selected.

Samantha Ambrose – Oklahoma State University (left)

Christina Herron-Sweet – Montana State University (middle)

Leslie A. Holland – New Mexico State University (right)

WSWS 2013 GRADUATE STUDENT PAPER AND POSTER AWARDS

Oral Paper Contest Awards – Range and Natural Areas & Basic Biology and Ecology

Third Place – Hally Berg, Montana State University, Bozeman

Second Place – Samantha Ambrose, Oklahoma State University, Stillwater

First Place – Christina Herron-Sweet, Montana State University, Bozeman

Oral Paper Contest Awards – Weeds of Agronomic Crops & Weeds of Horticultural Crops

Third Place – Jared Unverzagt, University of Wyoming, Laramie

Second Place – Christopher Van Horn, Colorado State University, Fort Collins

First Place – Craig Beil, Colorado State University, Fort Collins

Poster Presentation Awards – All Sections

First Place (left) **–** Amar Godar, Kansas State University, Manhattan

Second Place (right) **–** Carl Coburn, University of Wyoming, Laramie

Third Place – M Marcelo Moretti, University of California, Davis (not pictured)

Poster Presentation Awards – Undergraduate Poster

First Place – Leslie Holland, New Mexico State University, Las Cruces

WSWS 2013 ANNUAL MEETING NECROLOGY REPORT

Elena Raquel Sánchez Olguín – 1979-2012

Elena passed away in July 2012, in Hangzhou, China. She became ill while attending the VI International Weed Science Congress. She was a recipient of a student award from the International Weed Science Society to participate in the congress, which she also had earned for the previous congress in Vancouver. Elena was a Ph.D. candidate in the Weed Science Program at Oregon State University. Her dissertation project involved implementing novel molecular tools for studying the evolution of weedy relatives of wheat. She graduated from Conservatorio de Castella, Costa Rica, a high school specialized in arts, where she developed her artistic abilities particularly in dance. She earned a B.S. degree in Agronomy from Instituto Tecnológico de Costa Rica and graduated with a M.S. in Agricultural Sciences and Natural Resources (Biotechnology emphasis) with honors from Universidad de Costa Rica. She was active in the Association of Latin Students at OSU. Her mother, Leticia, and brother, Gerardo, survive her. She will be missed by her many friends in Oregon, Costa Rica and around the world.

Obituary for Mark Boyles – 1954-2013

Mark C. Boyles, 58, passed away in January 2013 in Tulsa, Oklahoma. Mark was born in 1954 in Guam, Mariana Islands. Mark graduated from Oklahoma State University with his Bachelor's degree in 1977, and again in 1979 with a Master's in Agronomy. After graduation, he began a career with Sandoz and BASF Agricultural Companies that spanned for 25 years as a research scientist until 2002. He had many patents and awards during this time, and in 2002 he created ProSearch One. In 2004, Mark went back to OSU as a faculty member and worked in Research and Extension for the Plant and Soil Science Department. While there, he co-developed and implemented the Okanola Project. He was a member of The Western, Northern and Southern Weed Science Societies where he served on several committees in 1992 through 1996 and is survived by his wife of 37 years, Maria, son Brandon and daughter Katie.

Obituary for Lowell Jordan – 1930-2013

Lowell S. Jordan, Professor Emeritus of Horticultural Science in the Department of Botany and Plant Sciences, UC Riverside passed away on March 2, 2013. He was 82 years old. Dr. Jordan's research interests were in the areas of herbicide efficacy, herbicide physiology, and the mode of action of herbicides. Dr. Jordan was a Fellow of the Western Society of Weed Sciences, and of the Weed Science Society of America, and in 1982 received their Outstanding Teaching Award. Born on April 23, 1930, in Vale, Oregon, Lowell Stephen Jordan received his B.S. in Agriculture from Oregon State University in 1954 and his Ph.D. in Agronomy and Agricultural Biology from the University of Minnesota in 1957. He taught for a year at Southern Illinois University, and in 1959 became Assistant Plant Physiologist in the Department of Horticulture at UC Riverside as. In 1967 he received professorial rank in addition to the Cooperative Extension title. He retired in 1993. Dr. Jordan is survived by his wife, Catalina, 3 daughters, 2 sons.

Richard J. (Dick) Aldrich – 1925-2012

Richard (Dick) Aldrich passed away in November 2012, in Bigfork, Minnesota at the age of 87.. He earned his Ph.D. at Ohio State University in 1950. His doctoral work involved pioneering field research on 2,4-D. From 1976 to 1978 he was administrator of the U.S.D.A. Cooperative State Research Service. He served as Editor of Weed Science from 1989 through 1993. His valuable contributions to weed science were recognized by his election as Fellow of WSSA in 1992.

Obituary for John Lydon

Dr. John Lydon, USDA-ARS National Program Leader for Weed Science in the Office of National Programs passed away on October 18, 2012. As National Program leader since 2009, john led ARS research initiatives involving invasive plants, herbicide resistance, and biological control. Prior to assuming his duties as NPL, John was a research scientist for the Sustainable Agricultural Systems Laboratory at the Beltsville Agricultural Research Center for many years. He was USDA-ARS' liaison to the National Invasive Species Council and USDA-APHIS technical Advisory Group(TAG) that evaluates exotic biological control agents for weeds.

WSWS ANNUAL MEETING ATTENDEES – San Diego 2013

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2012-2013 WSWS Standing and Ad Hoc Committees *(board contact)*

Awards *(President)*
Jeff Tichota, Chair (2014)
Jill Schroeder (2013)
Rick Arnold (2015)

Fellows and Honorary Members
(Immediate Past President)
Scott Nissen, Chair (2014)
Celestine Duncan (2013)
Rick Boydston (2012)

Finance
(Member-At Large-Private Sector)
Brian Mealor, Chair (2014)
Luke Samuel (2013)
Marvin Butler (2015)

Herbicide Resistant Plants
(Member-At-Large-Private Sector)
Sarah Ward, Chair (2013)
Andrew Kniss (2012)
Brian Jenks (2016)

Program *(President-Elect)*
Roger Gast, Chair (2013)
Tony White (2013)
Brad Hanson (2013)

Publications *(President-Elect)*
Roger Gast, Chair
Bill McCloskey, Proceedings
Traci Rauch, Research Progress Report
Cheryl Fiore, Newsletter
Tony White, Webmaster

Education *(Education Section Chair)*
Tim Prather, Chair
Scott Nissen
Sandra McDonald
Andrew Kniss
Andy Hulting
Liz Galli-Noble
Mike Moechnig
Ian Burke

Student Paper Judging *(President Elect)*
Guy Kyser, Chair (2014)
Jamshid Ashigh (2013)
Kelly Young (2015)
Samantha Ambrose (student representative)

Legislative *(WSSA Representative)*
Kirk Howatt, Chair (2014)
John Brock (2013)
Julie Kraft (2012)
Lee Van Wychen, Ex-officio

Local Arrangements *(President Elect)*
Jesse Richardson, Chair (2014)
Tim D'Amato (2015)
Gustavo Sbatella (2016)

Necrology *(Secretary)*
Eric Jemmett, Chair (2014)
John Roncoroni (2013)
Greg Dahl (2015)

Nominations *(Immediate Past President)*
Kassim Al-Khatib (2014)
Dan Ball (2013)
Pam Hutchinson (2015)
Vanelle Peterson, Past-President

Poster *(President-Elect)*
Chuck Rice, Chair (2014)
Roger Gast (2013)
Dirk Baker (2015)

Public Relations *(Education Section Chair)*
Deb Shatley, Chair
Kelly Young
Brian Olson
Mark Ferrell
Bill Cobb
Rich Affeldt
Brent Beutler
Cheryl Fiore

Site Selection *(President)*
Carol Mallory-Smith, Chair (2014)
John Fenderson (2013)
Pete Forster (2015)

Sustaining Membership *(Immediate Past President)*
Pat Clay, Chair (2014)
Curtis Rainbolt (2013)
Dennis Tonks (2015)