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2012

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PREFACE

The Proceedings contain the written abstracts of the papers and posters presented at the 2012 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.

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POSTER SESSION

Project 1. Weeds of Range and Natural Areas

Effects of Preemergence Application of Rimsulfuron, Imazapic, and Aminocyclopyrachlor on Downy Brome. Holden J. Hergert*, Brian A. Mealor, Andrew R. Kniss, Rachel D. Mealor; University of Wyoming, Laramie, WY (001)

Previous studies indicate that growth regulators may reduce annual brome seed production and viability. On September 23, 2010 aminocyclopyrachlor was evaluated at rates between 20 and 320 g ai ha^{-1}, and compared to rimsufuron and imazapic at rates between 4.5 and 72 g ai ha^{-1} and 12 to 208 g ai ha^{-1}, respectively at a downy brome-infested rangeland site in southeastern Wyoming. Herbicides were applied to 3 x 9 m plots in a RCBD with 4 replications and an untreated control. Vegetative cover and plant biomass data were collected on July 1, 2011. Seeds were harvested from 25 downy brome panicles $plot^{-1}$ to evaluate the effect of aminocyclopyrachlor on seed production and viability. Cover and seed data were analyzed with four-parameter log-logistic analysis. Downy brome biomass data were subjected to mean separation at the highest rate. Aminocyclopyrachlor did not affect downy brome cover. At the highest rate, rimsulfuron increased perennial grass cover by 28.5%, aminocyclopyrachlor decreased it by 11%, and imazapic had no discernible effect. Aminocyclopyrachlor increased the amount of visibly damaged seeds, but did not affect the total number of germinable downy brome seeds. At the highest rates, rimsulfuron and imazapic decreased downy brome biomass by 97.5% and 50%, and aminocyclopyrachlor increased downy brome biomass. Although aminocyclopyrachlor apparently injured downy brome seeds, its impact on seed germinability was negligible. More research is needed to better understand potential effects of aminocyclopyrachlor in downy-brome infested areas.

Returning Succession to Downy Brome Dominated Rangelands: Roadblocks to Perennial Grass Establishment. Daniel Harmon*[1], Charlie D. Clements[2], James A. Young[2]; [1]USDA-ARS, Reno, NV, [2]USDA, Reno, NV (002)

The most common cause of successional retrogression in the Great Basin is wildfires fueled by downy brome. Downy brome invasion has reduced fire intervals from an estimated 60-100 years down to 5-10 years. Our previous research found that establishment of long-lived perennial grasses is the best known method to suppress downy brome and reduce wildfire disturbance in order to assist succession. Shrubs provide downy brome understory safe sites and therefore perennial grass establishment and downy brome suppression must occur first. At the seedling stage, perennial grasses only compete to survive. Perennial grass seedlings do not out compete downy brome, only established mature perennial grass compete for resources an adequate amount to suppress downy brome. Reports of successful perennial grass establishment fall below 20 percent. We hypothesize that multiple factors are affecting the high failure rate such as downy brome resource competition and the species of perennial grass seeded. In a plot level seeding experiment we tested three treatments, 1) downy brome control with Glyphosate (Roundup®) at 5% rate), 2) seeded species (native vs. introduced mix) and 3) seeding depth (2cm vs. 7cm). We measured the number of seedlings/m² as the response variable. Seedlings were counted in May and July 2011. Our results found a significant effect ($P \leq 0.05$) of downy brome removal on seedling establishment (removal=19.5 seedlings/m², no-removal=0 seedlings/m² [all mixes and depths combined]). Complete die-off occurred by July if downy brome was not controlled. Most alarmingly, even with downy brome control, the native grass seed mix established very poorly. Seedling establishment of introduced species, 34.6/m², was significantly ($P \leq 0.05$) greater than native seed mix, 4.3/m² [both depths combined]. Contrary to most seeding depth recommendations, we experienced higher seedlings survival with increased seeding depth, 26.5/m² versus 12.4/m², respectfully. Our results find that effective downy brome control is paramount to establishing perennial grasses in an effort to decrease downy brome densities and fuel loads. Appropriate species selection and proper seed placement are also critical needs to increase success.

Integrated Management of Downy Brome in Dinosaur National Monument. Heather Elwood*[1], Corey V. Ransom[1], Thomas A. Monaco[2], Christopher A. Call[1]; [1]Utah State University, Logan, UT, [2]USDA, Logan, UT (003)

Downy brome (*Bromus tectorum*) is an increasing problem on rangelands throughout the western United States, including within Dinosaur National Monument, Jensen, UT. Studies were conducted at two sites within the Monument to evaluate the integration of spring-time seed production prevention methods (glyphosate at 193 g ai ha^{-1} or clipping at the purple stage, and an untreated control) combined with fall applied preemergence herbicides in reducing downy brome cover. Plots were arranged in a completely randomized design with seed production prevention as the whole-plots and fall herbicide treatments as the subplots. Herbicide 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}. Cover was evaluated using a point-intercept method. Plants were harvested at immaturity (time of clipping) and maturity to determine number of seeds produced and their viability. There was no interaction between seed production prevention methods and fall herbicide treatments. At one site, clipping and glyphosate both reduced downy brome cover. Neither clipping nor glyphosate reduced desirable grass cover at either site. Data for both sites were combined to analyze seed production and viability. None of the seed prevention methods significantly reduced the number of seeds produced by downy brome, but both methods reduced viability of seeds. Downy brome cover was significantly reduced by all herbicide treatments at both sites. All herbicide treatments increased bare ground at one location and desirable grass cover increased at one location.

Developing a Process for Prioritizing Species and Areas for Inventory within National Wildlife Refuges. Kimberly A. Edvarchuk*[1], Corey V. Ransom[1], Jenny Ericson[2], Giselle Block[3], Lindy Garner[4]; [1]Utah State University, Logan, UT, [2]US Fish and Wildlife Service, District of Columbia, DC, [3]US Fish and Wildlife Service, San Francisco, CA, [4]US Fish and Wildlife Service, Great Falls, MT (004)

Invasive species are considered one of the largest threats to habitat management in the National Wildlife Refuge System. An inventory provides critical information to land managers regarding the species present and the extent of the land impacted and allows managers to develop a more strategic approach to invasive plant management. While there are existing models to aid in the prioritization of invasive species for treatment, there are none that discuss the prioritization of species and areas for inventory. One of the greatest challenges with conducting an inventory on wildlands is the limited time, personnel, and resources available. Land managers must make critical decisions on the species and management areas to inventory but often are unsure as to which species and areas to include as well as which methods are the most appropriate given the needs of the refuge. A project was initiated in 2011 with the U.S. Fish and Wildlife Service to test a prioritization framework for refuges in conducting inventories and identifying species and areas that are a priority for inventory and subsequent management. During the summer of 2011, prioritization workshops were conducted at Silvio O. Conte National Wildlife Refuge (NWR), Alligator River NWR, Quivira NWR, and San Diego NWR. Field crews then spent approximately 12 days at three of the four refuges 2011 conducting an inventory, with the San Diego NWR inventory to occur in 2012. The results of those workshops indicate that early detection of newly invading species is a priority and that deciding which species should be considered as part of the "early detection species" list is challenging. It was also challenging for each refuge to decide how many species to include in the overall search list. Another similarity among the four refuges was the desire to know the extent of the invasive species infestations in order to be more effective and efficient with the allocation of treatment resources. The differences between refuges were numerous and included the variation in the number of species included on the target list with the lowest being at Alligator River NWR with seven species and the highest being an initial list of 85 species at San Diego NWR. The differences in terrain and vegetative cover also played a large role in the number of acres that could be inventoried. The number of acres at the three refuges included 10,162 acres at Quivira NWR, 8,989 acres in Alligator River NWR, and 1,358 acres in Silvio O. Conte NWR. The methodology used to search also differed and factored into the amount of land inventoried, even though crew members spent equal time at each refuge. Silvio O. Conte was inventoried with individual crew members riding ATVs and marking invasive species locations as points. Alligator River NWR was inventoried with crew members on foot searching areas with good visibility and highly visible target species, although infestations were marked using polygon features. Silvio O. Conte NWR management units were spread across three states and considerable time was spent accessing each of the three management units, in addition to challenging heavy vegetation at two of the three sites and crews used point features. Other differences included the reasons for collecting information. Alligator River NWR was particularly concerned about the spread of two species and time was spent delineating the outer perimeter of those species. Silvio O. Conte NWR knew little about the management units used in the inventory and the information collected was to add knowledge about the state of the lands to develop a management plan. Quivira NWR wanted to gain more information about species they knew were present, confirm the presence or absence of early detection species, and to verify historical reports of invasive species thought to be on the refuge. San Diego NWR was particularly concerned about the numerous threatened and endangered species present on the refuge and the huge impact the combination of invasive species and fire is having on these critical habitats. These differences and others indicate that no single method will apply to all refuges because refuges vary by management goals, the extent of invasive species present, terrain, accessibility, and ultimately resources available to conduct inventories. A common theme among refuges and other land management agencies in conducting inventories is not knowing the most effective way to implement an inventory and not knowing which species or areas to focus their efforts. This project is to develop a framework that refuges can use to prioritize inventory efforts that will provide the types of information vital to meeting their invasive plant management objectives.

Downy Brome: Evidence for Soil Engineering. Robert Blank*, Tye Morgan; USDA-ARS, Reno, NV (005)

Downy brome (cheatgrass) is an invasive Eurasian grass largely responsible for landscape level conversion of sagebrush/bunchgrass communities to annual grass dominance. We tested the hypothesis that downy brome alters or "engineers" the soil to favor its growth. The hypothesis was tested in a greenhouse using rhizotrons filled with either soil invaded by downy brome for 6 years or a similar soil not yet invaded. Seeds of downy brome (6 replicates) were sown in either invaded or non-invaded soil and allowed to grow for 70 days. Response variables were above-ground mass, root mass at selected depths, and several soil attributes. The experiment was conducted over two growth cycles. After the 1st growth cycle, downy brome above-ground mass was 189% greater when grown in invaded soil relative to the non-invaded soil. The soil variable, which explained 54% of downy brome growth, was the molar proportion of nitrite in the nitrate + nitrate extractable pool. These data, in addition to results of field experiments, suggest long-term occupation of a soil by *B. tectorum* facilitates greater N mineralization and reduces the kinetics of microbial nitrite to nitrate transformation. We conjecture that downy brome may have efficient nitrite root transport system(s). Overall, our data support the hypothesis that occupation of a soil by downy brome, overtime, facilitates an increase in its growth potential.

Pathogen Spill-Over and Cheatgrass Invasion: Incidence and Diversity of Pyrenophora semiperdia in Montana. Zachariah J. Miller, Jane Mangold*; Montana State University, Bozeman, MT (006)

Successful management of invasive plants requires understanding the processes that drive invasion. Cheatgrass (*Bromus tectorum*) can serve as a reservoir for *Pyrenophora semeniperda* (PYSE), a fungal pathogen that infects seeds of many grasses species and is thought to facilitate invasion. Prediction of pathogen-mediated impacts of cheatgrass requires understanding the drivers of pathogen abundance and relative impacts across co-occurring species. To investigate these drivers we conducted studies on cheatgrass and PYSE. First, pathogen prevalence was measured in cheatgrass populations in rangeland and agricultural sites across Montana. Second, we determined relative impacts of PYSE on cheatgrass and five grasses (*Avena fatua*, *Triticum aestivum, Hordeum vulgare, Pseudoroegneria spicata*, and *Pascopyrum smithii*) and the degree to which these impacts 1) differ among pathogen genotypes and 2) are explained by seed germination rates. Additionally, we tested if fungicide treatment protects seeds from pathogen infection. *P. semeniperda* was found in the majority of cheatgrass populations in rangeland and agricultural sites. All tested grasses were susceptible to PYSE infection. Infection and mortality rates differed among grasses and pathogen genotypes, and the fungicide seed treatment provided protection from infection. We found little support for the hypotheses that faster germinating seeds are less vulnerable to pathogen-induced seed mortality. Cheatgrass invasion dynamics are likely mediated by PYSE. Protecting seeds of native species from pathogen impacts may increase success of revegetation efforts. Our results suggest that impacts of pathogen spillover on plant community dynamics depend upon pathogen virulence, environmental conditions, and plant community composition, but cannot be predicted by germination rates.

The Effects of Downy Brome Invasion on Mule Deer Habitats. Charlie D. Clements*[1], James A. Young[1], Daniel Harmon[2]; [1]USDA, Reno, NV, [2]USDA-ARS, Reno, NV (007)

Downy brome (*Bromus tectorum*), also widely known as cheatgrass, is a highly invasive exotic weed that has spread over millions of hectares of rangelands throughout the Intermountain West. Native to Eurasia, this early maturing annual provides a fine textured fuel that increases the chance, rate, season and spread of wildfires. Historical wildfire intervals estimated at 60-110 years are now as frequent as every 5-10 years. In 1964 a firestorm, largely fueled by downy brome, swept through Elko County in northeastern Nevada burning 120,000 hectares of rangelands. Most of the burned area was converted from big sagebrush (*Artemisia tridentata*)/bunchgrass communities to downy brome dominance. In 1999, over 765,000 hectares burned in Nevada, consuming more critical browse communities. Before the firestorm of 1964, the Independence mule deer (*Odocoileus hemionus*) herd of northeastern Nevada was estimated at 38,000 animals. By 2001, the Independence mule deer herd was estimated at 9,000 animals. The use of herbicide and mechanical treatments combined with the seeding of native and introduced species was aggressively applied on selected areas to provide forage and cover to wintering mule deer. Understanding the importance of the inherent potential of specific seed species to compete with and suppress downy brome resulted in increased success of rehabilitation efforts. By 2010, the Independence mule deer herd was estimated at 14,000, 65% increase. Active and aggressive weed control practices of downy brome along with effective rehabilitation practices are critical in decreasing the frequency and intensity of wildfires as well as any hope at returning native shrubs back to the community for mule deer and other wildlife species.

Phenology of Exotic Invasive Weeds Associated with Downy Brome. Charlie D. Clements*[1], James A. Young[1], Daniel Harmon[2]; [1]USDA, Reno, NV, [2]USDA-ARS, Reno, NV (008)

The exotic and highly invasive annual grass downy brome has invaded millions of hectares of rangelands throughout the Intermountain West. Downy brome increases the chance, rate, season and spread of wildfires, resulting in the destruction of native plant communities and the wildlife that depend on these communities. The increased frequency of wildfires has led to the conversion of formerly big sagebrush/bunchgrass communities to annual grass dominance by downy brome. Downy brome is the aspect dominant of vast areas of rangelands, often referred to as downy brome mono-cultures. Upon further inspection, these so-called mono-cultures actually host a number of exotic species that are components of these downy brome dominated rangelands. We investigated the phenology of 11 exotic invasive annual species associated with downy brome communities to obtain knowledge on how this array of weeds contributes to the truncation of succession. The array of exotic weed species that we investigated segregated into 1) bare-ground stage, 2) mustard stage, 3) downy brome dominance, 4) extreme ephemeral, 5) downy brome cohorts, and 6) annual species that replace downy brome. The bar-ground successional species (i.e. halogeton) all mature in late summer and early fall, much later than downy brome. The increasingly diverse mustard species stage matures in late spring and early summer, generally later than downy brome. The extremely ephemeral bur buttercup germinates with downy brome in the winter, but matures before any species in the continuum. Several species repeatedly occur in downy brome dominated seral communities and have similar and contrasting life forms to downy brome (i.e. filaree). Annual species that can replace downy brome on specific sites such as medusahead and yellow starthistle are strikingly different in phenology. Yellow starthistle is much later in maturity, while medusahead mimics downy brome, but is slightly later to mature.

The Use of Goat Grazing to Biologically Suppress Perennial Pepperweed. Charlie D. Clements*[1], James A. Young[1], Daniel Harmon[2]; [1]USDA, Reno, NV, [2]USDA-ARS, Reno, NV (009)

Perennial pepperweed is a creeping rooted exotic weed that has infested riparian areas, native hay meadows and agronomic fields throughout the western United States. Perennial pepperweed is a highly invasive weed that causes management and economic problems through the loss of diversity and quality forage. In recent times there has been an increased interest in biologically controlling this aggressive weed through grazing management with sheep or goats. We investigated the grazing of perennial pepperweed by goats using eight 0.1 hectare enclosures in a dense perennial pepperweed infestation in northwestern Nevada. Four of the 0.1 hectare enclosures were grazed and combined with various herbicidal treatments, while the remaining 4 enclosures were grazed throughout the summer and seeded to the perennial grass, tall wheatgrass. Heavy grazing of perennial pepperweed decreased forage yield by 78%, yet did not decrease the number of perennial pepperweed plants in the plots. The control of perennial pepperweed using the grazing and herbicide treatments together was not significant ($P \geq 0.05$) compared to the herbicide treatments alone. Grazing perennial pepperweed as a control method followed by seeding was unsuccessful due to the fact that the sprouting perennial grass seedlings could not compete with the dense creeping rooted perennial pepperweed. The suppression of perennial pepperweed with the use of selective herbicides combined with the seeding of a competitive perennial grass, such as tall wheatgrass, was significantly ($P \leq 0.05$) more successful than the goat grazing treatments combined with seeding the same perennial grass.

***Diorhabda carinulata* and Tamarisk Control.** Charlie D. Clements*[1], Daniel Harmon[2], James A. Young[1], Jeff Knight[3]; [1]USDA, Reno, NV, [2]USDA-ARS, Reno, NV, [3]Nevada Department of Agriculture, Reno, NV (010)

Tamarisk (*Tamarix ramosissima*) also referred to as salt cedar, native to Central Asia, is a shrub or small tree that has invaded more than 1.9 million hectares of habitat in southwestern and western United States. Tamarisk was brought to the United States in the early 1800s as an ornamental and later planted for windbreaks and stream bank stabilization. Tamarisk escaped cultivation and spread in riparian and adjacent communities which negatively affected native plant and animal communities. In an effort to control tamarisk, the USDA-Agricultural Research Service started investigating a number of potential control insects in the 1970's. Following the identification of the leaf beetle (*Diorhabda carinulata*), formerly *Diorhabda elongata*, the United States Department of Agriculture was permitted to start field tests on the leaf beetle and the potential control of tamarisk. Following quarantine testing, the leaf beetle was brought to field cages in Nevada as well as five other states for testing in 1999. In 2001 the leaf beetle was released in an effort to biologically control tamarisk. Prior to the release in 2001, we marked 100 tamarisk trees at three release sites in northwestern Nevada to monitor vegetation changes over-time. The leaf beetle did not sufficiently populate at the Stillwater site therefore, Lovelock and Walker sites will be reported on. In the spring of 2001 we marked 100 tamarisk trees at each location and set up permanent quadrats to measure plant morphology [e.g. height, diameter, densitometer conditions (percent), foliage (green, senescing, dead foliage/defoliation, dead wood, regrowth), and flowering status], beetle presence and primary vegetation directly under and at the edge of the canopy. These measurements were taken the last week in May from 2001 through 2011. Previous reports suggest that following the release of the leaf beetle, defoliation of tamarisk tress is significant and that death of the tree can occur within 3-5 years. After measuring defoliation for a decade, complete defoliation (96-100%) reached a high of 54% in 2004 at the Lovelock site and a high of 18% at the Walker site in 2007. By 2011, complete defoliation was recorded at 41% and 14% for the Lovelock and Walker sites, respectfully. Saltgrass (*Distichlis spicata*) increased in density and percent cover from 2001 to 2011 at the Lovelock site, whereas the invasive weed tall whitetop (*Lepidium latifolium*), which was present in 47% and 38% of the quadrats beneath and at the edge of the canopies in 2001, was not recorded in any quadrats in 2011. The interpretation of a dead tamarisk tree has clouded the reality concerning on-the-ground discussions. A defoliated tamarisk tree that looks gray and dead actually has tremendous potential to re-grow reddish colored branches that are followed by leaf development and eventually flowering. Also of concern is even though defoliation is occurring, biomass removal in these dense stands remains a problem. The use of heavy equipment and herbicides are most likely tools that will ultimately be used to control tamarisk.

Factors Influencing the Germination of Forage Kochia Accessions. Cody F. Creech*[1], Blair L. Waldron[2], Corey V. Ransom[3], Dale ZoBell[3], Earl Creech[3]; [1]Utah State University, Cornish, UT, [2]USDA-ARS-FRRL, Logan, UT, [3]Utah State University, Logan, UT (011)

Forage kochia (*Kochia prostrata* [L.] Schrad.), a useful perennial forage species, was originally introduced into the western United States to compete with annual weeds and restore highly degraded sites. Successful establishment of forage kochia in the semi-arid regions of the West is difficult due to the harsh and unpredictable environmental conditions which occur in areas where forage kochia is utilized. Research was conducted to evaluate the influence of planting date, seed age, and accession on forage kochia germination. Recently harvested and one year-old cold-stored seed of Immigrant (green-type) and an experimental grey-type were used in the study. Fifty pure live seed of each entry were arranged on blotter paper in nylon mesh bags and placed on or near the soil surface at two locations using three replications to simulate planting dates in Jan., Feb., March, and April. Entries were retrieved every two weeks and germinated seeds were counted. Planting in January and February yielded the highest germination and March and April plantings had much lower germination. Recently harvested seed had five to six times higher germination compared to the same planting date of year-old seed. Year-old forage kochia seed loses germination mechanisms the most important being seed vigor which inhibits its ability to germinate under favorable conditions. Precipitation events and low temperatures positively affected germination across all entries. These results confirm that using recently harvested seed and planting before March when moisture and cold temperatures are prevalent, provides the best opportunity for forage kochia seeds to germinate and establish.

Applying Hydrologic Sediment Modeling Relationships to Landscape-Level Dispersal of Leafy Spurge Along the Big Lost River in Idaho. Larry W. Lass*[1], Angelina Cernick[2], Timothy Prather[1], Jan Boll[1], Alex Fremier[1]; [1]University of Idaho, Moscow, ID, [2]University of Idaho, Moscow, ID (012)

In Idaho, leafy spurge (*Euphorbia esula*) plants are reported in 40 of 44 counties. Leafy spurge distribution is influenced by seed movement in flowing water (hydrochory) and human activities. In southeastern Idaho, 25% of the infestations are within 100 m of water and 50% are near a road. Understanding how water may deposit seed is critical to survey success. The focus of this research was to characterize leafy spurge dispersal within riparian systems. Hydrochory is affected by bank full width, water width to depth ratio, channel sinuosity, slope, and bed roughness. Our research suggests leafy spurge dispersal patterns in riparian areas are predictable based on channel characteristics. Evidence for this was established with a International River Interface Cooperative hydrology model (iRIC) where seed characteristics were determined in the laboratory, and seed deposition was estimated along a defined water channel.

Modeling seeds as submerged particles using the hydrology model iRIC show increasing sinuosity or bed roughness will yield greater seed deposition, but increasing width to depth ratio reduced seed deposition. The average seed depth increased from a slope of 0.05% to maximum average seed depth at a slope of 0.5% after which seed depth decreased Stream power and carrying capacity most likely explain the deposition trends. In this case, as the slope increases the stream has a greater seed carrying capacity and hence more seeds are delivered to the deposition areas, but at some threshold value, the stream power is too high to allow seed deposition. Model accuracy was tested on a leafy spurge infested reach of the middle fork of the Potlatch River in northern Idaho.

Field and modeling results were also applied to the Lost River network in southern Idaho using the predictions from the hydrology model study and a predictive occurrence based on vegetation type associated with leafy spurge infestations. Leafy spurge locations near the Lost River were located with a GPS and mapped by Butte County Weed Control personnel. National Agricultural Imaging Program (NAIP) digital aerial photos with four spectral bands (red, green, blue, and nir at 1 meter spatial resolution) were radiometrically corrected to match Landsat 5. The corrected NAIP images were classified with a distance algorithm using leafy spurge training sites. Results indicated the probability of finding leafy spurge at each pixel in the image. Locations of river and canal channels were digitized from NAIP images then used to calculate bank full width, width to depth ratio, and sinuosity at 0.5 km grid intervals. A probabilistic logic algorithm was used to predict leafy spurge likelihood of occurrence in uplands, near a river, or near a canal based on related evidence from the NAIP classified images and the hydrology model.

The probabilistic logic model predicting leafy spurge occurrence near the river identified 98.9% of the leafy spurge infestations in the validation area with 51.4% of the infestations in the high to very high likelihood categories. Near canals results identified 92.2% of the leafy spurge infestations in the validation area with 43.8% of the infestation in the high to very high likelihood categories. The logic model predicting leafy spurge occurrence along a river or canal offers insight as to where seeds might be deposited by water.

***Rubus* Endophytes: Influence on Biological Control.** Ann C. Bernert*; Oregon State University, West Linn, OR (013)

Control methods for the Himalaya Blackberry (*Rubus armeniacus*) are laborious, environmentally damaging, and expensive. Biological control can be more environmentally-friendly and effective. Blackberry Rust (*Phragmidium violaceum*) is a potential control agent. The purpose of this research was to use a novel approach in addressing two major roadblocks preventing biological control of *R. armeniacus*. These roadblocks, inconsistent infections in the target weed and risk to commercial breeds, may be better understood and overcome by the exploration of *R. armeniacus* endophytes. Endophytes are symbiotic microorganisms colonizing in plants. If an endophyte from *R. armeniacus* leaves is significantly antagonistic toward other fungi, it may be protecting the target weed from the fungal control agent. Foliar endophytes were isolated from asymptomatic *R. armeniacus* and maintained on Potato Dextrose Agar. Three of them were used in *in vitro* antagonism tests and identified through molecular means. In antagonism tests, a *Nemania serpens* strain significantly inhibited the growth of both endophytic *Fusarium oxysporium* and *Aureobasidium pullans.* Results were consistent in the replication and no growth inhibition occurred in the controls. This suggests that endophytes may be playing a role in preventing fungal pathogen infection. Understanding the symbiotic microbial communities in this target weed could result in understanding why agent infection rates are inconsistent. These microorganisms may also hold potential for biologically controlling commercial *Rubus* crop pathogens. Future research should investigate the mechanisms of fungal inhibition in antagonistic endophytes, the incidence rates of specific endophytes in *R. armeniacus*, and *in vivo* antagonism tests with *P. violaceum*.

Austrian Fieldcress, Management and Biology. Andy Currah*, Julie Kraft; Sublette County Weed and Pest District, Pinedale, WY (014)

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. In 2010, Julie Kraft and Andy Currah of Sublette County Weed and Pest District conducted field test 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 are pending, but timing may be the limiting factor in the treatment of Rorippa austriaca.

Post Release Monitoring of a 2009 Release of *Jaapiella ivannikovi* Fedotova (Diptera, Cecidomyiidae) for the Control of Russian Knapweed in Fremont County, Wyoming. John (Lars) L. Baker*[1], Kimberly K. Johnson[1], Nancy A. Webber[1], Tim Collier[2], Kathleen Meyers[3], Urs Schaffner[4], Bruce Shambaugh[5], Jeff Littlefield[6]; [1]Fremont County Weed and Pest, Lander, WY, [2]University of Wyoming, Laramie, WY, [3]Univeristy of Wyoming, Laramie, WY, [4]CABI Europe CH, Delemont, Switzerland, [5]USDA/APHIS/PPQ, Cheyenne, WY, [6]Montana State University, Bozeman, MT (015)

Russian knapweed, *Acroptilon repens,* is well established in Fremont County Wyoming, infesting over 40,000 acres of crop and rangeland. It has been the target of a biological control of weed effort in Wyoming, USA, since 1992 when a nematode, *Subanguina picridus,* was released. The Russian Knapweed Consortium has collected funds primarily from Wyoming Weed and Pest Districts as part of a cooperative effort with USDA/APHIS and CABI Europe-Switzerland to find additional agents. *Jaapiella ivannikovi* Fedotova (Dip., Cecidomyiidae) was approved for release in 2009. It was released north of Riverton, Fremont County, Wyoming on 19May2009. By the end of the summer over 50 galls had been located. By the end of 2010, the insect had spread across several hectares of land with over 200 galls being identified. Pre-release data had been collected from permanent transects established at this site for a number of years in anticipation of future releases. Additional transects have been established to monitor population expansion and impact of the agent on the target species. Preliminary data indicates that *Jaapiella* reduces Russian knapweed plant size and seed production. Efforts will be made in 2011 to evaluate parasitism, habitat preferences and seasonal phenology of gall formation and adult emergence. Preliminary field data suggests that *Jaapiella* is a promising biological control agent for Russian knapweed that has established in Montana, Colorado and Wyoming, has significant impact and is spreading in both density and area.

Efficacy of Graminicides and Glyphosate Mixtures on Buffelgrass: Greenhouse Studies.
William B. McCloskey*[1], Dana Backer[2]; [1]University of Arizona, Tucson, AZ, [2]Saguaro National Park, Tucson, AZ (016)

Buffelgrass (*Pennisetum ciliare*) is a perennial bunchgrass from Africa that threatens the southern Arizona Sonoran Desert ecosystem including its signature saguaro forests by increasing the frequency and intensity of fires. Current control practices include hand pulling and individual plant treatment (IPT) with glyphosate; strategies that require lots of labor and are difficult to execute on steep rocky terrain. The extent and size of buffelgrass populations in remote areas and on rough terrain suggests that aerial herbicide applications may be needed to manage this invasive species. Experiments were initiated to investigate using broadcast herbicide applications to control buffelgrass such as those made by helicopter or fixed wing aircraft. In addition to investigating rates of glyphosate per unit area needed for control, the graminicides clethodim, fluazifop and sethoxydim were also investigated in the hope that tank mixtures could be used to reduce the collateral damage to desirable vegetation caused by glyphosate. Seed was collected from Saguaro National Park, aged at room temperature for several months to overcome dormancy and planted in pots in a greenhouse. Plants were grown until they had 8 to 10 tillers, were clipped about 3 to 5 cm above the soil, allowed to regrow and then were sprayed when they had 7 to 15 tillers. About 3 to 4 weeks after spraying, shoot fresh weight and dry weight 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. Herbicides were applied using a CO_2 pressurized backpack sprayer with a 3 nozzle boom and XR8001 nozzles typically calibrated to deliver about 93 L/ha (about 10 GPA). In one typical experiment, glyphosate (Aquamaster) was applied with a non-ionic surfactant (0.5% v/v) and ammonium sulfate (1% w/w) at 0.0 (untreated control), 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.86, 1.12, 1.4, 1.68, and 1.96 kg/ha. Even low rates of glyphosate were sufficient to stop the growth of these greenhouse plants and there were no significant differences in fresh or dry weights between any of the herbicide rates except that the untreated plants had much larger weights per plant than plants sprayed with glyphosate. It was difficult to visually estimate injury symptoms and this was compounded by the different symptoms caused by different herbicide modes-of-action. The only reliable indicator of phytotoxicity was regrowth after the first biomass harvest following spraying. In the above glyphosate experiment, shoot regrowth (dry weight) was 5.9, 5.3, 6.5, 1.2, 1.6, 3.4, 0.5, 0.4, 0, 0, 0, 0, and 0 g/plant, respectively. Clethodim (Select 2EC) was applied with 1% v/v methylated seed oil (MSO) at 0.0 (untreated control), 0.07, 0.14, 0.2, 0.27, 0.34, 0.41, 0.48, 0.54, 0.61, 0.68, 0.75, and 0.82 kg/ha. Similar to glyphosate, all rates above 0 substantially suppressed growth and there were only small differences in dry weight at the first biomass harvest; 56, 24, 17, 19, 15, 12, 17, 12, 15, 14, 15, 15 and 17 g/plant, respectively. At the second regrowth harvest, the dry weights were 3.9, 1.5, 1.0, 0, 0, 0, 0, 0, 0, 0, 0, 0, and 0 g/plant, respectively, indicating that most of the clethodim rates killed the plants. Sethoxydim was applied with 1% v/v methylated seed oil (MSO) at 0.0 (untreated control), 0.11, 0.21, 0.32, 0.42, 0.53, 0.63, 0.74, 0.84, 0.95, 1.05 and 1.16 kg/ha. All rates above 0 substantially suppressed growth and there were only small differences in dry weight at the first biomass harvest; 70, 15, 13, 14, 14, 17, 12, 12, 13, 11, 11, and 13 g/plant, respectively. At the second regrowth harvest, the dry weights were 5.74, 0.24, 0, 0, 0, 0, 0, 0, 0, 0, 0 and 0 g/plant, respectively, indicating that most of the sethoxydim rates killed the plants. Fluazifop-p-butyl was applied with 1% v/v methylated seed oil (MSO) at 0.0 (untreated control), 0.11, 0.21, 0.32, 0.42, 0.53, 0.63, 0.74, 0.84, 0.95, 1.05, 1.16 and 1.26 kg/ha. Again all rates above 0 substantially suppressed growth and there were only small differences in dry weight at the first biomass harvest; 44, 18, 19, 17, 15, 16, 22, 16, 16, 18, 16, 19 and 17 g/plant, respectively. At the second regrowth harvest, the dry weights were 4.0, 2.4, 5.2, 4.2, 3.8, 2.2, 5.1, 0.9, 3.7, 2.4, 1.4, 0.9 and 0 g/plant, respectively, suggesting that although fluazifop-p-butyl suppressed growth following application, it was not as effective in killing buffelgrass as clethodim or sethoxydim. As expected, the greenhouse plants were much more susceptible to the herbicides than mature perennial plants in the wild. However, the greenhouse experiments will allow us to determine if tank mixtures of graminicides with glyphosate will be synergistic and useful in field applications.

Using Herbicides Followed by Bunchgrass Seeding to Rehabilitate Medusahead Infested Rangelands in Central Oregon. Rhonda B. Simmons, Marvin D. Butler*; Oregon State University, Madras, OR (017)

Medusahead (*Taeniatherum caput-medusae*) is an annual grassy weed capable of invading established stands of bunchgrasses, reducing forage, and increasing the risk of fire and soil erosion. Plots were established in the fall of 2007 north of Madras, Oregon in rangeland highly infested with medusahead. Six species of bunchgrasses were planted following treatment with imazapic or imazapic + glyphosate. Grass stand establishment improved as a result of close to normal average precipitation during the 2009-2011 periods. In 2011, the most vigorous grass stands were observed in crested wheatgrass, intermediate wheatgrass, Sherman big bluegrass, and bluebunch wheatgrass, while Sandberg's bluegrass and particularly smooth brome were unsuccessful in establishment.

Optimal Herbicide Application Time for Canada Thistle Control. Darrell L. Deneke*, Mike J. Moechnig, Dave A. Vos, Jill K. Alms; South Dakota State University, Brookings, SD (018)

It is generally thought that the optimal herbicide application times for Canada thistle (*Cirsium arvense*) control occurs at the bud to early flowering growth stage and in the fall after a light frost but prior to a desiccating frost. These recommendations are partially based on research that indicates these are the times when carbohydrate mobilization from the shoots to the roots is greatest. The objective of this research was to evaluate Canada thistle control associated with several different herbicide application times to determine which application time is most effective. Six studies were established at four locations in eastern South Dakota grasslands and pastures from 2007 to 2011. Herbicides included aminopyralid (88 – 123 g ae/ha), aminocyclopyrachlor (123 g ae/ha), clopyralid (315 g ae/ha), and picloram (420 g ae/ha). Application times varied among studies, but application times generally included May, June, July, August, September or August, September, October, November. In South Dakota, Canada thistle often flowers in late June, the first light frost often occurs in mid-September, and complete desiccation from frost often occurs around mid-October. The magnitude of thistle control varied among herbicides, locations, and years, but trends regarding application times appeared consistent. The optimal herbicide application time for Canada thistle was June to August. Although September appeared to be the best time for fall applications, control from a September application was equal to or less than control associate with an August application. Therefore, results from this research contradicts some previous Canada thistle control recommendations as several herbicides may be most effective if applied from June until the end of August while control may decline prior to or after that period.

Yellow Toadflax Control in Rangeland with DPX-MAT28. Brian M. Jenks*; North Dakota State University, Minot, ND (019)

Yellow toadflax (*Linaria vulgaris* P. Mill.) has spread over hundreds of acres of rangeland in western North Dakota that were previously infested with leafy spurge. Leafy spurge was controlled 10-20 years ago through biological and chemical means. Given less competition, yellow toadflax has now replaced one yellow-flowered noxious weed with another. The objective of this study was to evaluate DPX-MAT28 (aminocyclopyrachlor) for yellow toadflax control in rangeland compared to picloram. DPX-MAT28 is an experimental herbicide being developed by DuPont for weed control in rangeland, pasture, and non-cropland areas. Treatments were applied to 10 by 30 ft plots with a hand boom using standard small plot procedures. Treatments were applied at the vegetative stage (Jul 25), flowering stage (Sep 11), and in late fall (Oct 16) of 2008. No other treatments have been applied. The treatments were evaluated for percent visual control in 2009, 2010, and 2011. Weed density was recorded prior to application in 2008 and again in 2009, 2010, and 2011. Picloram (2 pt/A) provided 23-60% yellow toadflax visual control in 2009, but decreased to 0-10% in 2011. Picloram reduced toadflax density 6-55% in 2009, but density gradually increased in 2010 and 2011. DPX-MAT28 at 1.5 oz ai/A provided 90-95% yellow toadflax visual control in 2009, but decreased to 27-43% in 2011. Toadflax density was reduced 84-98% in 2009; however, density increased from 0.2-1.0 plants/ft^2 in 2009 to 3.1-4.9 plants/ft^2 in 2011. DPX-MAT28 at 3 oz ai/A provided 98-100% visual control and reduced density 100% in 2009 and 2010. Plants are just beginning to appear again in 2011 with 0-0.3 plants/ft^2. DPX-MAT28 at 2 oz ai/A tank mixed with chlorsulfuron at 0.75 oz ai/A provided 99-100% yellow toadflax visual control in 2009, but decreased to 76-89% in 2011. Toadflax density was reduced 99% in 2009; however, density increased from 0-0.1 plants/ft^2 in 2009 to 0.9-1.3 plants/ft^2 in 2011. Grass injury from all treatments was 6% or less in 2009, but no visual injury was observed in 2010 or 2011.

Yellow Toadflax Control with Fall Herbicide Applications. Jill K. Alms*, Mike J. Moechnig, Dave A. Vos, Darrell L. Deneke; South Dakota State University, Brookings, SD (020)

Yellow toadflax (*Linaria vulgaris*) has become a troublesome invasive weed in pastures, roadsides, and turf throughout eastern South Dakota and in the Black Hills in western SD. Picloram and chlorsulfuron are currently registered for yellow toadflax control, but these herbicides often fail to provide acceptable control. Aminocyclopyrachlor has been effective in several previous studies. Therefore, the objective of these studies was to identify the optimal aminocyclopyrachlor rate and herbicide application timing for yellow toadflax control. Dose response trials were established in 2009 and 2010 and were evaluated one to two years after application. Results from these trials indicated that the minimum aminocyclopyrachlor rate to consistently achieve at least 85% control one year after application was 140 g ae/ha. In one trial, this rate resulted in greater than 85% control for two years after application. In another study, aminocyclopyrachlor (175 g ae/ha), picloram (560 g ae/ha), and chlorsulfuron (65 g ai/ha) were applied in August, September, or October 2010 and yellow toadflax control was evaluated in August, 2011. Picloram resulted in 15 – 80% control and was most effective if applied in Sept. or Oct. whereas chlorsulfuron resulted in 15 – 28% control and was most effective if applied in Sept. Picloram + chlorsulfuron was more effective than either product applied alone (53 – 84% control) and was most effective if applied in Sept. or Oct. Aminocyclopyrachlor was the most effective herbicide resulting in greater than 97% control regardless of application date. Therefore, results from this study demonstrated that aminocyclopyrachlor may be more effective on yellow toadflax than picloram or chlorsulfuron and may be less affected by application timing in fall.

Integrated Management of Yellow Starthistle with Burning, Aminopyralid, and Revegetation. Guy B. Kyser*[1], Arthur W. Hazebrook[2], Joseph M. DiTomaso[1]; [1]University of California, Davis, CA, [2]United States Army, Fort Hunter Liggett, CA (021)

Previous studies have shown that yellow starthistle can be nearly eradicated by an integrated strategy of summer burning followed by winter application of clopyralid. The burn flushes the soil seedbank, enhancing the effects of the herbicide application. In this project, we had three objectives: 1) to confirm that burning followed by the newer herbicide aminopyralid is an effective treatment for yellow starthistle; 2) to evaluate whether revegetation can be successfully conducted in tandem with application of aminopyralid; and 3) to compare timing and planting techniques for success in revegetation seeding. We set up study locations at two sites in Fort Hunter Liggett, Monterey County, CA. Both sites were in valley bottom grassland within mixed oak-foothill pine woodland, on sandy to gravelly loam at ~1300 ft elevation. The sites were burned in late October 2009. Following the burns, a flush of yellow starthistle seedlings emerged with the first fall rains. Treatments included three reseeding times (in two seeding methods) crossed with three times of aminopyralid application. Each site was established in a strip-plot design with seeding time and method randomized as the vertical factor, and timing of clopyralid application randomized as the horizontal factor. Seeding strips were 10 ft wide and clopyralid application strips were 30 ft wide, making sub-subplots 10 ft by 30 ft. Treatments were replicated three times at each site. A native seed mix, mostly perennial grasses, was planted 9 December 2009, 11 January 2010, and 11 March 2010. Seeding methods included drill seeding (15 to 20 lb acre^{-1}), broadcast seeding (12 to 17 lb acre^{-1}), and no seeding. We applied aminopyralid (0.75 oz ae acre^{1}) 24 November 2009, 28 January 2010, and 19 March 2010. Applications were made with a CO_2 backpack sprayer at 30 psi and a 10-ft boom with six 8002 nozzles. The spray volume was 20 gallons acre^{-1}, and all treatments included 0.25% v/v nonionic surfactant. We evaluated the plots 20 July 2010 at peak yellow starthistle flowering. Three one-m^2 quadrats were thrown along the center of each sub-subplot and relative cover of all plant species was visually estimated. Mean cover was compiled into cover classes (yellow starthistle, native grasses, introduced annual grasses, legumes, native forbs, and introduced forbs). Cover in each class was compared among treatments using ANOVA for a strip-plot design. Summer burning alone resulted in 43% and 84% cover of yellow starthistle in the Mission and Back sites, respectively. Aminopyralid applied in January or March reduced yellow starthistle cover to 0.3% or less at both sites. November applications resulted in cover of 17% to 21%, probably because soil residual was not sufficient to control late-germinating seedlings. These results are comparable to previous trials with burning followed by clopyralid. Native grasses established the strongest stands in December and January drill planted strips, particularly in sub-subplots treated with aminopyralid in January. Results from this study indicate that properly timed burning, aminopyralid application, and revegetation can be integrated for yellow starthistle management.

Perennial Weed Control with Aminopyralid and Aminocyclopyrachlor. Gregory J. Endres*[1], Tim Becker[2], Sheldon Gerhardt[3], Kacey Holm[4], Emily Kline[5]; [1]NDSU, Carrington, ND, [2]NDSU, New Rockford, ND, [3]NDSU, Napoleon, ND, [4]NDSU, Ellendale, ND, [5]NDSU, McClusky, ND (022)

Field trials are being conducted in four south-central North Dakota counties to evaluate long-term perennial weed control with aminopyralid and aminocyclopyrachlor. Experimental design for all trials was a randomized complete block with three replicates. Aminopyralid and aminocyclopyrachlor treatments included NIS at 0.25 to 0.5% v/v. In Sheridan County hayland, fall-applied (October, 2008) aminopyralid at 0.08 lb ai/A provided excellent (99%) control of absinth wormwood when visually evaluated 12 months after treatment (MAT) and 80% control 34 MAT. Summer-applied (July, 2009) aminopyralid at 0.08 lb ai/A provided 95% and 83% control of absinth wormwood 12 and 25 MAT, respectively. Summer-applied aminocyclopyrachlor at 0.059 lb ai/A plus chlorsulfuron at 0.023 lb ai/A provided 80% control of absinth wormwood 25 MAT. Canada thistle control at three sites (Sheridan County, Dickey County - CRP, and Eddy County - riparian) with fall-applied (October 2008 or 2010) aminopyralid averaged 82% at 0.08 lb ai/A and 92% at 0.11 lb ai/A 12 MAT. Fall-applied aminocyclopyrachlor at 0.059 lb ai/A plus chlorsulfuron at 0.023 lb ai/A provided an average of 94% control of Canada thistle 12 MAT in Dickey and Logan counties. In Sheridan County, summer-applied aminocyclopyrachlor at 0.059 lb ai/A plus chlorsulfuron at 0.023 lb ai/A provided 87% control of Canada thistle 25 MAT. In Logan County pasture, fall-applied (September, 2010) aminocyclopyrachlor at 0.156 lb ai/A plus chlorsulfuron at 0.063 lb ai/A provided 94% yellow toadflax control 12 MAT while control with aminopyralid at 0.11 lb ai/A was 20%.

Black Greasewood Community Response to Aminocyclopyrachlor. Jordana J. LaFantasie[1], Brian A. Mealor*[2], Andrew R. Kniss[2]; [1]Fort Hays State University, Hays, KS, [2]University of Wyoming, Laramie, WY (023)

Black greasewood is a widely distributed shrub on saline soils throughout western North America. Greasewood communities are susceptible to invasion by several invasive plant species such as Russian knapweed, halogeton, downy brome and others. Greasewood contains oxalates which are capable of poisoning both cattle and sheep if sufficient quantities are consumed, and therefore may also be targeted for removal from some areas. Aminocyclopyrachlor, a new synthetic auxin herbicide, promises to be useful for target weeds often found in association with greasewood, but the effects of aminyclopyrachlor application on greasewood communities have not been documented. To evaluate the effects on greasewood communities, we applied aminocyclopyrachlor to three greasewood sites at 0 to 0.133 kg ai acre^{-1} within a randomized complete block design at each site. We recorded vegetation canopy cover using the line-point intercept method at 0, 1 and 2 years after treatment. We also evaluated greasewood control (% visual) and mortality at all three sites. Canopy cover of bare ground and annual forbs increased with increasing rates of aminocyclopyrachlor, whereas shrub and cool-season perennial grass cover decreased. While aminocyclopyrachlor application reduced the overall amount of shrub cover, greasewood mortality was ≤ 50%. These changes in canopy cover remained evident 2 years after application. Our results indicate that, as with many other broadleaf-selective herbicides, caution and proactive planning to avoid nontarget injury should be used when incorporating aminocyclopyrachlor into rangeland weed management programs.

Timing of Application and Surfactant Affects Control of Rush Skeletonweed with Aminocyclopyrachlor. Alan J. Raeder*[1], Jared L. Bell[1], Dennis Pittmann[1], Randall E. Stevens[2], Ian C. Burke[1]; [1]Washington State University, Pullman, WA, [2]Palouse Conservation District, Pullman, WA (024)

Aminocyclopyrachlor is a growth regulator herbicide used for broadleaf weed control in non-crop and rangeland systems. Three field efficacy studies were conducted to evaluate application timing and surfactant effect on rush skeletonweed (*Chondrilla juncea*). Three studies with a randomized complete block design and four replications each were established near LaCrosse, WA in 2009 and 2010. Each study was initiated at a different time in the growing season. Treatments were applied in late spring (June 16, 2009), fall (December 1, 2009), and early spring (April 19, 2010). Aminocyclopyrachlor was applied at four rates (32.9 g ai/h, 65.8 g ai/h, 131.6 g ai/h, and 197.5 g ai/h) with 0.5% v/v non-ionic surfactant (NIS) or 1.0% v/v methylated seed soil (MSO). Comparison treatments consisted of aminocyclopyrachlor at 32.9 g ai/h and 65.8 g ai/h plus chlorsulfuron at 13.3 g ai/h and 26.6 g ai/h, respectively, with 0.5% v/v NIS or 1.0% v/v MSO. A nontreated control was included for comparison purposes. Efficacy was evaluated by visual percent control ratings of rush skeletonweed at 815 (late spring applied), 647 (fall applied), and 508 (early spring applied) days after application. In the late spring applied study, rush skeletonweed was controlled with 197.5 g ai/h. In the fall applied study, rush skeletonweed was controlled with 131.6 g ai/h. In the early spring applied study, rush skeletonweed was controlled with 197.5 g ai/h + NIS and 131.6 g ai/h + MSO. No difference was observed in treatments containing NIS compared to treatments containing MSO when aminocyclopyrachlor was applied at the same rate. Chlorsulfuron applied with aminocyclopyrachlor also did not increase control of rush skeletonweed from the control provided by similar rates of aminocyclopyrachlor alone. Increased control of rush skeletonweed was observed for fall and early spring applications when compared to the late spring applications. A fall applied rate of aminocyclopyrachlor at 131.5 g ai/h plus 0.5% v/v NIS or 1.0% v/v MSO achieves similar control as a late spring or early spring application of aminocyclopyrachlor at twice the rate.

Fourth Year Density of Medusahead, *Taeniatherum caput-medusae*, in Herbicide Treated and Untreated Central Oregon Rangeland. Marvin D. Butler, Rhonda B. Simmons*; Oregon State University, Madras, OR (186)

Medusahead (*Taeniatherum caput-medusae*) is an annual grassy weed that degrades range and wildlands of the Pacific Northwest. Imazapic was applied at the South Junction meadow location north of Madras, Oregon in the fall of 2007 and at the South Junction bench and Warm Springs locations during the fall of 2008. Treatment provided near 99 percent control of medusahead the following spring at each location, with 45-60% suppression one year later. To evaluate the residual affect three and four years after treatment, one square foot samples were taken from treated and untreated areas to compare medusahead plant population, plant height and biomass weight. The trend was for the medusahead plant population in imazapic-treated areas to remain much less (12-31% of untreated), often with an increase in plant height (up to 80 % over untreated) and somewhat less total biomass (50-90% of untreated) than untreated areas.

Project 2. Weeds of Horticultural Crops

Host Status of Common Weeds to *Globodera pallida* found in Idaho Potato Fields. Rick A. Boydston*[1], Hassan Mojtahedi[2]; [1]USDA-ARS, Prosser, WA, [2]Washington State University, Prosser, WA (025)

The potato cyst nematode, *Globodera pallida (PCN), is a restricted pest in the USA and* was first reported in Idaho in 2006. The USDA-APHIS and Idaho State Department of Agriculture hope to eradicate it from infested fields. Cysts can remain viable in the soil for 20 years or more. Eradicating PCN will require depriving the nematodes of their hosts over a protracted time period until no viable cysts are present in the soil. Functional eradication might be achieved using relatively high dosages of soil fumigants. The presence of host weeds of PCN can play a significant role in success of the eradication program. To determine the host status of common weeds found in potato (*Solanum tuberosum*) growing regions of the Pacific Northwest, host suitability tests were conducted in a secured greenhouse located at the University of Idaho at Moscow. Reproduction of PCN on twenty-three weed species including hairy nightshade (*S. physalifolium*), cutleaf nightshade (*S. triflorum*) (biotypes from ID and WA), and black nightshade (*S. nigrum*) (WA biotype) were compared to reproduction on potato cultivar 'Desiree' (known host). Plants were grown in 10-cm diameter clay pots containing sandy loam soil previously fumigated with methyl bromide. Cysts were raised in the greenhouse (diapause period elapsed) and pots were inoculated with 15 cysts within nylon mesh sachets. Treatments were replicated five times and each trial lasted 3 months and all trials were repeated. Cysts were extracted from soil using a Fenwick can, and the reproductive factor (RF = final cyst count ÷ initial inoculum) was determined. Both ID and WA biotypes of cutleaf nightshade were hosts of Idaho PCN; RF=1.0 and 1.7, respectively. Similarly, ID and WA biotypes of hairy nightshade were suitable hosts of Idaho PCN; RF= 2.4 and 1.8, respectively. Black nightshade collected from WA and twenty non-solanaceous weed species (six grass and fourteen broadleaf weeds) tested were not suitable hosts of Idaho PCN. Desiree potato proved to be a suitable host (RF = 17.8) of Idaho PCN. Hairy nightshade and cutleaf nightshade should be closely monitored and controlled in PCN infested fields in order to successfully eradicate the pest.

Preemergence and Postemergence Weed Control in Potatoes with Pyroxasulfone. Brent Beutler*[1], Pamela Hutchinson[2]; [1]University of Idaho, American Falls, ID, [2]University of Idaho, Aberdeen, ID (026)

Potato growers throughout the Pacific Northwest rely almost completely on herbicides for weed control. The majority of these herbicides are applied preemergence in at least two-way tank mixtures, while postemergence herbicide options are limited. Replicated field trials were conducted in 2010 and 2011 to evaluate pyroxasulfone weed control and crop safety in potatoes applied pre- and postemergence, in Aberdeen, ID. Treatments included pyroxasulfone at 0.106 lb/A or 0.213 lb/A applied alone or in two-way tank mixtures with several common potato herbicides. Preemergence treatments were applied after hilling, prior to potato and weed emergence, and sprinkler incorporated within 48 hours of application. In both years, all preemergence applications of pyroxasulfone alone or in tank mixtures provided greater than 95 percent control of redroot pigweed and green foxtail. Hairy nightshade control ranged from 82 to 100 percent control from preemergence treatments across three trials. While pyroxasulfone alone applied preemergence provided greater than 90 percent common lambsquarters control in 2011, control levels were below 55 percent in 2010 by end of season. Crop injury for preemergence applications was less than 7 percent for all treatments. Pyroxasulfone applied postemergence provided excellent control of redroot pigweed, hairy nightshade, and green foxtail, however, common lambsquarters control was below 50 percent for the high rate of pyroxasulfone and below 30 percent for the low rate. Additionally both rates of pyroxasulfone applied postemergence resulted in lower total tuber and US 1 tuber yields.

Field Bindweed Suppression in Processing Tomato. Wayne T. Lanini*; University of California, Davis, Davis, CA (027)

Field bindweed is extremely difficult to control in tomatoes. Tillage is generally not effective, as the cut root pieces have a great capacity for regenerating new plants. Seedlings can be controlled with tillage when very young, but they develop the capacity to regenerate new shoot growth very rapidly. Field studies were conducted to evaluate the potential of preemergence applications of sulfentrazone, rimsulfuron, trifluralin, pendimethalin, or S-metolachlor applied alone or with either carfentrazone or rimsulfuron applied postemergence to control field bindweed. Trifluralin treatments were applied prior to the final bed shaping. The remaining preemergence treatments were applied to preformed beds just ahead of tomato transplanting. Postemergence treatments were applied three weeks after transplanting. The herbicides tested suppressed field bindweed growth, but none of the herbicides provided complete control. Trifluralin was the most effective preemergence treatment for suppressing established field bindweed. Postemergence applications of carfentrazone or rimsulfuron also reduced field bindweed levels. Tomato canopy growth was also not affected by treatment, as determined by canopy light extinction. Tomato yield was negatively correlated with field bindweed cover at harvest.

Weed Control in Established Strawberry in the Pacific Northwest. Carl R. Libbey*, Timothy W. Miller; Washington State University, Mount Vernon, WA (028)

Herbicide combinations were evaluated for weed control in established strawberry at WSU NWREC from 2008 through 2011. ‘Hood’ strawberry was planted in July, 2008 and 2009 and ‘Totem’ in May, 2010. Split-blocks of these established strawberries were then treated with simazine in late fall and the main plots were treated with sequential dormant-season herbicides applied in late winter. Visual crop injury and weed control were evaluated through the growing season. Mature berries were harvested 3-4 times and marketable berries were counted and weighed. In 2009 the higher rates of flumioxazin resulted in > 20% injury by March, 2009, while all treatments, including the nontreated control, had winter injury of >20% at the March, 2010 rating. Higher rates of sulfentrazone and all flumioxazin treatments resulted in >20% injury in 2011. Early season injury was increased for all dormant-season herbicides when applied sequentially with simazine all three growing seasons. Flumioxazin following simazine resulted in the highest injury. By harvest, however, injury was < 10% for all treatments all years. Weed control was improved with the use of simazine prior to the dormant applications. The majority of improvement was due to improved common chickweed (*Stellaria media*) control. Isoxaben provided >80% weed control either used alone or with simazine in 2009, and >88% in 2010. Other treatments giving acceptable early-season weed control were clopyralid, sulfentrazone, flumioxazin, and napropamide. Few treatments provided adequate weed control at harvest when applied alone in 2009 and 2010. In 2011 all treatments alone or with simazine provided good to excellent weed control through June. Dormant-season herbicides did not significantly affect berry yield or fruit size in comparison to hand-weed strawberries in any year. Fall-applied simazine also did not significantly improve either yield or fruit size any year.

Barriers to Controlling Spurge in Nursery Containers. Kelly M. Young*; University of Arizona, Phoenix, AZ (029)

Spurges, or sand mats are difficult to control, warm season, broadleaf weeds. Formerly included in the genus *Euphorbia*, the low-growing, herbaceous spurges are now classified in the genus *Chamaesyce* (pronounced 'kamma-sice-ee'). Although there are 30 species of *Chamaesyce* in Arizona alone, only a handful are commonly encountered as weeds. Despite an arsenal of effective products available to growers, control remains poor in nursery containers. Factors that contribute to unsatisfactory control include: incorrect spurge identification, inadvertent dispersal of seeds on tools and shoes, poor sanitation practices that allow onsite accumulation of seed, application of preemergence herbicides at below labeled rates, inadequate irrigation incorporation of preemergence herbicides, and disruption of the herbicide barrier after incorporation. Most of these barriers can be overcome with proper worker training. Training materials should be presented in the native language of the workers, which poses additional barriers. The University of Arizona Cooperative Extension in Maricopa County created simple posters in both Spanish and English to educate workers in the best practices for managing spurge in nursery containers.

Bur Buttercup Control in Turf. Mike J. Moechnig*, Jill K. Alms, Robert Fanning, Dave A. Vos, Darrell L. Deneke; South Dakota State University, Brookings, SD (030)

Bur buttercup (*Ceratocephala testiculata*) is a small winter annual weed that has become common in pastures, waste areas, road sides, gardens, and turf. Bur buttercup is particularly troublesome in turf because it matures early in the spring at which time it produces a bur that becomes very prickly after it dries. The short vegetative life span in the spring makes timely herbicide applications difficult. Therefore, the objective of this study was to determine if fall herbicide applications would control bur buttercup. Herbicides were applied on November 19, 2010 and control was evaluated April 6, 2011. Treatments were replicated three times in a randomized complete block design and treatment comparisons were determined with ANOVA and LSD analysis. Herbicides resulting in greater than 90% control included 2,4-D ester (1 kg ae/ha), metsulfuron (63 g ai/ha), sulfosulfuron (37 g ai/ha), or propoxycarbazone (34 g ai/ha). The addition of soil residual herbicides with 2,4-D, such as pendimethalin, prodiamine, or isoxaben) did not increase control. Therefore, results from this study demonstrated that bur buttercup could be effectively controlled in turf by applying broadleaf herbicides in late fall.

Postemergence Chemical Control Options for Glyphosate-paraquat Resistant Hairy Fleabane (*Conyza bonariensis*) in California Orchards. Marcelo L. Moretti*[1], Brad Hanson[2], Kurt J. Hembree[3], Anil Shrestha[4]; [1]University of California - Davis, Davis, CA, [2]Univ. of California, Davis, Davis, CA, [3]UCCE, Fresno, CA, [4]California Fresno State University, Fresno, CA (031)

Glyphosate-resistant hairy fleabane is spread throughout the tree nut cropping systems of California. Management of glyphosate-resistant hairy fleabane is complicated in some areas by the presence of populations resistant to both glyphosate and paraquat. The objective of this study was to evaluate postemergence herbicides for controlling escapes and preventing a rapid increase of the multiple-resistant population. Glyphosate-paraquat resistant (R) and susceptible (S), hairy fleabane plants grown outdoors in pots were treated at the 6- to 8-leaf stage using a spray chamber calibrated to deliver 25 GPA. Treatments included glyphosate, glufosinate, 2,4-D, saflufenacil, and carfentrazone, alone or in combination with glyphosate. Combinations of glufosinate with 2,4-D or saflufenacil, a sequential application of glyphosate followed by paraquat 10 days later, paraquat alone, and an untreated control were also included. Visual injury was evaluated 35 DAT. The experimental design was a randomized complete block with six replicates and the experiment was repeated. Glyphosate alone injured S and R plants 82 and 60%, respectively. Paraquat alone or in sequential treatment with glyphosate injured S 98-99%, but only injured R 17 and 82%, respectively. Saflufenacil and glufosinate were the only solo treatments consistently causing more than 98% injury. Herbicides mixtures outperformed single herbicide treatments and injured both populations >92%. The study showed that glufosinate, saflufenacil, and all tested herbicides mixtures can control the R population of hairy fleabane in tree nut crops. Additional research is ongoing to validate these results under field conditions.

Investigations into Resistance Mechanisms in Two Glyphosate-Resistant *Conyza* Species in California. Joi Abit*[1], Brad Hanson[2]; [1]University of California-Davis, Davis, CA, [2]Univ. of California, Davis, Davis, CA (032)

Glyphosate is a post-emergence, broad spectrum herbicide that has been extensively used for more than 25 years in orchards and vineyards. In California, evolved resistance to glyphosate has been reported in five weed species, including *Conyza bonariensis and Conyza canadensis*. Seedlings of glyphosate-resistant and susceptible *C. bonariensis* and *C. canadensis* were treated with ^{14}C-glyphosate in an effort to determine the mechanisms of resistance to glyphosate. There were no differences in ^{14}C-glyphosate leaf uptake between the susceptible and the glyphosate-resistant biotypes of either *Conyza* species; however, the patterns of ^{14}C-glyphosate translocation were significantly different between biotypes. In both glyphosate-resistant biotypes, a greater percentage (80 to 93%) of absorbed ^{14}C-glyphosate moved distal to the treated section but remained in the treated leaf. In contrast, in the susceptible biotypes of each species, 16 to 26% of ^{14}C-glyphosate moved to non-treated leaves and roots 1 and 3 days after treatment. Glyphosate resistance in *C. canadensis* and *C. bonariensis* appears to be at least partially conferred by limited translocation (nontarget site-based). Further studies are being conducted to determine if other target site or non-target site mechanisms also contribute the glyphosate resistance in these species.

Does the Timing of Incorporation of Lime or Gypsum Affect Penoxsulam Efficacy? Byron B. Sleugh*[1], Deb Shatley[2], Garrick Stuhr[3]; [1]Dow AgroSciences, Clovis, CA, [2]Dow AgroSciences, Lincoln, CA, [3]Dow AgroSciences, Fresno, CA (033)

Tree nut producers in California often apply lime or gypsum as soil amendments to their orchards in the fall or winter and it is incorporated by irrigation or rainfall. Residual herbicide application during the same time frame is common. The influence of applying soil residual herbicides before or after amendment incorporation on weed control has not been determined. Penoxsulam is a new residual herbicide with ALS mode of action (an active ingredient in Pindarä GT) offered by Dow AgroSciences with broad spectrum weed control in tree nut crops and non-crop land. The objective of this study was to determine the efficacy of penoxsulam at 17.5 or 35 g ai ha^{-1} applied over lime or gypsum either before or after the amendments were incorporated with irrigation or rainfall. All herbicide treatments included glyphosate at 1680 g ai ha^{-1} (3 pts acre^{-1} of a 4 lb gal^{-1} product). At 56 days after application (DAA) marestail (*Conyza canadensis*) control with 17.5 g ai penoxsulam ha^{-1} was 96, 89 and 67%, respectively, where no lime was applied, penoxsulam was applied after lime incorporation, and penoxsulam was applied before lime incorporation. At 35 g ai penoxsulam ha^{-1}, marestail control was 95, 98, and 85%, respectively, where no lime was applied, penoxsulam was applied after lime incorporation, and penoxsulam was applied before lime incorporation. Increasing the rate of penoxsulam to 35 g ai ha^{-1} increased herbicide efficacy when applied before amendment incorporation. Differences in efficacy between penoxsulam rates and timing of herbicide application in relation to incorporation were not as notable when gypsum was the amendment. Small flower mallow (*Malva parviflora*) responded to treatments in a manner similar to marestail. In contrast, grass control appeared to not be affected by penoxsulam application timing before or after amendment incorporation. The recommendation is that producers should apply penoxsulam after incorporation of soil amendments with rainfall or irrigation to achieve a desired level of weed control.

Penoxsulam Plus Oxyfluorfen - First Year Commerical Results in California Tree Nuts. Deb Shatley*[1], Barat Bisabri[2], James Mueller[3], Byron B. Sleugh[4], Jesse M. Richardson[5], Richard K. Mann[6], Fred Rehrman[7]; [1]Dow AgroSciences, Lincoln, CA, [2]Dow AgroSciences LLC, Orinda, CA, [3]Dow AgroSciences LLC, Brentwood, CA, [4]Dow AgroSciences, Clovis, CA, [5]Dow AgroSciences, Hesperia, CA, [6]Dow AgroSciences, Indianapolis, IN, [7]Elysian Fields, Woodland, CA (034)

Penoxsulam plus oxyfluorfen, marketed under the trade name of Pindar™GT, is a broad spectrum tree nut herbicide product launched in California during the fall of 2010. Pindar GT is a 4.04 lb ai/gallon SC (Suspension Concentrate) formulation premix containing 10 g of penoxsulam + 476 g of oxyfluorfen/liter**.** Pindar GT is a dual mode of action herbicide product that provides pre-emergence and post-emergence control of glyphosate resistant and susceptible horseweed (*Conyza canadensis*) and fleabane (*Conyza bonariensis*), as well as the control of many other winter annual weeds in almonds, walnuts, pistachios and pecans.

Pindar GT was applied to approximately 150,000 acres with a majority of applications made during the dormant period between October 2010 and mid-February 2011. Pindar GT was applied as a single entity at the rate of 3 pints (35 gai/ha penoxsulam+ 1680 gai/ha oxyfluorfen) per acre and in tank-mix combinations. Mix partners included post-emergent materials such as glyphosate, gramoxone or 2,4-D and residual grass products such as oryzalin or pendimethalin

The winter of 2010/2011 proved to be a significant test for the residual performance of Pindar GT as above normal rainfall amounts were recorded throughout the San Joaquin and Sacramento Valleys. Data sourced from the National Oceanic and Atmospheric Administration (NOAA) website indicate total water year amounts ranging from 159% in Bakersfield, 156% at Fresno and 125% of normal in Sacramento.

Visual observations were made in 12 grower treated orchards, located in 7 different counties in the major tree nut producing areas of California. The products applied and rates along with the application date were recorded. Observations were made and documented in a picture diary at 92 to 210 days after application to substantiate first year performance of Pindar GT. Pindar GT applied at 3 pints per acre provided excellent broad spectrum control of key weeds including glyphosate resistant horseweed (*Conyza canadensis*) and fleabane (*Conyza bonariensis*) for up to 6 months in California tree nut orchards.

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Isoxaben for Weed Control in Vineyards and Tree Crops. Richard K. Mann*[1], James Mueller[2], Deb Shatley[3], Barat Bisabri[4], Jesse M. Richardson[5]; [1]Dow AgroSciences, Indianapolis, IN, [2]Dow AgroSciences LLC, Brentwood, CA, [3]Dow AgroSciences, Lincoln, CA, [4]Dow AgroSciences LLC, Orinda, CA, [5]Dow AgroSciences, Hesperia, CA (035)

Isoxaben is registered for pre-emergence control of broadleaf weeds in bearing and non-bearing perennial tree and vine crops as TRELLIS™. TRELLIS can be used to control broadleaf weeds in 35 different species of non-bearing tree fruit, tree nut and grape crops. TRELLIS is now registered for pre-emergence control of weeds in 14 different bearing tree nut crops and grapes, including important crops such as almond, pecan, pistachio, walnut and grapes (American, European and muscadine).

For effective weed control, TRELLIS must be applied pre-emergence to the soil prior to susceptible broadleaf weed seed germination. TRELLIS does not control emerged weeds; any existing weeds must be controlled with cultivation or post-emergence herbicides.

TRELLIS mode of action (inhibition of cell wall (cellulose) synthesis; WSSA Group 21; HRAC Group L) and benzamide chemistry make it an important pre-emergence weed control product for broad-spectrum broadleaf weed control and an important tool to control and prevent the potential development of herbicide resistant broadleaf weeds. It is exceptionally broad-spectrum, providing extended pre-emergence control of at least 93 broadleaf weeds, including many hard to control species such as coast fiddleneck (*Amsinckia intermedia* Fisch. & C.A. Mey.), shepherds'-purse (*Capsella bursapastoris* (L.) Medik.), redmaids (*Calandrinia ciliata* (Ruiz & Pavón) DC.), filaree (*Erodium* spp.*)*, prickly lettuce (*Lactuca serriola* L.), mallow (*Malva* spp.), hyssop loosestrife(*Lythrum hyssopifolia* L.), annual sowthistle (*Sonchus oleraceus* L.), common chickweed (*media* (L.) Vill.) and panicle willowherb (*Epilobium brachycarpum* K. Presl). TRELLIS provides pre-emergence control of glyphosate-susceptible and tolerant horseweed (*Conyza canadensis*) and fleabane (*Conyza bonariensis*). Research trials conducted in 2004 through 2010 demonstrate that TRELLIS can provide three to six months of residual control of many susceptible broadleaf weeds, with excellent crop safety to trees and vines.

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A Multi-year Review of Weed Control in TNV Crops with Indaziflam. Hank J. Mager*[1], Darren Unland[2]; [1]Bayer CropScience, Fountain Hills, AZ, [2]Bayer CropScience, Research Triangle Park, NC (036)

Alion is a new preemergence herbicide containing the active ingredient indaziflam developed by Bayer CropScience for use in perennial tree nut, fruit, and vine crops. Trials have been conducted for several years by University, private, and Bayer CropScience researchers to determine the weed spectrum and length of weed control to relative standards. Alion has been shown to provide broad spectrum weed control for 6 months or longer in many cropping systems. Alion will provide residual preemergence control of monocot and dicot weeds with excellent crop safety when applied alone or in a tankmix with other herbicides such as glufosinate. Alion will be an effective tool to manage weed populations that are resistant to other modes of action including EPSP synthase inhibitors, ALS inhibitors, and PSII inhibitors.

Project 3. Weeds of Agronomic Crops

Pyroxsulam and Florasulam Injury to Pea, Lentil, and Chickpea. Joan Campbell*, Traci Rauch, Donn Thill; University of Idaho, Moscow, ID (037)

Pyroxsulam and florasulam were registered in 2009 for weed control in wheat with a legume crop rotational restriction of 9 months. In 2010, some lentil crops in northern Idaho showed evidence of pyroxsulam injury due to soil residual from application to a winter wheat crop in 2009. In response, pea, lentil, and chickpea tolerance to pyroxsulam and florasulam was investigated in two experiments at Moscow, ID. Pyroxsulam and florasulam use rates are 0.016 and 0.00438 lb ai/a, respectively. The two herbicides were applied at 1/2, 1/4, 1/16, 1/64, and 1/256 of the use rates to simulate carryover of herbicide from a prior wheat crop. Assuming a 30 day half-life, these rates would correspond to half-lives of 1, 2, 4, 6, and 8, respectively. Untreated plots were included for comparison. The herbicide was incorporated twice with a field cultivator after application. 'Aragorn' pea, 'Sierra' chickpea, and 'Pardina' lentil were seeded across the herbicide treatments 2 days after application. Crops were evaluated visually and harvested at maturity. In a second study, the effect of pyroxsulam and florasulam in combination was evaluated on pea, lentil, and chickpea at the same site. Herbicide application and planting methods were the same as the first experiment. Each herbicide was applied at 1/4 and 1/8 use rates plus untreated and every combination. Crops were harvested at maturity. In the first experiment, there was no statistical difference between pyroxsulam and florasulam. Averaged over herbicides, lentil yield was reduced with 1/4 and 1/2rates compared to the untreated, chickpea yields were reduced only at the 1/2 rate, and pea yield was not different from the untreated. To compare yield among the three crops, data was converted to percent of untreated. Lentil yield (80%) was lower than pea yield (105%). Chickpea yield (93%) was between pea and lentil, but it was not statistically different. In the combination study, pyroxsulam injury was greater than florasulam for both lentil and chickpea. At the zero rate of pyroxsulam, chickpea yield was not affected with florasulam at 1/8 or 1/4 rates and lentil yield was reduced at the 1/4 rate only. However, at the zero rate of florasulam, chickpea and lentil yields were reduced at both the 1/8 and 1/4 rates of pyroxsulam compared to the untreated. Pea yield was not different statistically from the untreated with any treatments. A third experiment compared florasulam and pyroxsulam soil residual at 1X, 2X and 4X use rates to sulfosulfuron and mesosulfuron at 1X and 2X use rates. Herbicides were applied to winter wheat in November and wheat was killed with glyphosate in April to simulate winter kill. Lentil was planted in May and visible injury and seed yield was compared among treatments. Lentil chlorosis, necrosis, stunting, and stand reduction (injury) was greatest at 5 WAP (weeks after planting). Lentil injury increased with herbicide rate (except with mesosulfuron) and decreased with time across all treatments. At all visual evaluations dates, spring lentil was injured by pyroxsulam (22 to 90%). Sulfosulfuron injured lentils 18 to 56% at the 1X rate and 41 to 78% at the 2X rate. At 5 WAP, all florasulam rates injured lentil 52 to 78% but by 8 WAP lentil injury was below 15% for the 1X and 2X rates. Mesosulfuron did not injury lentil. Lentil seed yield was reduced 25 to 60% by sulfosulfuron, florasulam, and the two highest rates of pyroxsulam compared to the untreated check.

Field Pea Competitive Abilities for Weed Suppression in Organic Agriculture. Aman Anand*[1], Greta G. Gramig[2], Kevin McPhee[3]; [1]North Dakota State University, Bozeman, ND, [2]North Dakota State University, Fargo, ND, [3]NDSU, Fargo, ND (038)

A field experiment was conducted during summer 2011 at the Dickinson Extension Research Center, ND, to evaluate competitive abilities of field pea culitvars against endemic weed pressure in an organic cropping system. Four strategically-chosen field pea cultivars/lines (Cooper, NDP080102, NDP080106, PS07100091) and crop-free weedy checks were established in a randomized complete block design with four replications. Three permanent 0.25 m^2 quadrats were established in each 4.5 by 3.5 m plot for destructive data collection. Using a ceptometer, leaf area index (LAI) measurements were made at three critical pea growth stages to quantify pea and weed canopy development. Total canopy LAI was measured, then peas were removed from the quadrats and LAI was measured again, allowing for separation of weed vs. pea LAI and biomass. The weed suppressive ability (S_{var}) of each cultivar was determined as percentage reduction in weed growth associated with each cultivar compared to maximal weed growth in the weedy check. S_{var} was regressed over time against associated weed LAI values to calculate the sensitivity of S_{var} to weed LAI for each cultivar. S_{var} varied with pea growth stage, but not among cultivars. S_{var} measured during the first sampling period was greater than S_{var} measured during the other two sampling periods. Tested via ANOVA, per plant yield of PS07100091 was greater than Cooper, even though the weed biomass in PS0710091 plots was equal to the weedy check biomass. Result suggests that weed tolerance may be more important to competitive outcomes among culitvars than weed suppressive ability.

Dry Bean Response to Fluthiacet-methyl. Jared C. Unverzagt*[1], Andrew R. Kniss[1], Ryan Rapp[2], Robert G. Wilson[3], Shiv D. Sharma[4]; [1]University of Wyoming, Laramie, WY, [2]University of Nebraska, Concord, NE, [3]University of Nebraska-Lincoln, Scottsbluff, NE, [4]FMC Corporation, Philadelphia, PA (039)

Field studies were conducted in 2010 and 2011 to evaluate the response of Great northern ('Orion') and pinto ('Othello') bean to fluthiacet-methyl as affected by adjuvant system. Herbicide treatments included fluthiacet-methyl at 0, 4, 5.6, 7.2, 11.2, and 22.4 g ai ha^{-1}, as well as a hand weeded check and a comparison POST herbicide combination of bentazon + imazamox at 560 and 35 g ai ha^{-1}, respectively. Fluthiacet-methyl was applied with either nonionic surfactant (NIS) or crop oil concentrate (COC) in 2010, and NIS or methylated seed oil (MSO) in 2011. Dry bean injury was evaluated 2, and 30 DAT. Plots were harvested on Sep 15th, 2010 and Sep 27th, 2011. The effects of fluthiacet-methyl rate, bean market class, and adjuvant type were analyzed with ANOVA, then nonlinear regression was used to investigate significant effects. A fluthiacet-methyl dose by adjuvant interaction was observed. In 2010, fluthiacet-methyl at 5.6 g ai ha^{-1} applied with COC caused 39 to 40% injury, compared with 17 to 18% injury when applied with NIS 2 DAT. Injury decreased by 29 DAT with 8% and 6 to 8% injury for COC and NIS respectively. The same fluthiacet-methyl rate in 2011 caused 31% and 31 to 39% injury 2 DAT for MSO and NIS, respectively, but no injury was observed by 30 DAT for either adjuvant. All dry bean treatments recovered from injury by harvest, and no yield differences were observed among treatments. Fluthiacet-methyl may be a viable POST herbicide option for dry bean.

Eco-Efficiency as a Tool to Compare Herbicide-Resistant and Conventional Cropping Systems. Andrew R. Kniss, Carl W. Coburn*; University of Wyoming, Laramie, WY (040)

Conventional and herbicide-resistant cropping systems utilize different inputs to obtain similar outputs. The term eco-efficiency was developed to describe the environmental impact of a production system. This concept has previously been used to measure cropping systems, but not to compare them. Eco-efficiency analysis can be used to compare the environmental impact of cropping systems by determining the ratio of crop yield to the environmental impact of inputs. Inputs that may differ between herbicide-resistant and conventional crops include tillage, pesticides, fertilizers, and irrigation. The eco-efficiency concept differs from many previous comparisons of herbicide-resistant and conventional crops because it incorporates the productivity of the system in combination with the environmental impact. A measure of the environmental impact of pesticide use can be obtained by combining the rate applied with an ecological impact quotient. Tillage operations are quantified by the energy required, represented primarily by fuel usage. The nitrogen fertilizer rate is used to quantify fertilizer use impact. The ratio of yield to input for each input category can be combined to determine the eco-efficiency of a cropping system. Greater eco-efficiency values indicate less environmental impact.

Effect of Flaming and Cultivation on Weed Control and Yield in Sunflower. Robert K. Higgins*[1], Brian D. Neilson[2], Strahinja V. Stepanovic[3], Avishek Datta[3], Chris A. Bruening[2], George Gogos[2], Stevan Knezevic[4], Drew Lyon[5]; [1]University of Nebraska-Lincoln, Sidney, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, Concord, NE, [4]University of Nebraska, Concord, NE, [5]University of Nebraska-Lincoln, Scottsbluff, NE (041)

Previous studies of propane flaming and mechanical cultivation have demonstrated potential for weed control in corn and soybean. Therefore, the objective of this study was to evaluate the effectiveness of cultivation alone, flaming alone, and various combinations of cultivation and flaming for weed control in sunflower. Field studies were conducted in 2010 at the Haskell Agricultural Laboratory, University of Nebraska-Lincoln, Concord, NE and the High Plains Agricultural Laboratory, University of Nebraska-Lincoln, Sidney, NE. The broadcast flamer and flamer-cultivator (designed to conduct banded flaming) were developed by UNL scientists. The weed control treatments included: weed-free control, weedy season-long control, and combinations of banded flaming (intra-row), broadcast flaming (inter- and intra-row), and mechanical cultivation (inter-row). Each weed control treatment was applied one or two times based on the VC (cotyledons emerged but not yet fully open), V4-V6 and V10-V12 growth stages of sunflower. Propane doses were 20 and 45 kg/ha for the banded and broadcast flaming treatments, respectively. Weed control and crop injury were evaluated visually at 1, 7, 14, and 28 days after treatment (DAT). Yield was evaluated at harvest. At Concord, the best weed control (75%) and highest yield (1.6 t/ha) were obtained from plots broadcast flamed at VC and V10-V12. Sunflower cultivated once at the V4-V6 had lower weed control (42%) and yield (1.3 t/ha), whereas broadcast flaming conducted once at V4-V6 had the lowest weed control level (12%) and the lowest yield (0.9 t/ha), suggesting that a single weed control operation does not provide sufficient weed control. At Sidney, the greatest weed control (85%), least crop injury 28 DAT (9%), and highest yield (0.86 t/ha) were obtained from plots receiving inter-row tillage and intra-row flaming at V4-V6 and V10-V12. Flaming, with or without inter-row mechanical cultivation can provide acceptable weed control in sunflower without significant crop injury and with minimal yield loss, when conducted twice. Additional work will be conducted at both locations to better define the optimum time and method of weed control in sunflower with flaming and/or mechanical tillage.

Clearfield Sunflower Tolerance to Pyroxasulfone. Justin Mack*[1], Rich Zollinger[1], Brian M. Jenks[2], Phillip W. Stahlman[3], Siyuan Tan[4], Leo Charvat[5], Scott Fitterer[6]; [1]North Dakota State University, Fargo, ND, [2]North Dakota State University, Minot, ND, [3]Kansas State University, Hays, KS, [4]BASF Corporation, Research Triangle Park, NC, [5]BASF Corporation, Lincoln, NE, [6]BASF Corporation, Fargo, ND (042)

Herbicide options for use in sunflower (Helianthus annuus) are limited, especially for control of herbicide-resistant weeds. Pyroxasulfone has displayed excellent control and longer residual of target weeds, including resistant types, than currently labeled products in sunflower. Field trials were conducted in North Dakota and Kansas, in 2011, to determine tolerance levels of imazamox-resistant sunflower to pyroxasulfone. These studies were conducted with higher pyroxasulfone rates than will be labeled to establish tolerances for residue studies. Pre-emergence (PRE) and post-emergence (POST) applications were made at 100, 200, and 400 g ai/ha with and without imazamox at 35 g ai/ha. No visual sunflower injury was observed with any rate applied PRE. Crop phytotoxicity was detected following POST applications, injury included leaf deformity, necrosis, and chlorosis. Crop injury was rate dependent with the most phytotoxicity occurring when the 400 g ai/ha rate of pyroxasulfone PRE was followed by the 400 g ai/ha rate of pyroxasulfone POST tank mixed with imazamox at 35 g ae/ha. The injury observed from this treatment ranged from 20 to 35% in Fargo, ND and from 35 to 40% in Buffalo, ND. Injury was limited to leaves present at application and did not affect new growth.

Plant population, late season plant height, yield, and oil content were not affected at these locations.

Rotational Comparisons of Mesosulfuron and Pyroxsulam With and Without Pyrasulfotole Plus Bromoxynil in Eastern Washington. Monte D. Anderson*; Bayer CropScience, Spangle, WA (043)

In 2010 some commercial fields of lentil, chickpea, and pea were suspected to have carryover from herbicide use in the previous year's winter wheat in eastern Washington, northern Idaho, and northeastern Oregon. These fields had a common appearance of stunted and yellowed plants. Many of these fields had been treated with a combination of pyrasulfotole plus bromoxynil in addition to other broadleaf and grass herbicides. Previous work over many years had indicated that mesosulfuron or pyrasulfotole plus bromoxynil alone did not exhibit carryover to pulse crops in this area of the country, in part due to typically low soil pH. This research evaluated the carryover response to various plantback crops approximately one year after mesosulfuron and pyroxsulam were applied alone or in combination with pyrasulfotole plus bromoxynil in winter wheat. Trials were conducted during the 2009/2010 and 2010/2011 seasons with these combinations at plot sites having soil pH ranging from 5.2 to 5.5 in eastern Washington. All treatments were applied at twice the labeled rates to insure a margin of plantback safety identical to previous rotational studies. Results confirmed previous findings for mesosulfuron and pyrasulfotole plus bromoxynil alone, and also indicated that tank mixing of these herbicides did not exhibit carryover to lentil, chickpea, or pea. Both studies indicated substantial plantback response from pyroxsulam to lentil and to a lesser degree to chickpea. The addition of pyrasulfotole plus bromoxynil to pyroxsulam did not significantly increase this response. Rotational sensitivity observed in these studies as well as 2010 commercial fields was concluded to be from pyroxsulam. Pyroxsulam plantback to pulse crops has been adjusted from its original 9-month interval in 2009 to its current 18-month interval where the soil pH is less than 6.

Feral Rye Control with Imazamox Plus Growth Regulator Herbicides. Louise Lorent*[1], Ryan Rapp[2], Jared C. Unverzagt[1], Andrew R. Kniss[1]; [1]University of Wyoming, Laramie, WY, [2]University of Nebraska, Concord, NE (044)

Previous field and greenhouse research demonstrated that MCPA ester enhanced imazamox efficacy on feral rye. A greenhouse study was conducted to investigate whether other synthetic auxin herbicides also synergize imazamox for feral rye control. Rye plants were seeded in the greenhouse and sprayed with imazamox at five rates ranging from 4 to 70 g ai ha^{-1} alone or in mixture with 2,4-D ester, 2,4-D amine, MCPA ester, MCPA amine, dicamba, and fluroxypyr. The experiment was a factorial randomized complete block with seven replicates per treatment, and was repeated once. Synthetic auxin herbicides were applied at the recommended field use rate for broadleaf weed control in wheat. Rye was sprayed when it had two to three leaves. Mortality of each rye plant was evaluated 21 days after treatment, and analyzed with nonlinear regression appropriate for a binomial response. MCPA-ester and 2,4-D ester applied at 560 g ai ha^{-1} decreased the rate of imazamox required to cause 50% mortality (LD_{50}) by >70% compared with imazamox alone. MCPA amine and 2,4-D amine at the same rate did not result in a similar increase in imazamox activity. Dicamba and fluroxopyr caused similar effects as 2,4-D amine and MCPA-amine. These results indicate that while ester formulations of phenoxy-carboxylicacid hericides synergize imazamox for feral rye control, a similar synergistic effect was not observed with the amine formulations or with other synthetic auxin herbicides. Further study is needed to elucidate the role of esters in imazamox efficacy.

Analyzing Terrain Attribute Effects on Italian Ryegrass Presence using Zero Inflated Poisson and Poisson GLM Models. Rachel Unger*[1], Mark E. Swanson[1], Ian C. Burke[1], David R. Huggins[2], Eric R. Gallandt[3], Stewart Higgins[1]; [1]Washington State University, Pullman, WA, [2]USDA-ARS, Pullman, WA, [3]University of Maine, Orono, ME (045)

Understanding how terrain influences the presence of weed species, in particular Italian ryegrass (*Lolium multiflorum*), may help identify field-related factors that contribute to increased or decreased weed pressure. Italian ryegrass is a common and troublesome weed species in the inland Pacific Northwest. A terrain attribute study was conducted on a 37 ha field of the Cook Agronomy Farm near Pullman, WA. A specific objective of the study was to understand how terrain attributes affect the presence of Italian ryegrass. Soil cores were taken in 2010 from 369 geo-referenced locations across the farm. Samples were exhaustively germinated and germination was recorded weekly by species over the course of the study. Every four weeks samples were re-randomized on the greenhouse benches. Topographic variables and cropping systems were assessed as predictors of viable Italian ryegrass seed levels within the seed bank. Topographic variables were calculated from a 2 m-resolution Digital Elevation Model (DEM). The data were analyzed using Poisson generalized linear model (GLM) and zero-inflated Poisson regression model. In order to analyze all of the terrain attributes using zero-inflated Poisson regression, a bootstrapping technique was implemented due to the low number of degrees of freedom. Global irradiation, slope, and elevation were all negatively correlated with Italian ryegrass. Transformed aspect and wetness index were positively correlated.

Effects of Planting Density and Weed Pressure on Grain Quality in Eastern Washington. Misha R. Manuchehri*, E. P. Fuerst, Ian C. Burke; Washington State University, Pullman, WA (046)

Weed control in grain production in Eastern Washington presents many challenges. Spring crops, in particular, are weak competitors against weeds. The practice of increasing seeding rate is a common cultural weed management option for growers; however, there is concern that increased planting densities may reduce grain quality. In an effort to understand the effects of seeding rate and oat (*Avena sativa*) density on yield and grain quality, organic spring crop trials were established near Pullman, WA in May of 2010 and 2011. Grain weight, test weight, moisture content, diameter, and hardness characteristics were evaluated for both wheat and barley. Additionally, protein content was assessed for wheat. The experiment was a split-split plot design with four replications. Main plots included spring plantings of barley and wheat at two different seeding rates (a recommended and a doubled rate) and subplots were two oat density treatments (22 kg ha^{-1} and 88 kg ha^{-1}) and a weed free control. Barley and wheat yields increased when seeding rates were doubled regardless of oat density treatment. Grain weight, diameter, and hardness values were lower in 2010 than in 2011 for both crops. All grain characteristics that were analyzed were not affected by oat density or seeding rate, suggesting that increasing seeding rates may be a practical weed management strategy for growers to implement.

Broadleaf Herbicide Tolerance in *Brassica carinata*. Eric N. Johnson*; Agriculture and Agri-Food Canada, Scott, SK (047)

Ethiopian mustard (*Brassica carinata* L.) is being developed as an industrial oilseed crop for the southern part of the Canadian Prairies and their bordering US states (Montana, North and South Dakota). Ethiopian mustard is 7 to 10 days later maturing than *Brassica napus* canola but has desirable agronomic characteristics such as heat and drought resistance. In order to become a successful crop, weed control solutions are required. In 2010, screening studies were conducted at Scott and Saskatoon, SK to evaluate tolerance to ethametsulfuron (15 and 30 g ai ha^{-1}), quniclorac (100 and 200 g ai ha^{-1}), clopyralid (150 and 300 g ai ha^{-1}), and dicamba (70, 140, and 280 g ai ha^{-1}). At both sites, Brassica carinata exhibited acceptable visual tolerance to both rates of ethametsulfuron, quinclorac, clopyralid, and the lowest rate of dicamba. Higher rates of dicamba resulted in unacceptable visual injury. At Scott, the 2X rates of quinclorac and clopyralid and dicamba rates $\geq$ 140 g ai ha^{-1} resulted in significantly lower seed yields than the untreated check. At Saskatoon, none of the treatments resulted in a significant yield reduction. Further screening studies were conducted in 2011 at Scott, Saskatoon, Osler, Swift Current, SK and Lethbridge and Duchess, AB. Treatments included ethametsulfuron (15 and 30 g ai ha^{-1}), dicamba (50 and 100 g ai ha^{-1}), and clopyralid (100 and 200 g ai ha^{-1}). Ethametsulfuron tolerance was acceptable at all locations with no statistical yield reductions. Dicamba tolerance was acceptable at the 50 g ai ha^{-1} rate and yields were not reduced. Yield reductions of 21 to 23% occurred at 2 of the sites when the 100 g ai ha^{-1} rate of dicamba was applied. Tolerance to clopyralid was acceptable at 100 g ai ha^{-1} with no statistical yield reduction. Two of the sites had a 20% yield reduction when 200 g ai ha^{-1} clopyralid was applied. Minor use submissions for ethametsulfuron and clopyralid have been made to the Pest Management Regulatory Agency. Dicamba may be considered in the future, particularly for problematic weeds like dicamba.

Kochia in Western Kansas: Prevalence, Post-Wheat Harvest Management, and Glyphosate Resistance. Amar S. Godar*[1], Phillip W. Stahlman[2], Johanna A. Dille[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS (048)

In the years following the confirmation of four glyphosate-resistant kochia (*Kochia scoparia*) populations in western Kansas in 2007, proliferation of the problem was suspected as complaints of poor control of kochia throughout the western Kansas increased yearly. We conducted a visual survey to determine the level of kochia infestation and evaluate kochia control effectiveness in nearly 1,600 wheat stubble fields in the western half of Kansas in 2011. By the first week of August, 49% of wheat stubble fields had been sprayed with herbicides and 30% of the fields had been tilled. Nothing had been done to manage weeds post-harvest in 21% of the fields. A high proportion of the non-controlled fields had been sprayed with herbicide by the end of August, whereas the proportion of the tilled fields remained nearly the same. Of the sprayed fields, 4% were heavily infested, 52% were moderately infested, and 44% were lightly infested with kochia. Control of kochia in 1, 28, and 71% of infested fields was rated poor, fair, and good or excellent, respectively. A shikimate accumulation assay to determine resistance to glyphosate was performed on excised leaf discs of four kochia plants from each of 44 randomly sampled fields. Glyphosate-resistant individuals were detected in more than half of the sites in a frequency ranging from one-fourth to all of the plants tested. Sites with glyphosate-resistant kochia were widely distributed throughout approximately the western one-third of Kansas. This study shows pervasiveness of kochia in western Kansas with high presence of glyphosate resistance.

Dynamic of Sugarcane Herbicides Applied on the Crop Residue Influenced by Drought Conditions. Ana B. Prado*, Caio A. Brunharo, Marcel S. Melo, Flávio E. Obara, Marcelo Nicolai, Pedro J. Christoffoleti; ESALQ/USP, Piracicaba, Brazil (049)

The dynamic of herbicides applied on the crop residue left on the soil surface of sugarcane areas harvested mechanically without burning is not very well known in Brazil. Therefore, it was developed this study to evaluate the dynamic of six herbicides applied on sugarcane straw after crop harvest, at different interval times of drought conditions after application. The trial was set in field conditions and had eight treatments: control with straw, control without straw, sulfentrazone, imazapic, tebuthiuron, amicarbazone, clomazone and isoxaflutole, under two of drought conditions after application, four replications. At 10, 20 and 30 days after herbicide application it was collected one soil sample per plot, that was set for a bioassay in the greenhouse. Pots were seeded with cucumber (*Cucumbus sativus*) and oat (*Avena strigosa*), considered sensitive plants to all herbicides studied, being evaluated the plant injury at 7, 14, 21 and 28 days after seeding. Data were submitted to ANOVA and followed by the Tukey test (5%). It was concluded that tebuthiuron was the herbicide that gave highest injury symptoms to the test plant, therefore this herbicide was able to stand drought condition and transposed the mulch after long periods of drought conditions after application.

Volunteer Plant of Green Manure Control in Sugarcane. Caio A. Brunharo*[1], Scott J. Nissen[2], Marcelo Nicolai[1], Luiz F. Campos[1], Marcel S. Melo[1], Ana B. Prado[1], Pedro J. Christoffoleti[1]; [1]ESALQ/USP, Piracicaba, Brazil, [2]Colorado State University, Fort Collins, CO (050)

Green manures can provide an efficient tool to improve the physical, chemical and biological properties of soils degraded by long term sugarcane production. The cultivation of certain green manure species can be problematic when green manure species are not adequately managed. And end up competing directly with sugarcane when production resumes. A viable alternative would be to chemically manage these green manure species; however, there is no published literature dealing with this issue. An experiment was conducted in a greenhouse at University of São Paulo, Piracicaba, São Paulo, Brazil, from September to November 2011. Six herbicides were evaluated at two rates for the control of five different plants commonly used as green manure. The treatments were: control; sulfentrazone (500 and 700 gm/ha); isoxaflutole (57 and 86 gm/ha); tebuthiuron (600 and 900 gm/ka); clomazone (820 and 1148 gm/ha); ametrine (1000 and 1500 gm/ha); and S-metolachlor (1600 and 2400 gm/ha). The species of green manure used were: *Canavalia ensiformis, Mucuna cinereum, Dolichos lablab, Crotalaria juncea, Crotalaria spectabilis*. For *Crotalaria spectabilis* and *Crotalaria juncea*, only the S-metolachlor treatments did not provide satisfactory control. Ametrine (1000 gm/ha), S-metolachlor (1600 and 2400 gm/ha), provided less than 80% *Dolichos lablab* control. *Mucuna cinereum* was not adequately controlled with the low rate of isoxaflutole or either rate of ametrine. Finally, *Canavalia ensiformis* was satisfactorily controlled with both rates of isoxaflutole, tebuthiuron, and clomazone.

Sourgrass Resistance to Glyphosate in Soybean Crop in Brasil. Fernando S. Adegas*[1], Scott J. Nissen[2], Philip Westra[3]; [1]Embrapa, Londrina, Brazil, [2]Colorado State University, Fort Collins, CO, [3]Colorado State University, Ft. Collins, CO (051)

Soybean is the main agricultural crop in Brazil, with 23.9 million hectares grown last season (2010/11). One of the most important problems in this crop is the weed control, especially after the release of the planting of soybeans resistant to glyphosate in 2005, because of the appearance of cases of weed resistant to this herbicide. One of them is sourgrass (*Digitaria insularis)* that is a perennial and an aggressive weed that infests many crops in Brazil. The normal control of sourgrass is difficult. Currently, with the resistant populations are being even more difficult. So, to manage correctly this weed it will be necessary to know if the populations are resistant to glyphosate, which was the objective of this research. Young plants of the three biotypes of sourgrass suspected of being glyphosate-resistant, and another one susceptible, that were collected in different soybeans crops in Brazil were sprayed with ten rates of glyphosate (between 0 to 17,280 g ae/ha) to dose-response assay. After that (24 hs) leaf-discs were collected in all treatments to verify the level of shikimic acid using an in vivo shikimate accumulation assay. The average ratio between the suspected and susceptible biotypes (R/S_{50} coefficient) was 4,6 for visual control; 3.94 for fresh weight; 3.39 for dry weight; 7.07 for fresh regrowth weight; 2,77 for dry regrowth weight, and 10.58 for new tillers. In addition, the shikimate accumulation was greater in susceptible than the suspected biotypes. These results confirmed the glyphosate resistance to the three suspected biotypes.

Glyphosate-resistant Kochia Control in Failed Winter Wheat. David Brachtenbach*[1], Phillip W. Stahlman[2]; [1]Colorado State University, Ft. Collins, CO, [2]Kansas State University, Hays, KS (052)

A field study was conducted in western Kansas in 2011 to evaluate the effectiveness of several POST-applied herbicide treatments for control of kochia (*Kochia scoparia*) that had survived an early spring application of glyphosate and 2,4-D. All treatments in the study included dry ammonium sulfate at 2% w/v (2 kg/100 L). Glyphosate plus dicamba at 1,260 + 560 g/ha plus 0.5% v/v non-ionic surfactant (NIS) controlled kochia less than 50% at 21 DAT, indicating low level glyphosate resistance in the population. At 7 DAT, only saflufenacil at 25 g/ha with 1% v/v methylated seed oil (MSO) mixed with 840 g/ha linuron, 280 g/ha atrazine, or 840 g/ha paraquat, and a mixture of paraquat + linuron + metribuzin at 840 + 840 + 630 g/ha plus 0.5% v/v NIS controlled kochia by as much as 90%. Control with the paraquat + linuron + metribuzin treatment increased to 95% at 14 and 21 DAT, whereas the saflufenacil-based treatments decreased each of those times. Paraquat + linuron + NIS and paraquat + glyphosate + dicamba + NIS provided 80-85% kochia control for the duration of the trial. Tembitrione at 92 g/ha + 1% v/v MSO mixed with 357 g/ha fluroxypyr & bromoxynil , 560 g/ha dicamba, or dicamba and metribuzin at 560 + 630 g/ha was slow performing but control increased to >80% at 21 DAT. Topramezone at 25 g/ha plus 280 g/ha atrazine and 1% v/v MSO or 1260 g/ha glyphosate and 1% v/v MSO were marginally effective at 74 and 65%, respectively, at 21 DAT.

Control of Rattail Fescue in Winter Wheat. Nevin Lawrence*, Ian C. Burke; Washington State University, Pullman, WA (053)

Rattail fescue (*Vulpia myuros*) is a problematic weed for small grain producers in the Pacific Northwest. Trials were conducted in 2010 and 2011 at the Palouse Conservation Field Station near Pullman, WA to evaluate control of rattail fescue in winter wheat utilizing postemergence herbicides and application timings. Fall applications consisted of a prepackaged mixture of flufenacet (304 g ai ha-1) and metribuzin (76 g ai ha-1). Early spring and late spring applications consisted of pyroxsulam (18.4 g ai ha-1); mesosulfuron-methyl (15 g ai ha-1); or a prepackaged mixture of florasulam (1.8 g ae ha-1), fluroxypyr (105 g ae ha-1), and pyroxsulam (11 g ae ha-1). Additionally, sequential treatments that included a prepackaged mixture of flufenacet and metribuzin applied post-plant preemergence followed by a late spring application of pyroxsulam, mesosulfuron-methyl; or a prepackaged mixture of florasulam, fluroxypyr, and pyroxsulam. All non-sequential early and late spring applications included were applied with and without ammonium sulfate (1,700 g ha-1). Visual assessment of rattail fescue control, rattail fescue biomass collected prior to grain harvest, and grain yield were used to evaluate treatment efficacy. In 2010, treatments that received a fall herbicide application controlled between 75% and 92% of rattail fescue, while treatments that did not receive a fall application only controlled between 13% and 38% of rattail fescue. Rattail fescue biomass collected prior to grain harvest was less in treatments receiving a fall herbicide application compared with control. However, rattail fescue biomass in treatments receiving a fall application were not different than early spring applications of pyroxsulam or mesosulfuron-methyl with ammonium sulfate. Grain yield in 2010 was higher in treatments receiving sequential herbicide applications than in control treatments. In 2011, similar relationships were observed in regards to visual assessment of rattail fescue control, biomass, and grain yield however treatments were not statistically different in 2011 and therefore results could not be averaged over year.

Rattail Fescue Control in Winter Wheat. Traci Rauch*, Joan Campbell, Donn Thill; University of Idaho, Moscow, ID (054)

Rattail fescue is a winter annual grass that is found in direct-seed cereal production systems in the Pacific Northwest. Rattail fescue can be controlled by tillage; however, populations are expanding with the increased use of low disturbance farming systems. Few herbicides are specifically registered for rattail fescue control, and no postemergence herbicide consistently controls rattail fescue in winter wheat. Rattail fescue control and winter wheat response was determined in four studies established in Idaho between 2009 and 2011. The experimental design in all studies was a randomized complete block. Herbicides were applied preemergence in the fall and/or early postemergence in the spring. Rattail fescue control and wheat response were evaluated visually where 0% represented no control or injury and 100% represented complete weed control or crop death. In most studies, wheat injury ranged from 0 to 6%. Generally, all treatments containing flufenacet/metribuzin applied preemergence controlled rattail fescue 90 to 99%. Likewise, pyroxasulfone applied preemergence controlled rattail fescue 92 to 96%. Rattail fescue control usually was poor when postemergence treatments were applied without flufenacet/metribuzin or pyroxasulfone. The best postemergence treatments included sulfosulfuron, flucarbazone applied post or as a split application (preemergence and postemergence), and pyroxsulam (70 to 86%).

Comparison of Fluroxypyr Herbicide Combinations for Broadleaf Weed Control in Spring Wheat. Vipan Kumar*[1], Prashant Jha[2], Nicholas Reichard[2]; [1]Student, Huntley, MT, [2]Montana State University, Huntley, MT (055)

Weed management is a challenge in Montana cereal production systems, especially due to the presence of herbicide-resistant weed species including kochia, Russian thistle, and prickly lettuce. Use of tank-mix herbicide products with more than one mode of action is recommended to improve weed control and to reduce selection pressure for resistance development in weed biotypes. In the same context, a field experiment was initiated at the Montana State University Southern Agricultural Research Center, Huntley, MT, in 2011, to compare fluroxypyr herbicide combinations for broadleaf weed control in spring wheat. The experiment was conducted in a randomized complete block design with 4 replications. Spring wheat variety 'Vida' was planted on April 20, 2011, under dryland conditions. Herbicides were applied with a handheld boom calibrated to deliver 94 L ha^{-1} at 276 kPa. Broadleaf weeds present at the test site were kochia (*Kochia scoparia* L.) and prickly lettuce (*Lactuca serriola* L.). Weeds were 8-10 cm in height at the time of application. Weed control was visually estimated on a scale of 0 to 100 (0 being no control and 100 being complete control) at 15 days interval after herbicide application, and wheat yields were recorded at harvest. All data were subjected to ANOVA and means were separated using Fisher's Protected LSD test at $\alpha = 0.05$. Kochia control with bromoxynil + pyrasulfotole (0.200 kg/ha), fluroxypyr + florasulam (0.185 kg/ha) plus 2, 4-D (0.288 kg/ha) or MCPA ester (0.397 kg/ha), and fluroxypyr + thifensulfuron-methyl + tribenuron-methyl (0.147 kg/ha) plus 2, 4-D (0.288 kg/ha) or MCPA (0.775 kg/ha) was superior among all treatments, with an average of 95% control 30 DAA. Clopyralid + fluroxypyr (0.216 kg/ha) plus MCPA ester, fluroxypyr + florasulam (0.185 kg/ha), fluroxypyr + thifensulfuron-methyl + tribenuron-methyl (0.147 kg/ha) plus MCPA ester (0.775 kg/ha), and *thifensulfuron methyl + tribenuron methyl (0.0213 kg/ha) plus MCPA ester (0.597 kg/ha) provided > 85% control of kochia 30 DAA. In contrast, f*luroxypyr + thifensulfuron-methyl + tribenuron-methyl, florasulam + MCPA (0.071 kg/ha) plus penoxaden + fluroxypyr (0.168 kg/ha), and p*yroxsulam* + fluroxypyr + *florasulam (0.118 kg/ha) provided < 75% control of kochia. For prickly lettuce, control with* clopyralid + fluroxypyr plus MCPA ester was 100% at 30 DAA, and was superior to all other treatments, except fluroxypyr + thifensulfuron-methyl + tribenuron-methyl plus MCPA ester or 2, 4-D. Prickly lettuce control with bromoxynil + pyrasulfotole, fluroxypyr + thifensulfuron-methyl + tribenuron-methyl, fluroxypyr + florasulam plus MCPA ester or 2,4-D, and florasulam + MCPA ester plus penoxaden + fluroxypyr ranged from 82 to 87%. Pyroxsulam + fluroxypyr + florasulam provided 61% control of prickly lettuce, whereas, thifensulfuron methyl + tribenuron methyl plus MCPA ester provided < 10% control, which was least among all treatments. No differences in grain yields were observed with any of the fluroxypyr treatments. In conclusion, except pyroxsulam + fluroxypyr + florasulam combination, all fluroxypyr combinations provided adequate control of kochia and prickly lettuce in spring wheat. Addition of 2,4-D or MCPA could potentially improve weed control efficacy of fluroxypyr-based products in spring wheat.

Florasulam Plus Fluroxypyr for Broadleaf Weed Control in Cereals. Joseph P. Yenish*[1], Harvey Yoshida[2], Roger E. Gast[3], Kevin D. Johnson[4]; [1]Dow AgroSciences, Billings, MT, [2]Dow AgroSciences, Richland, WA, [3]Dow AgroSciences, Indianapolis, IN, [4]Dow AgroSciences, Barnesville, MN (056)

Starane® Flex by Dow AgroSciences, is a suspo-emulsion liquid containing a 20:1 ratio of fluroxypyr-meptyl (ae) and florasulam (ai). Starane Flex is labeled at a product rate of 987 mL per hectare which delivers 5 g ai and 100 g ae/ha of florasulam and fluroxypyr, respectively. As of 2012, Starane Flex is labeled for broadleaf weed control in wheat (including durum), barley, oats, rye, and triticale. The combination of florasulam (Group 2) plus fluroxypyr (Group 4) provides broad spectrum broadleaf weed control, rotational flexibility, and resistance management. Multi-year studies were conducted in the U.S. from 2008 through the 2011 growing seasons to evaluate Starane Flex for postemergence broadleaf weed control in wheat and barley. Starane Flex applied over a number of locations and years provided excellent control of kochia (*Kochia scoparia)*, wild buckwheat (*Polygonum convolvulus)*, wild mustard (*Sinapis arvensis*), prickly lettuce (*Lactuca serriola)*, catchweed bedstraw (*Galium aparine*), redroot pigweed (*Amaranthus retroflexus*), volunteer sunflower (*Helianthus annuus*), and Russian thistle (*Salsola iberica*). Moreover, crop safety was excellent when applied from the 3-leaf growth stage up to flag leaf emergence. Starane Flex will provide excellent broadleaf control though two modes of action while allowing greater rotational flexibility. Additionally, the product can be tank mixed with the most common grass herbicides used in wheat or barley.

Weed Control in Sunflower with Premixed S-Metolachlor and Sulfentrazone. Seshadri S. Reddy*[1], Phillip W. Stahlman[2]; [1]Kansas State university, Hays, KS, [2]Kansas State University, Hays, KS (057)

A study was conducted at Hays and Colby, KS in 2011 to evaluate the efficacy of premixed *S*-metolachlor & sulfentrazone (9:1 ratio, F7583-1) at four rates compared to single rates of *S*-metolachlor, pendimethalin, and premixed sulfentrazone & carfentrazone-ethyl applied 21 days preplant versus preemergence for weed control and crop tolerance in sunflower. Palmer amaranth (*Amaranthus palmeri* S. Wats.) was the predominate weed species at Hays and kochia [*Kochia scoparia* (L.) Schrad.] and puncturevine (*Tribulus terrestris* L.) were predominate weeds at Colby. Preplant-applied F7583-1 at 860 g ai/ha controlled Palmer amaranth 96% at 28 days after planting (DAP) and 85% at 96 DAP. Higher rates of F7583-1 (1100 to 1840 g/ha) controlled Palmer amaranth 99-100% at 28 DAP and maintained season long control of ≥94%. Preplant-applied sulfentrazone & carfentrazone-ethyl (138 g/ha) followed by clethodim (105 g/ha) + methylated seed oil (MSO) POST for annual grasses controlled Palmer amaranth 97% throughout the season. Regardless of rate, F7583-1 PRE controlled Palmer amaranth 99-100% at 28 DAP and 94-100% at 96 DAP in response to increased rate. Sulfentrazone & carfentrazone-ethyl followed by clethodim + MSO POST and F7583-1 controlled Palmer amaranth similarly throughout the season. Regardless of rate or application timing, F7583-1 treatments maintained complete kochia control for more than 7 weeks after planting. Sulfentrazone & carfentrazone followed by clethodim and MSO (both timings) also provided complete control for that length of time. Control of puncturevine with F7583-1 treatments at 29 DAP ranged from 80 to 89% and did not differ between rates within application timings. Puncturevine control declined rapidly beyond 28 DAP; no treatment was satisfactory at 48 DAP. Both *S*-metolachlor at 1070 g/ha and pendimethalin at 1600 g/ha applied either preplant or PRE were considerably less effective on all three weeds compared to F7583-1 and sulfentrazone & carfentrazone treatments. They were more effective at the end of the season when applied PRE compared to preplant application. However, neither herbicide was as effective as F7583-1 or sulfentrazone & carfentrazone treatments. No treatment reduced sunflower plant population or visibly injured sunflower anytime during the season.

Broadleaf and Grass Control with Sulfentrazone and Metolachlor. Brian M. Jenks[1], Gary P. Willoughby*[2]; [1]North Dakota State University, Minot, ND, [2]North Central Research Ext. Center, Minot, ND (058)

FMC has developed a premix of two commercialized herbicides that control many broadleaf and grass weeds. The new herbicide carries the trade name of BroadAxe and contains Spartan (sulfentrazone) plus Dual Magnum (metolachlor). In this study, BroadAxe was evaluated for broadleaf and grass control in sunflower in 2010 and 2011. Studies were conducted at Minot, ND in 2010 and 2011 using traditional small plot techniques with treatments replicated three times. Herbicide treatments were evaluated for visual crop injury and weed control. BroadAxe was applied at 17, 25, and 34 fl oz. Spartan + Dual Magnum was applied at equivalent rates. Spartan and Dual Magnum were also applied alone at three rates. No sunflower injury was observed with any treatment. BroadAxe efficacy increased as rate increased. BroadAxe and Spartan + Dual Magnum generally provided similar weed control at equivalent rates. BroadAxe alone provided good season-long foxtail control in 2011, but not in 2010 at the lower rates. BroadAxe or Spartan provided good to excellent broadleaf control at the equivalent of 4.5 fl oz or higher. BroadAxe or Spartan + Prowl followed by Select provided the most complete weed control. Dual Magnum alone provided poor broadleaf control in 2010, but excellent pigweed control in 2011. Dual Magnum at 21 fl oz provided fair foxtail control in 2010, but excellent control in 2011.

Dissipation of Pyroxasulfone Under Minumum, Strip, and Conventional Till Furrow Irrigated Corn in Northern Colorado. Jordan A. Driscoll*[1], Philip Westra[2], Neil C. Hansen[1], Troy A. Bauder[1], Erik Wardle[1]; [1]Colorado State University, Fort Collins, CO, [2]Colorado State University, Ft. Collins, CO (059)

Understanding herbicide dissipation is a key aspect of understanding efficacy and environmental fate processes. Furrow irrigation is prevalent in many irrigated regions and creates a distinct microenvironment for soil applied herbicides. The objective of this project was to determine dissipation of three herbicides, pyroxasulfone, s-metolachlor, and atrazine, under furrow irrigation with three different tillage systems, conservation till (CT), minimum till (MT), and strip till (ST). A field study was conducted in 2011 with each tillage system replicated twice. Herbicide application rates were 0.21 kg ai ha^{-1} for pyroxasulfone, 1.98 kg ai ha^{-1} for s-metolachlor, and 0.739 kg ai ha^{-1} for atrazine. Soil samples were taken on top of the bed of the crop row in 30 cm zero contamination tubes collected at one day, one week, two weeks, four weeks, and eight weeks after application. The 30 cm samples were separated into four sub-samples of 0-7.5 cm, 7.5-15 cm, 15-22.5 cm, and 22.5-30 cm. The herbicides were extracted from the soil with toluene and analyzed by GC/MS. Very little herbicide leached past the 0-7.5 cm depth of the soil. By the eighth week, atrazine was almost completely dissipated, followed by s-metolachlor with only slightly higher levels. However, pyroxasulfone still was present at high levels in the soil through the last sampling date. There appears to be no difference of dissipation rates among the three tillage systems, despite large differences in corn residue biomass on the soil surface of the MT and ST plots when the herbicides were applied.

Translocation Rate of Foliar-applied Quinclorac and Aminocyclopyrachlor in Field Bindweed. Andrew R. Kniss, Jared C. Unverzagt, Ariana E. Roe*; University of Wyoming, Laramie, WY (060)

Field bindweed is a perennial broadleaf weed that reproduces by seed and rhizomes. Integrating herbicides with tillage to control field bindweed could be beneficial, but only if the herbicide is able to translocate to the roots prior to the tillage treatment. A greenhouse study was conducted to evaluate how the timing of top-growth removal in relation to herbicide application influenced the probability of field bindweed regrowth. Quinclorac and aminocyclopyrachlor were applied to bindweed at rates of 280 and 35 g/ha, respectively, plus methylated seed oil at 1.4 L/ha when bindweed vines were approximately 10 cm long. Prior to herbicide treatment, soil was covered with plastic wrap to ensure herbicide absorption was primarily through plant foliage. Field bindweed was then harvested at seven different harvest times ranging from 0.5 to 48 hours after treatment (HAT). At each harvest time, leaf area was recorded and above ground biomass was dried and weighed. The number of plants that resprouted following herbicide application were recorded 7 days after treatment. When field bindweed top growth was removed 4 HAT, the probability of regrowth was 0.53 and 0.20 when treated with quinclorac and aminocyclopyrachlor, respectively. When top growth was removed 48 HAT, the probability of regrowth decreased to less than 0.07 for both herbicide treatments. These results suggest that aminocyclopyrachlor may translocate out of treated foliage more quickly than quinclorac.

Use of Pyroxasulfone for Preemergence Residual Weed Control in Glyphosate-Resistant Corn. Prashant Jha*[1], Vipan Kumar[2], Nicholas Reichard[1]; [1]Montana State University, Huntley, MT, [2]Student, Huntley, MT (061)

Pyroxasulfone (Zidua®) is a new chemistry being evaluated for preemergence (PRE) residual weed control in glyphosate-resistant corn. Field experiments were conducted at the Southern Agricultural Research Center in Huntley, MT, and at a grower's field in Yellowstone County, MT, in 2011, to evaluate crop safety and weed control efficacy of pyroxasulfone in comparison to other standard PRE herbicide programs in glyphosate-resistant corn. Experiments were conducted in a randomized complete block design with four replications. Treatments included: 1) a nontreated control, 2) pyroxasulfone (Zidua®) alone at 0.149 kg ai ha^{-1}, 3) pyroxasulfone (Zidua®) alone at 0.298 kg ai ha^{-1}, 4) dimethenamid (Outlook®) alone at 0.840 kg ai ha^{-1}, 5) saflufenacil + dimethenamid-P (Verdict®) at 0.737 kg ai ha^{-1}, 6) acetochlor (Harness®) alone at 1.960 kg ai ha^{-1}, 7) pyroxasulfone at 0.119 kg ai ha^{-1} + pendimethalin (Prowl H_2O®) at 1.064 kg ai ha^{-1}, and 8) dimethenamid-P at 0.840 kg ai ha^{-1} + pendimethalin at 1.064 kg ai ha^{-1}, 9) saflufenacil + dimethenamid-P at 0.737 kg ai ha^{-1} + pendimethalin 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 at 3, 5, and 9 wk after application (WAA) 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. Kochia control 5 WAA with the tank-mix application of pyroxasulfone + pendimethalin was 92%, which was superior to all other treatments, except saflufenacil + dimethenamid-P + pendimethalin mixture. Kochia control 5 WAA did not differ between 0.149 kg ai ha^{-1} (low) and 0.298 kg ai ha^{-1} (high) rates of pyroxasulfone applied alone, and averaged 72%, which was no different from saflufenacil + dimethenamid-P treatment. Dimethenamid alone and acetochlor alone were the least effective treatments for kochia control, which averaged 55% at 5 WAA. Common lambsquarters control 5 WAA with pyroxasulfone + pendimethalin mixture and dimethenamid-P + pendimethalin mixture averaged 82%, and was higher than pyroxasulfone alone or dimethenamid-P alone treatment. With pyroxasulfone alone, common lambsquarters control was 69% at the high rate compared with 46% control at the low rate. Acetochlor was the least effective treatment for common lambsquarters control. Tank-mix of saflufenacil + dimethenamid-P + pendimethalin provided the most effective control (82%) of wild buckwheat 5 WAA, although it did not differ from the saflufenacil + dimethenamid-P treatment. Wild buckwheat control 5 WAA with pyroxasulfone alone at the high rate was 46%, and was higher than the 16% average control obtained from pyroxasulfone alone at the low rate and dimethenamid-P alone treatment. Acetochlor provided < 5% control of wild buckwheat 5 WAA. Corn yield with pendimethalin-containing herbicide programs, pyroxasulfone (0.298 kg ai ha^{-1}) alone, and saflufenacil + dimethenamid-P averaged 7109 kg ha^{-1}, which was 36% higher compared with the average yields obtained from dimethenamid-P alone and pyroxasulfone (0.149 kg ai ha^{-1}) alone treatments, and 91% higher than the acetochlor alone treatment. In conclusion, pyroxasulfone applied PRE at 0.298 kg ai ha^{-1} would be a valuable tool for residual weed control, especially for glyphosate-resistant kochia management in glyphosate-resistant corn.

Volunteer Glyphosate Resistant Canola Control: Increasing the Database. Rich Zollinger*, Angela Kazmierczak; North Dakota State University, Fargo, ND (062)

Studies were conducted from 2008 to 2011in North Dakota to evaluate control of volunteer glyphosate resistant canola from soil- and post-applied herbicides. Many herbicides were applied preemergence up to 6-leaf canola. Attempts from growers to control herbicide resistant canola are usually delayed after the first glyphosate application when plants are larger and plants escape herbicide phytoxicity. Therefore, recent studies evaluated herbicide efficacy on canola beginning to bolt (stage 3.2) and beginning flowering (stage 4.1). Preemergence herbicides controlling canola greater than 90% were: atrazine, mesotrione, imazethapyr, cloransulam, halosulfuron, metribuzin, saflufenacil. Postemergence herbicides controlling 3-leaf canola greater than 90% were: atrazine, bromoxynil + 2,4-D, mesotrione, tribenuron, imazamox, imazethapyr, cloransulam, fomesafen, bromoxynil + pyrasulfatole, glufosinate, tembotrione, MCPA, foramsulfuron, halosulfuron, saflufenacil, acifluorfen, and 2,4-D. Postemergence herbicides controlling 6-leaf canola greater than 90% are: mesotrione, fomesafen, bromoxynil + pyrasulfatole, tembotrione, MCPA, foramsulfuron, saflufenacil, and 2,4-D. Postemergence herbicides controlling canola beginning to bolt greater than 90% are: mesotrione, fomesafen, bromoxynil + pyrasulfatole, tembotrione, 2,4-D. Postemergence herbicides controlling canola beginning to flower greater than 90% are: mesotrione, fomesafen, and bromoxynil + pyrasulfatole.

Effects on Spray Droplet Size, Drift, and Efficacy from an Acidic, AMS Replacement Adjuvant. Jim T. Daniel*[1], Geig R. Kuger[2], Scott K. Parrish[3], Philip Westra[4]; [1]Self, Keenesburg, CO, [2]University of Nebraska-Lincoln, North Platte, NE, [3]Agrasyst, Sponkane, WA, [4]Colorado State University, Ft. Collins, CO (063)

Two potential adjuvants, AQ 268 and AQ 284, were evaluated for their effects on droplet size, drift, coverage and efficacy when used with glyphosate or dicamba and compared with a standard. AQ 268 is modified seed oil with multiple emulsifiers, and AQ 284 is modified seed oil with multiple acidified emulsifiers to be used as an ammonium sulfate replacement. The standard was a modified vegetable oil and emulsifier adjuvant with nonionic surfactant.

Droplet size was initially evaluated on water sensitive paper with a track sprayer at Colorado State University and then with a Sympatec Helos Vario KF laser diffraction instrument at the University of Nebraska-Lincoln West Central Research and Extension Center. Efficacy was evaluated by mixing the standard, AQ 268 and AQ 284 with glyphosate in two greenhouse trials and two fall field trials conducted near Fort Collins, CO. The initial drift study was conducted by placing petri dishes downwind of a running electric fan and spraying the adjuvants mixed with dicamba at a 90-degree angle to the petri dishes. Rinstate from the petri dishes was subjected to HPLC analysis to quantify the amount of spray solution collected.

Droplet size analysis showed that AQ268 and AQ 284 reduced droplet fines (less than 150 microns) an average of 50% while not increasing the number of large droplets. Similar results were found for the standard. The efficacy studies showed that the droplet size control materials with glyphosate gave weed control equal to control obtained with glyphosate plus ammonium sulfate and nonionic surfactant. Analysis of the rinstate from the petri dish study showed that mixtures with AQ 268, AQ284 and the standard increased recovered dicamba by over 14% when compared to the treatment without droplet control materials.

Project 4. Teaching and Technology Transfer

WSWS Noxious Weed Short Course. Sandra K. McDonald*; Mountain West PEST, Fort Collins, CO (064)

The Western Society of Weed Science Noxious Weed Short Course is an intensive three-day study of current technologies and best management practices associated with the noxious and invasive weeds in the Western United States. The Short Course targets local, state, federal government, and other land managers throughout the western region who desire a better understanding of noxious weed management. The course stresses ecologically-based plant management and includes prevention, cultural, mechanical and chemical plant management, and restoration and revegetation. The 2012 Noxious Weed Short Course will be held April 16-19, 2012 at the Sylvan Dale Guest Ranch in Loveland, Colorado.

The WeedOlympics: A National Weed Science Contest. Greg Armel*[1], James T. Brosnan[1], Jose J. Vargas[1], Gregory K. Breeden[1], Vanelle F. Peterson[2]; [1]University of Tennessee, Knoxville, TN, [2]Dow AgroSciences, Mulino, OR (065)

The WeedOlympics was the first national weed science contest involving student members of the Western Society of Weed Science (WSWS), the Northeastern Weed Science Society (NEWSS), the North Central Weed Science Society (NCWSS), and the Southern Weed Science Society (SWSS). A total of 137 graduate and undergraduate students from across the United States and Canada participated in the event hosted at the University of Tennessee (Knoxville, TN) in 2011. A total 16 WSWS students participated in the WeedOlympics. Universities represented included Kansas State University, New Mexico State University, Oklahoma State University, and Washington State University. At the regional level, New Mexico State University (Joni Blount, Andy Dyer, Drew Garnett, and Heather Bedale) took top honors in the undergraduate competition. In the graduate division, Washington State University (Jared Bell, Misha Manuchehri, Nevin Lawrence, and Alan Raeder) placed first in the WSWS regional competition. The top undergraduate and graduate individuals at the regional level were Joni Blount (New Mexico State University) and J.D. Riffel (Kansas State University). At the national level, the top graduate team was from Purdue University; members were Jared Roskamp, Ryan Terry, Chad Barbham, and Paul Marquardt. The top undergraduate team at the national level was from the University of Guelph; team members included Thomas Judd, Adam Parker, Michael Vanhie, and Jessica Gal. The overall national winners in the individual graduate and undergraduate competition were Jason Parrish from The Ohio State University and Dan Tekiela from Virginia Polytechnic Institute, respectively. Distinguished WSWS member, Dr. Robert Norris, spoke at the awards banquet on the history of the WSWS and presented WSWS students with their awards along with current WSWS president, Dr. Vanelle Peterson. Thank you to all the students, coaches, and volunteers who made the WeedOlympics a memorable event.

A Classroom Activity for Teaching Proactive Herbicide Resistance Management. Andrew R. Kniss*; University of Wyoming, Laramie, WY (066)

Herbicide resistant weeds are a major problem in agronomic cropping systems worldwide. A common recommendation from university and industry weed scientists is to incorporate multiple herbicide modes of action to proactively manage herbicide resistant weeds (i.e. prevent or herbicide resistance from occurring). Recent research indicates the optimal way to prevent the increase in herbicide resistant weed biotypes is to tank-mix multiple herbicide modes of action, or at the very least utilize multiple modes of action within the same crop year. A classroom activity and lesson was developed to teach upper-division undergraduate and graduate students how to develop a proactive herbicide resistance management plan, and the difficulty in implementing such a plan. Students were provided background information on herbicide resistant weed management, and the information was discussed in an online forum and class discussion. Subsequently, the students were required to develop herbicide recommendations for 4 different crops that would provide effective proactive management of herbicide resistant weeds. After students developed their recommendations, barriers to adoption of their plans were discussed. Primary barriers that were identified included cost and crop rotation restrictions.

Advanced Plant Identification System (APIS): The Answer to EDRR? George E. Meyer[1], Ashok Samal[1], Stephen L. Young*[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (067)

The goal for managing invasive plant species should include the prevention of new invasions and the reduction of existing populations. In most circumstances, prevention is the cheapest and should be the preferred method for managing against invasive plant species. Unfortunately, land owners and managers are at a disadvantage when implementing preventative measures necessary to restrict newly invading plant species or stop existing populations from further expansion. A lack of trained field staff combined with large expanses of land to manage remains a particular problem. Because of this unmanageability by one or even a few individuals, prevention strategies are significantly hampered, including Early Detection Rapid Response (EDRR). Therefore, new technology is needed to assist land owners and managers implementing EDRR, which would allow them to cover and manage more area with less experienced volunteers or personnel. Components of a user-friendly and portable system are being developed at the University of Nebraska-Lincoln to reliably identify and monitor invasive plant species in real-time. Such a system would be used to monitor and potentially prevent the spread of invasive plant species into existing or new areas. The system or advanced plant identification system (APIS) is being developed for field use and equipped with communication capabilities to transmit data to a centralized, web-based location (cloud). When the APIS is available for retail sales, land owners, managers and various groups including outdoor enthusiasts, recreationists and service clubs, and the general public would be equipped and better able to help in the prevention of new invasive plant species populations.

Education & Outreach Efforts to Achieve Land Stewardship Awareness. Chad Clark*; Larimer County Weed District, Ft. Collins, CO (068)

The Larimer County Weed District, Ft. Collins Colorado, has expanded its focus from noxious weed management and weed law compliance, to a much broader mission addressing land stewardship issues on private and public lands county-wide. This expanded focus has created partnerships with local, state and federal land management agencies, as well as with private landowners. The Weed District works closely with these entities and constituents to ensure best management practices are conducted in noxious weed management, rangeland / pasture management and restoration, landscape and erosion control, forestry issues such as mountain pine beetle and wildfire awareness and mitigation, and livestock grazing. The Weed District's best management practice recommendations are obtained through attendance and participation in professional associations and establishment of research and demonstration field plots. Field research, often conducted in collaboration with Colorado State University, provides locally derived and current management data. The research sites are also an excellent outreach tool, providing sites for educational tours. Other outreach efforts in Larimer County include management recommendation guides, plant identification guides, a comprehensive and interactive website, educational presentations and site visits. The broad focus of the Larimer County Weed District has been very successful in encouraging private landowners to comply with the weed law. Land management agencies have an increased awareness of stewardship issues and devote more resources to public land management.

Project 5. Basic Biology and Ecology

Perennial Pepperweed: Monitoring Stem Density During 18 Years of Invasion. Robert Blank*, Tye Morgan; USDA-ARS, Reno, NV (069)

Perennial pepperweed (tall whitetop) is a weedy alien crucifer that has invaded wetlands throughout the western United States. We are monitoring the invasion of an tall wheatgrass community at the Honey Lake Refuge in northeastern CA. A $40 m^2$ plot was established in 1993 and we have measured perennial pepperweed stem density yearly. In 1993, two single plants were present. From 1994 through 2000 density of perennial pepperweed increased to greater than 120 stems m^{-2}, and was most pronounced following flooding in 1997. At its height of stem density and stature in 1999, it appeared that tall wheatgrass had been extirpated. From 2001 through 2006 stem density and plant stature of perennial pepperweed declined, but there were still areas of the plot where stem density exceeded 60m^{-2}. From 2007 through 2009 stem density decreased considerably and averaged less than 30 m^{-2} and a healthy recovery of tall wheatgrass occurred. The years 2010, and especially 2011, stem density increased, but individual plants were small in stature. The decline in stem density over time supports our hypothesis that phosphorus is the nutrient "Achilles heel" of perennial pepperweed. Rooting architecture of perennial pepperweed dictates phosphorus uptake largely occurs deep in the soil profile where higher water content occurs. Biocycling of phosphorus to the soil surface, over-time, decreases its availability at depth.

Determining Whether a Population of Japanese Knotweed *s.l.* (*Fallopia japonica*) Contains Multiple Biotypes. John J. Miskella*, Elena Sanchez, Andrew G. Hulting; Oregon State University, Corvallis, OR (070)

Three closely-related invasive knotweeds, Japanese knotweed (*Polygonum cuspidatum*), Sakhalin knotweed (*Polygonum sachalinense*) and Bohemian knotweed (*Polygonum x bohemicum*) have become serious weed management problems in both Europe and North America. The Japanese knotweed biotype that has become invasive was thought to be a clone. However, in 2007, three MA populations were found to be reproducing sexually. If a plant species only spreads clonally, there is little opportunity for the species to evolve in response to selection pressures, such as chemical control or climate change. Plants that reproduce sexually can evolve in response to their environment. For an invasive plant, genetic diversity allows the species to colonize new habitats and to adapt to management strategies. The objective of our research was to determine if an OR knotweed population contained a single biotype or multiple biotypes. DNA from 16 knotweed plants was extracted from a Hebo, OR population. Simple sequence repeats (SSRs), di- or trinucleotide repeats that do not vary for ramets of a clone, were used as molecular markers. One of these SSRs was a species-specific marker for Sakhalin knotweed. None of the Hebo samples contained this marker. At each SSR loci tested, the individual knotweed plants did not show any variability within the population. The SSRs in our study provide evidence that the population contains a single biotype. Because of the lack of genetic diversity, this population may not be able to adapt quickly to changes in environmental conditions or control measures.

Using Aminocyclopyrachlor to Control Dalmation Toadflax and Promote Native Plant Community Recovery and Diversity. James R. Sebastian*[1], George Beck[2], Derek Sebastian[3], Sam Rodgers[4]; [1]CSU, Loveland, CO, [2]Colorado State University, Ft. Collins, CO, [3]Creighton University, Omaha, CO, [4]University of Colorado, Boulder, CO (072)

Dalmatian toadflax, (*Linaria dalmatica* L.*;* LINDA) is an aggressive escaped ornamental that reproduces from seed and creeping roots. LINDA has rapidly expanded its range in Colorado and often grows in diverse, foothill habitats where there is a broad spectrum of native forb, shrub, and grass species. Land managers have been challenged with controlling LINDA without injuring or eliminating native plants. Biological control has been ineffective for controlling the spread of LINDA in Colorado; however, integrated systems work well. Aminocyclopyrachlor (MAT) is a new herbicide developed by DuPont for managing invasive weeds in non-crop areas. The objective of this study was to determine if MAT effectively controls LINDA and MAT's effects on native species density and diversity. This study was sprayed on June 19, 2009 when

LINDA was at flowering growth stage. There were 6 herbicide treatments and an untreated control arranged as a randomized complete block with 6 replications. Density counts were conducted in the entire 10'x 20' plots for each species in 2010 and 2011. There were 16 forb, 6 shrub, 6 weed, 4 cool-, and 5 warm-season grass species evaluated (37 species total). Densities were compared to untreated plots for individual species and species functional groups (forb, shrub, etc). Most forb species decreased slightly in density but were not eliminated in 2011. Wild onion (*Allium textile* N.), fleabane (*Erigeron flagellaris* G.), mariposa (*Calochortus gunnisonii* W.), spiderwort *(Tradescantia occidentalis* B.), and bladderpod (*Lesquerella montana* N.), increased in density in MAT treatments compared to checks. Mariposa and spiderwort plants were not found in any of the check plots and were only found in MAT treated plots. Both of these species emerge in early spring and likely benefited from less competition from early emerging plants such as LINDA, forbs, and grass species that decreased in MAT treated plots. Species richness (number of species per plot) was also determined. MAT + metsulfuron decreased forb species richness by 57% compared to the checks. Porter's aster (*Symphyotrichum porteri* G.) and heathaster (*Symphyotrichum ericoides* G.) were eliminated with MAT (2 oz ai/a) or the MAT + metsulfuron tank mix. Shrub species decreased more than any other functional group in this study. There was 45 to 76% decrease in total shrub density and 20 to 50% decrease in shrub richness from all MAT treatments. Prairie junegrass (*Koeleria macrantha* L.; KOEMA, cool-season grass) and most of the warm-season grass species increased dramatically in density in MAT treated plots. As a whole, warm-season grasses increased in density 113 to 259% compared to checks. With the exception of KOEMA, cool-season grass species tended to decrease but were never eliminated. MAT (2 oz ai/a) decreased forb or shrub species richness by 32 and 57%, respectively; however, MAT (0.5 and 1.0 oz ai/a) sprayed alone had forb, grass, and weedy species richness similar to the checks. There was 90 to 97% LINDA control 1 YAT from MAT at 2 oz ai/a or MAT 1 oz ai/a tank mixes. LINDA seedlings appeared in all sprayed plots 15 months after treatment. There was only 4 to 26% LINDA control approximately 2 YAT from MAT. This site had extremely shallow, rocky soils where MAT may have dissipated much faster than in deeper soils or those with more clay or organic matter. Other research conducted by CSU has shown longer term LINDA control with similar rates of MAT. It may be necessary to spot spray or spray follow-up treatments to control LINDA seedlings that emerge after original treatments are applied. At this particular site, native forbs and cool-season grasses decreased slightly in density 2 YAT but still were present. Warm-season grasses, KOEMA, and 5 forb species increased in density compared to the checks. The shrub species component dramatically decreased in density and richness in MAT-treated plots. In locations where invasive species need to be controlled and shrub species are desired it may be advantageous to spot spray MAT or use alternative herbicides. It may also be advantageous to spray MAT alone rather than tank mixed since overall species richness decreased significantly from MAT tank mixes. MAT (0.5 and 1.0 oz ai/a) sprayed alone had forb, grass, and weedy species richness similar to the checks.

Synergistic Interaction of Flumioxazin and Emulsifiable Concentrate Formulations of Pesticides. Jamshid Ashigh, Nina S. Klypina*, Brian Schutte, Isaac Dorrance; New Mexico State University, Las Cruces, NM (073)

Previous field studies indicated significant alfalfa injury following the between-cutting application of flumioxazin (commercial product, Chateau WDG herbicide) plus trifluralin formulated as emulsifiable concentrate (commercial product, Treflan 4 EC herbicide). The objectives of this study were to determine the interaction of flumioxazin and EC formulations of pesticides on growth of alfalfa and associated weeds. Greenhouse studies were conducted using the recommended field rates of flumioxazin and trifluralin. Compared to nontreated controls, applications of flumioxazin plus EC formulated trifluralin, or EC formulation blank of trifluralin (blank), caused at least 75% reduction in alfalfa biomass, however, the application of flumioxazin, or EC formulated trifluralin alone did not reduce the alfalfa biomass. The enhanced burndown activity of flumioxazin with EC formulations on alfalfa was also confirmed when flumioxazin application followed by an EC formulated azadirachtin insecticide (commercial product, Azatrol EC insecticide) application. The application of flumioxazin plus EC formulated trifluralin, or blank, also increased the post-emergence control of Palmer amaranth, spurred anoda, junglerice and Johnsongass compared to flumioxazin alone. Results indicate that the combination of flumioxazin and the EC formulated pesticides may result in significant yield reduction in alfalfa. However, in situations where the direct contact of herbicide(s) with crops is limited (e.g., orchards) or not a concern (e.g., pre-plant applications), this combination could enhance the post-emergence weed control of the flumioxazin.

Absorption and Translocation of Aminopyralid and Clopyralid in Rush Skeletonweed.
Jared L. Bell*, Misha R. Manuchehri, Heather Malone, Ian C. Burke; Washington State University, Pullman, WA (074)

Aminopyralid is a recently developed pyradine-based auxin type herbicide for control of broadleaf weeds and shrubs in noncropland systems including roadsides, industrial areas, and rangeland. Aminopyralid and the related compound clopyralid control forbs in several dicot families including Asteraceae, Fabaceae, Chenopodiaceae, Convolvulaceae, Solanaceae and Euphorbiaceae. Aminopyralid is structurally similar to other pyridine-based herbicides such as picloram and clopyralid. Rush skeletonweed is an herbaceous perennial with an extensive taproot system that can reach over two m in length. Clopyralid, when applied at labeled rates, requires multiple applications over several years to reach the equivalent level of control as that achieved with a single application of aminopyralid. The objective of these studies were to compare the absorption and translocation of aminopyralid versus clopyralid in rush skeletonweed to determine how the growth regulator effect of the two herbicides affected their fate in the plant. A study was conducted with a split-split plot treatment arrangement and four replications to evaluate absorption and translocation of clopyralid and aminopyralid in vernalized rush skeletonweed. The study was repeated in time. Absorption was biphasic for both herbicides, with absorption peaking at 24 hours after treatment (HAT). Rush skeletonweed absorbed 73.1% of the applied clopyralid. Less aminopyralid was absorbed – at 72 HAT 41.4 % of the applied aminopyralid had been absorbed by rush skeletonweed. Significantly more clopyralid was translocated out of the treated leaf to the rest of the plant than aminopyralid. At 72 HAT, 48.8% of the applied clopyralid had been moved out of the treated leaf to the rest of plant. At the same time interval, only 8.3% of the applied aminopyralid and moved out of the treated leaf. Translocation to the root, important for control of a perennial like rush skeletonweed, was greater with clopyralid than with aminopyralid. The movement of clopyralid to root portions of rush skeletonweed was greatest at 72 HAT, and was 5.9% of the applied. Translocation of aminopyralid increased linearly with time, and no asymptote was observed. At 72 HAT, 2% of applied aminopyralid was recovered from the root portions. Significantly more clopyralid was accumulated in the crown of rush skeletonweed than aminopyralid. Based on absorption and translocation and cessation of the source-sink relationship, it appears that aminopyralid is the most active molecule on rush skeletonweed.

Downy Brome Seed Ecology: From Flower to Emergence. Daniel Harmon*[1], Charlie D. Clements[2], James A. Young[2]; [1]USDA-ARS, Reno, NV, [2]USDA, Reno, NV (075)

Downy brome seed is very common in seed banks throughout Great Basin rangelands. Previously, using a soil bioassay method, we tested 100 separate sites within the Great Basin (1000 samples) to measure downy brome seed bank densities. The locations differed greatly by precipitation, disturbance history, plant community, and soil type. Out of the 1000 samples, very few did not contain downy brome seed. Based on our observations of vegetative plasticity, we hypothesized that characteristics of downy brome reproduction would also differ by population. We monitored flowering, seed maturation, seed dormancy, emergence, and seed banks of five downy brome population categories. A total of 15 locations, three replicates of population categories, were monitored and sampled. All locations were within the Truckee watershed. Our results found that flowering occurred as early as April with viable seed being produced the first few days of May. Seed production existed through July based on the observance of green seed. Only the high elevation population differed greater than the annual intra population flower timing difference. Primary seed dormancy differed by population. Salt desert populations exhibited greater dormancy than higher elevation or Wyoming big sagebrush invaded populations. Emergence timing differed by year more than population, except for the high elevation population which, similar to flowering, exhibited delayed emergence. The only seed characteristic that differed among population habitat types regardless of the annual weather conditions was primary seed dormancy. Seed dormancy could be an adaptive response to avoid summer germination, which was observed at the salt desert locations. Seed banks differed by population and were not ultimately determined by primary seed dormancy patterns. Secondary induced seed dormancy principally affects seed banks. Downy brome reproductive phenology is largely determined by the unpredictable annual weather making seed dormancy predictability a useful tool for management.

Population Level Response of Downy Brome to Soil Growing Medium. Daniel Harmon*[1], Charlie D. Clements[2]; [1]USDA-ARS, Reno, NV, [2]USDA, Reno, NV (076)

Downy brome is the most ubiquitous exotic invasive weed in the Intermountain West. A major issue for management is the extreme generalist plastic nature of downy brome. We hypothesized that soil growing medium would affect all measured response variables representing some degree of plasticity. In a greenhouse reciprocal garden we tested two treatment variables 1) seed source population (n=5) and 2) soil type (n=5). We measured four response variables, 1) total biomass 2) seed to total biomass ratio 3) days to flowering and 4) total life duration. Our results found that biomass differed by soil type and seed source (Figure 1). High elevation populations had the largest biomass irrespective of soil medium. Among the lower elevation populations only the salt desert populations ranked the greatest in its own soil*, possible indicating adaptation to the harsh salt desert habitat. Seed to total biomass ratios responded to soil type and seed source. Plants exhibited lower resource allocation to seed production when grown in silt salt desert soils. Downy brome seed from higher elevations displayed the lowest percent of seed to total biomass. Days to flowering differed by seed source. Soil type had little effect on flower timing. High elevation seed source exhibited delayed flowering and a long life span. Total life span differed more by soil type than seed source. Salt desert soils lead to shorter life spans. While most of the results concur with previous findings, the population level fixed biomass response has not been observed before. High elevation downy brome seed produced larger plants. Population level biomass differences could have important wildfire fuels management implications.

Impacts of Insect Biological Control on Soil N Transformations in Tamarix-Invaded Ecosystems in the Great Basin. Shauna M. Uselman*, Keirith A. Snyder, Robert Blank; USDA-ARS, Reno, NV (077)

Understanding the impacts of insect biological control of *Tamarix spp.* on soil nitrogen (N) transformations is important because changes to N supply could alter plant community succession. We investigated short-term and longer-term impacts of herbivory by the northern tamarisk beetle (*Diorhabda carinulata*) on soil N availability in *Tamarix*-invaded ecosystems by surveying soils (organic horizon and mineral soil, 0-10 cm) from three sites and assaying for potential net N mineralization using laboratory incubations as an index of soil N availability. Results partially supported our hypothesis that beetle herbivory would result in stimulated rates of net N mineralization in the short-term (i.e. in the first year of exposure to herbivory), and did not support our hypothesis that beetle herbivory would result in a sustained increase in net N mineralization rates in the longer-term (i.e. after several years of exposure). Short-term effects of herbivory differed by site, and were likely influenced by differences in the prevailing soil N status. In the longer-term, there was no impact on overall net N mineralization rates, even though there was a trend towards greater N immobilization in the mineral soil with more years of herbivory. This trend in the mineral soil may be attributable to declining organic matter inputs to soil due to progressive growth limitation from herbivore-induced stress. These results suggest that soil N availability will increase in the short-term and eventually decrease in the longer-term at low fertility sites, while soil N availability will not be impacted by beetle herbivory at high fertility sites.

Invasive Weed Mapping of Lebanon. Mustapha A. Haidar*, Alia Sabra; American University of Beirut, Beirut, Lebanon (078)

Surveying and early detection of invasive weeds is essential for strategic management and monitoring. Accordingly, a weed mapping was conducted during July 2011 against native and non native weeds of Lebanon velvetleaf, dodder, jimsonweed, branched broomrape, silverleaf, johnsongrass, cocklebur and crownbeard using a global positioning system (GPS) Garmin© 2006 for precise waypoint, elevation, navigation and distance. The result of interviewing and interacting with the public in 95 villages distributed between the Beq'aa plain and the North of Lebanon, along with the observation made on the route yielded the first detection of velvetleaf, while silverleaf and crownbeard were not found in agro-ecosystems. This is the first report of the introduction of velvetleaf in Lebanon and the establishment of a baseline data on weeds of Lebanon. Dodder, branched broomrape and johnsongrass*,* were found to be the most invasive in various agro-ecosystems, especially in vegetables. The adoption of an integrated weed management (IWM) is required to manage the spreading and to lessen the ability of invasive weeds to adapt to our ecosystem.

Delayed Seed Germination and Seedling Emergence of Scotch Broom (Cytisus scoparius) Under Logging Debris: Evidence of a Phytochrome-Mediated Response. Timothy B. Harrington*; USDA Forest Service, Olympia, WA (187)

Scotch broom (*Cytisus scoparius*) is a large, non-native, invasive shrub that has widespread distribution in 22 U.S. states, particularly California, Oregon, and Washington. The species has a hard seed coat that enables its seeds to retain their viability in the soil for decades. Three years after harvesting Douglas-fir (*Pseudotsuga menziesii*) forest near Matlock WA, crown cover of seedbank-origin Scotch broom was lower in a site-preparation treatment having a high abundance of logging debris (8%) than in one having a low abundance (27%). Laboratory studies were conducted in 2010 and 2011 to test the hypothesis that delayed broom development under logging debris was associated with a phytochrome-mediated response (i.e., a plant growth response resulting from reductions in the ratio of red to far-red light (R/FR)). The R/FR ratio of transmitted sunlight was lower under either brown needles or green shoots of Douglas-fir then for open sky conditions. Intensity of transmitted sunlight was ranked as: bare mineral soil > under green shoots > under brown needles. Within plastic boxes containing glacial outwash soil, the rates of broom seedling emergence were lower when seeds were sown under a layer of green shoots than on bare mineral soil. Rates of seedling emergence for seeds sown under brown needles were similar or somewhat greater than those for seeds sown under green shoots. Soil surface temperatures were about 0.5 degrees C higher under a layer of brown needles than under a layer of green shoots. Weight loss of soil from evaporation was greater for bare mineral soil than for soil covered in either brown needles or green shoots. Colored cellophane was used to simulate shifts in the R/FR ratio from logging debris. In two separate trials, rates of broom seed germination (i.e., on filter paper within petri dishes) were ranked as: clear cellophane > red cellophane > green cellophane. However, final germination and Weibull parameters for the seed germination models did not differ statistically among cellophane colors. These research results provide evidence that logging debris causes a phytochrome-mediated (R/FR ratio shift) response in Scotch broom that delays seed germination and seedling emergence.

GENERAL SESSION

Presidential Address. Vanelle F. Peterson*; Dow AgroSciences, Mulino, OR (079)

WSSA and Regional Weed Science Societies Report. Lee Van Wychen*; WSSA, Washington, DC (080)

See WSWS Board of Directors Minutes for complete report.

Historical Perspectives on the First Regional Weed Science Society. Robert F. Norris*; University of California, Davis, Davis, CA (081)

The Western Weed Control Conference predates all other regional weed science societies by 5 to 10 years. The first Conference was held in Denver in June 1938, following an organizational meeting the previous year in Boise. Harry L. Spence, from Idaho, convened the first meeting and served as the chair of the fledgling organization. The second conference was held in Berkeley in 1939, and except for a few years meetings have been held regularly since then. The Conference name was changed to the Western Society of Weed Science (WSWS) in 1968. Eleven Western States were represented in 1938; in 2011 the membership included 18 Western States and 3 Western Canadian Provinces. J. Lamar Anderson, from Utah State University, was elected to the newly created position of Treasurer-Business Manager in 1965. Lamar put, and kept, the Society on a solid organizational footing until he retired in 1989. Wanda Graves took over from Lamar and managed the Society from 1989 until 2006; Phil Banks currently serves as the Treasurer-Business Manager. A major perspective about the 'Western' is the geographic and ecological diversity that is encompassed within the region. Altitude ranges from below sea level to over 20,000 ft. Annual rainfall varies from an inch or two in the deserts to over 200 inches in the Olympic Peninsula, which results in our agriculture being any combination of rain-fed to fully irrigated. Crops vary from cool season vegetables to tropical fruit, and everything in-between. The West also has extensive areas of wilderness and many National Parks. The diversity of the agricultural and natural ecosystems means that weed management in the West is often more complicated than in regions without such diversity. Historically, W.W. (Doc) Robbins ran the first open discussion section in 1941, leading to the birth of the 'discussion society'. The Research Section dates back to 1946, when the first session was organized by Bill Harvey. The 'Research Projects' were developed in 1951 by F. L. (Tim) Timmons and V. F. Bruns, and they oversaw the publication of the first Research Progress Report in 1952. The 'What's New from Industry' section was first held in 1963, and continues to this day. Student paper competitions were initiated in 1983, and have been held annually ever since. Poster sessions were first tried in 1985 and are now a major component of the annual meeting. The Society membership grew from 24 weed scientists at the original meeting in 1938 to 332 attendees at the 2011 meeting.

An Ethical Challenge. Robert Zimdahl*; Colorado State University, Ft. Collins, CO (082)

I intend to ask and answer how one determines what to do? How do we know what we do is right? We have personal and professional ethical standards and are aware of a set of societal principles that govern views of what is right and wrong. Our ethical standards guide us toward helping to create a world that is just, peaceful, generally prosperous, democratic, free of prejudice, and humane. Achieving these worthy goals is not agriculture's responsibility; it is shared with all segments of society. We have assumed that as long our research and the resultant technology increased food production and availability we were exempt from negotiating the moral bargain that is the foundation of the modern democratic state. It is a moral good to feed people and agriculture does that. Therefore, its practitioners assume that anyone who questions the morality of the ends or its technology simply doesn't understand the importance of what is done. I conclude that agriculture needs a new ethic that does not ignore the importance of increasing food production and availability, but does not end there. My challenge to you is to create a broader ethical position and a new definition of professionalism in weed science.

Aquatic Weed Management at Lake Tahoe: Collaborative Research, Regulatory and Response Actions are Working! Lars W. Anderson*; USDA-ARS Exotic and Invasive Weed Research, Davis, CA (083)

Lake Tahoe is a 120,200-acre alpine lake designated as an Outstanding National Resources Water under the U.S. Clean Water Act. However, the introduction and spread of Eurasian watermifoil (*Mryiophyllum spicatum*) and curlyleaf pondweed (*Potamogeton crispus*) have impaired ecosystems services and created economic impacts over the past 25 years, particularly in Southshore marinas. Management of these plants has been primarily through repeated cutting and harvesting with the Tahoe Keys, with no effort to restrict dispersal or introductions of new aquatic invaders such as quagga and zebra mussels. Limitations on management methods were mainly due to policies of the Lahontan Regional Water Quality Control Board (LRWQCB) that precluded the use of any aquatic herbicides. The *status quo* changed radically in the aftermath of two-day workshop on aquatic invasive species in 2007, which also happened to coincide with the discovery of quagga mussels in Lake Mead. Threats from quagga mussels coupled with strong public demand to improve management of *M. spicatum* and *P. crispus* led to the formation of a multi-agency Lake Tahoe Aquatic Invasive Species Advisory Group, two new AIS coordinators (USFWS and TRPA), and approval of ANS plans the ANST/Western Regional Panel. This group and its members have implemented effective water craft inspections at a cost of over $1million per year, established decontamination stations, and have garnered and channeled resources to develop integrated methods to control *M. spicatum*, *P. crispus* and the Asian Clam in Lake Tahoe. The intense vessel inspection program has prevented launches of hundreds of boats containing quagga or zebra mussels and other invasive species over the past five years. A parallel effort by the team and through public stakeholders has resulted in approval by the Lahontan Regional Water Quality Control Board of policy-changes that, if approved by Federal EPA this summer, will provide protocols for review and approved uses of aquatic herbicides at Lake Tahoe. This success is due to the collective and collegial efforts of dedicated local, state, federal agency staff and similarly determined private stakeholders. The results at Lake Tahoe demonstrate that effective responses to AIS can be achieved when action-agencies, research groups, regulatory agencies and the concerned public work together to solve problems rather than assuming adversarial positions.

PROJECT 1: WEEDS OF RANGE AND NATURAL AREAS

Yellowtuft Alyssum: A Super Weed in a Super Place. Shawna L. Bautista*[1], Kelly Amsberry[2]; [1]US Forest Service, Portland, OR, [2]Oregon Department of Agriculture, Salem, OR (084)

Two species of yellowtuft alyssum (*Alyssum murale* (Waldst. & Kit.) and *A. corsicum* (Duby)) were introduced into the Illinois Valley of southern Oregon in 2003 and are now spreading widely into natural areas. Spread of yellowtuft is of grave concern to natural area managers because this region is a large surface deposit of serpentine soils and has a unique rare plant community. The circumstances surrounding the introduction of these weeds provides a cautionary tale to land managers throughout the U.S. Yellowtuft accumulates nickel from the soil and has been used in remediation of mine tailings. However, this introduction was an experiment to obtain usable nickel from the ash of burned plants in a "phytomining" operation. Phytomining differs from phytoremediation in that the extensive distribution of native soil is suitable for the plant's growth, rather than a unique patch of mine tailings. An initial report by Oregon State University Extension Service indicated that uncontrolled spread was unlikely - however, this report inaccurately portrayed the ease of control with herbicides, inaccurately described seed dispersal, and never acknowledged the risk to unique plant communities on serpentine soils. Current publications on development of hyperaccumulator plants for mining puposes also fail to acknowledge the potential risks to native plant communities when extensive areas of native soil are the target growing sites. Introduction of yellowtuft into the Illinois Valley has been a case study of "Murphy's Law" in action. The low nutrient levels and toxic characteristics of serpentine soils, combined with hot, dry summers have, until now, provided protection from most weeds, but yellowtuft thrives in these conditions. Seeds of *A. murale* sent to the National Seed Lab germinated at every temperature tested. Both species produce abundant seeds, are difficult to control and are now listed as noxious weeds in Oregon. *A. corsicum* is not currently reported from anywhere else in North America according to the USDA Plants Database. Viridian Resources, the company that conducted the plantings, failed to comply with the required measures designed to prevent spread of these plants and has since left the area, transporting its stockpile of seed to destinations unknown. Yellowtuft is negatively impacting private land by infesting crop land. These *Alyssum* species may be transported to distant locations via crops, compost, vehicles, and equipment. Yellowtuft may be toxic to livestock with one reported death of a cow that foraged in a planted field. Some infestations occur on property of hostile, absentee, or uncooperative landowners and some people in the local community are vehemently opposed to herbicide use. The rare, endemic plant communities of southern Oregon and northern California are globally significant, provide a source of tourism and are now threatened by the spread of yellowtuft. If the perfect weed disaster had been planned, it could hardly have been better executed. Despite these daunting challenges, a working group of concerned citizens, agencies, and non-profit organizations has formed to attempt to eradicate yellowtuft from Oregon.

Predicting Wind Dispersal of Rush Skeletonweed Within Canyon Grasslands of Central Idaho. Sandya Rani Kesoju*, Bahman Shafii, Timothy Prather, Larry W. Lass, William Price; University of Idaho, Moscow, ID (085)

Rush Skeletonweed (*Chondrilla juncea* L.) is a deep-rooted perennial forb in the family *Asteraceae,* growing 1m in height. It infests well-drained, light soils commonly found in the mountain foothills and canyon grasslands of the Northwest, and currently infests several million acres of rangeland and cropland in Washington, Oregon, Idaho, and Montana. The species can spread locally by rhizomes and longer distance via wind with a pappus-bearing seed. Our research objective was to produce a dispersal model that would aid land managers in their efforts to find new populations of this invasive plant species. A study area including the Salmon River Canyon, Idaho was used to develop wind dispersal model for rush skeletonweed. Wind speed and direction collected from RAWS USA climate archive were used to construct wind maps in order to create the wind dispersal models. Bivariate interpolation technique was used at 100x100m resolution and then converted to 10x10m resolution in the IDRISI software to create wind maps. The wind maps were then used in a multi-layer perceptron routine, along with aspect, elevation, and vegetation to produce predicted wind speed and wind direction. Predicted wind speed and direction were subsequently used in IDRISI GIS software using five area polygons as starting points to run the DISPERSE module. Several runs of the dispersal module were considered to evaluate settings of module parameters. Finally, wind dispersal maps were created that provide information about how far the rush skeletonweed seeds move and in which direction. The model resulted in 80-90 percent coverage of known infestations and showed the expected pattern and directionality of seed movement for the five areas. The distance of seed dispersal ranged from 4 to 12 km and consistently moved in the direction of the wind for the canyon grasslands of central Idaho.

Using Soil Bioassays to Assess Imazapic Degradation to Improve Cheatgrasss Management. Krista A. Ehlert*[1], Rick Engel[1], Jane Mangold[2]; [1]Montana State University - Bozeman, Bozeman, MT, [2]Montana State University, Bozeman, MT (086)

The herbicide imazapic is used to control the invasive annual grass downy brome (*Bromus tectorum*), but its efficacy in Montana has been inconsistent. The objectives of this study were to investigate imazapic persistence in the soil across a range of application rates (0, 279, 560, and 840 g ai/ha), in the presence and absence of litter. Field trials were established at two sites (rangeland and Conservation Reserve Program land (CRP)) with downy brome. Soil cores of 10 cm depth were collected at 0, 2, 4, 8, and 24 weeks following herbicide application and used for a cucumber (*Cucumis sativus* L.) bioassay in a greenhouse. Plants were grown for four weeks before biomass (root and shoot) was harvested. In soils collected from the rangeland site, cucumber biomass was reduced by 30 to 54% at all sampling dates, regardless of rate. In contrast, in soils from the CRP site, imazapic rate did not affect cucumber biomass 0, 2, and 4 weeks post-herbicide application. However, 8 weeks post-herbicide application, cucumber biomass was decreased by 50% when imazapic was applied at 560 or 840 g ai/ha. At 24 weeks, biomass across rates was 31 to 62% lower than the control. The results of this study show that imazapic persistence is influenced by rate depending on the site, and persistence is not influenced by litter.

Timing of Low Rates of Glyphosate for Control of Downy Brome in Rangeland. Earl Creech*[1], Kent McAdoo[2], Guy B. Kyser[3], Joseph M. DiTomaso[3]; [1]Utah State University, Logan, UT, [2]University of Nevada Cooperative Extension, Elko, NV, [3]University of California, Davis, CA (087)

Although glyphosate is usually used nonselectively, some researchers report that low rates can be applied over the top of established perennial plants for control of seedling annuals in the understory. In 2009 and 2010 we evaluated the effects of low rates of glyphosate for downy brome (*Bromus tectorum*) control and safety on sagebrush in two trials in northern Nevada sagebrush scrub (64 km north of Elko, Elko County, 1940 m elevation). We applied a rate series of 0, 79, 158, 237, 316, 395, 474, 553, 632, 711 g a.e. ha^{-1} glyphosate at two timings in each trial: mid to late April (downy brome in seedling to early tillering stage) and late May (boot stage). Plots were 3 m by 9 m in randomized complete blocks with four replications for each rate and timing. In early July before downy brome senescence, we made estimates of vegetative cover for all dominant species in three 1-m^2 quadrats per plot, and took biomass samples in three 0.1-m^2 quadrats per plot. Downy brome cover declined with increasing rates of glyphosate, and the late-season application was found to be most effective. In rate series regression models, we achieved 95% control of downy with 160 g a.e. at the late-season application timing. Downy brome seed production reflected changes in cover, although plants tended to compensate at low densities. Non-target forbs and perennial plants appeared tolerant to these treatments. With the right timing, overspraying with low rates of glyphosate may be an effective and relatively inexpensive technique for controlling downy brome in sagebrush ecosystems.

Response of Native Species to Imazapyr and Triclopyr Soil Residues. Cameron Douglass*, Scott J. Nissen; Colorado State University, Fort Collins, CO (088)

Imazapyr and triclopyr are frequently used to control woody invasive species like tamarisk. Our field research compares the relative impacts of aerial imazapyr applications to individual plant applications of imazapyr and triclopyr on tamarisk and understory plant communities. We have subsequently carried out a series of field and laboratory studies to quantify the herbicides' relative soil degradation rates and the sensitivity of common native species to herbicide soil residues. In the laboratory, six field soils ranging in texture from clay loam to loamy sand (organic matter content = 1.5 ± 0.57%) were uniformly moistened to 0.75X field capacity, treated with 1 µg/mL triclopyr and imazapyr solution and then incubated at 23 to 25 °C. Triclopyr degradation occurred 5.5 times faster than imazapyr degradation, and percent clay content was positively correlated with degradation. For field sensitivity studies, imazapyr and triclopyr (butoxyethyl ester) were applied at serial dilutions (1X, 0.5X, 0.25X, 0.125X, 0.063X, 0.031X and 0.016X) where X = 0.28 kg ai ha^{-1} and X = 3.92 kg ai ha^{-1}, respectively. Native grass and forb species were immediately seeded perpendicular to herbicide treatments. The two highest rates of both herbicides resulted in significant reductions in plant species establishment and growth. Overall species sensitivity varied, but western and slender wheatgrass were the most tolerant grass species tested, and wild licorice and common sunflower were relatively tolerant forbs. This study demonstrates that native species re-establishment can occur alongside woody invasive species management, and further aid in ecosystem restoration.

Aminocyclopyrachlor for Invasive Weed Control in Western Rangeland. Jim Harbour*[1], Norm McKinley[2], Keith Johnson[3], Bill Kral[4]; [1]DuPont Crop Protection, Lincoln, NE, [2]DuPont, Salem, OR, [3]DuPont Crop Protection, Wilmington, DE, [4]DuPont, Twin Falls, ID (089)

Aminocyclopyrachlor is a new herbicide candidate under development by DuPont Crop Protection. Aminocyclopyrachlor has a potential fit in many markets including rangeland and pasture. Field testing of aminocyclopyrachlor began in 2004 and registration was received in early 2011 for use in noncrop markets in premixtures and sold under several trade names. Aminocyclopyrachlor has both foliar and residual activity on a broad spectrum of broadleaf weeds. Premixtures with other herbicides including sulfonylureas are being investigated for broadleaf weed control in pastures including Leafy spurge (Euporbia esula), Canada thistle (Circium arvense), Musk thistle (Carduus nutans), Perennial pepperweed (Lepidium latifolium), kochia (Kochia scoparia), and Serecia lespedeza (Lespedeza sericea). The mixtures increase the spectrum of species controlled and will be beneficial in controlling or delaying the onset of ALS resistant species.

Aminocyclopyrachlor: A New Active for Brush Control in Range and Pasture. Craig M. Alford*[1], Jeff H. Meredith[2], Eric P. Castner[3], Case Medlin[4]; [1]DuPont Crop Protection, Lakewood, CO, [2]DuPont Crop Protection, Memphis, TN, [3]DuPont Crop Protection, Weatherford, TX, [4]DuPont Crop Protection, Wilmington, DE (090)

Aminocyclopyrachlor is a new herbicide from DuPont™ Crop Protection for the control of broadleaf weeds and brush in pasture and rangeland. Aminocyclopyrachlor has been tested under the DuPont research codes of DPX-MAT28 or DPX-KJM44 since 2005 and has been shown to control annual and perennial weeds as well as numerous brush species. Trials conducted in Texas have demonstrated control of key brush species including honey mesquite (*Prosopis glandulosa*) and huisache (*Acacia smallii*) with broadcast applications of aminocyclopyrachlor alone and in tank mixtures with other herbicides. Trials conducted in Texas, Oklahoma and New Mexico have also shown excellent control of key weed species including western ragweed (*Ambrosia cumanensis*), woolly croton (*Croton capitatus*), annual broomweed (*Amphiachyris dracunculoides*) and broom snakeweed (*Gutierrezia sarothrae*).

Aminocyclopyrachlor and Various Herbicides Applied to Relatively Large Russian Olive. Thomas J. Getts*[1], Philip Westra[2], Brad Lindenmayer[3], Dale L. Shaner[4]; [1]Colorado State University, Fort Collins, CO, [2]Colorado State University, Ft. Collins, CO, [3]Syngenta Crop Protection, Inc., Fort Collins, CO, [4]USDA, Fort Collins, CO (091)

Russian olive (*Elaeagnus angustifolia*), originally planted as windbreaks in Colorado, now is listed as a B List species on Colorado's noxious weed list requiring it to be eradicated, suppressed, or destroyed. Although it can grow in a variety of environments, it commonly invades wet riparian areas surrounding lakes and streamsides. This research project was undertaken to determine if various formulations of aminocyclopyrachlor offered commercial control similar to other currently accepted herbicidal cut stump treatments.

Two Russian olive sites were located in Colorado during the fall of 2010 about 50 miles apart, one along a streamside, and the other along a moist lakeshore. The study focused on larger *E. angustifolia*, as previous work showed that smaller diameter trees, less than 9 inches, were relatively easy to control. Across both sites the average diameter of the treated stumps was 16 inches, and the diameter of stumps treated ranged from 6 to 38 inches. Bole circumference was measured and trees were blocked into four size classes. Eighteen treatments including the control were applied at both research sites. The treatments tested consisted of 3 rates of four aminocyclopyrachlor formulations; KJM44-097, MAT28-112, MAT28-111, and MAT28-128. Two other treatments containing aminocyclopyrachlor were also tested; 5% Streamline and 5% Viewpoint. These were tested against the three currently accepted control treatments: 20% Garlon 4, 8% Habitat, and 50% Rodeo. Herbicides were mixed into JLB Oil Plus, a vegetable based basal bark oil.

Effects on Established Perennial Grasses of DPX-MAT 28 Combined with Selected Sulfonylurea Herbicides Applied in Spring. Gustavo M. Sbatella*[1], Robert G. Wilson[2]; [1]Oregon State University, Madras, OR, [2]University of Nebraska-Lincoln, Scottsbluff, NE (092)

Two field studies were initiated in spring of 2011, near Scottsbluff, NE to determine the response of established perennial grasses to different applications of DPX-MAT 28 combined with selected sulfonylurea herbicides when applied in spring. The site at the Panhandle Research and Extension Center was under irrigation, while the site located at University Lake was conducted in dry land conditions. The herbicide treatments were tested over 8 species of established perennial grasses, but orchardgrass, crested, and intermediate wheatgrass were the only species planted at both sites. Herbicide treatments included, DPX-MAT28 + chlorsulfuron (70 + 28 gr ai ha^{-1}; 133 + 49 gr ai ha^{-1}), DPX-MAT28 + metsulfuron (70 + 21 gr ai ha^{-1}; 133 + 42 gr ai ha^{-1}), DPX-MAT28 + rimsulfuron (70 + 70 gr ai ha^{-1}; 105 + 70 gr ai ha^{-1}), DPX-MAT28 + 2,4 D (70 + 525 gr ai ha^{-1}), and aminopyralid (123 gr ai ha^{-1}). The visual evaluations performed 15 days after treatment (DAT) indicated that the highest grass injury for orchardgrass, crested, and intermediate wheatgrass was observed when DPX-MAT28 was combined with rimsulfuron, regardless the rate. The impact of this treatment was associated with a significant stunting as reflected in the height reduction, and a decrease in the percent of plants that produced heads. No grass injury was recorded in Scottsbluff 140 DAT, while at University Lake grass injury was still evident on orchardgrass, crested, and intermediate wheatgrass. The three species showed signs of injury with DPX-MAT28 + rimsulfuron, while orchard grass and crested wheatgrass also showed signs of injury with DPX-MAT28 + metsulfuron.

Response of Duncecap Larkspur and Associated Vegetation to Aminocyclopyrachlor. Brandon J. Greet*, Andrew R. Kniss, Brian A. Mealor; University of Wyoming, Laramie, WY (093)

Duncecap larkspur is an important perennial weed on high elevation rangelands where cattle are grazed because of significant losses due to toxic alkaloids. Aminocyclopyrachlor was evaluated at rates between 17.5 and 315 g ai/ha for duncecap larkspur control alone and in combination with chlorsulfuron 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 3 m by 12 m plots on June 18, 2010, in a randomized complete block design with four replicates. 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 and aminocyclopyrachlor + chlorsulfuron provided maximum duncecap larkspur control of 96% and 99%, respectively; which did not differ statistically. Metsulfuron-methyl and picloram provided 100% and 41% control, respectively. Species diversity was reduced 5% and larkspur was controlled 82% when aminocyclopyrachlor was applied alone at 165 g ai/ha. The same rate of aminocyclopyrachlor plus chlorsulfuron increased control of duncecap larkspur to 96%, but reduced species diversity 41%. Graminoid biomass was not significantly impacted by herbicide or rate. Aminocyclopyrachlor may be a useful tool for duncecap larkspur control. Addition of chlorsulfuron to aminocyclopyrachlor increased larkspur control, but with a greater impact on plant diversity.

Soil Residual Activity of Aminocyclopyrachlor, Aminopyralid, and Clopyralid. Brad Lindenmayer*[1], Philip Westra[2], Scott J. Nissen[3], Dale L. Shaner[4], Thomas Mueller[5], Greg Armel[6]; [1]Syngenta Crop Protection, Inc., Fort Collins, CO, [2]Colorado State University, Ft. Collins, CO, [3]Colorado State University, Fort Collins, CO, [4]USDA, Fort Collins, CO, [5]Univeristy of Tennessee, Knoxville, TN, [6]University of Tennessee, Knoxville, TN (094)

Herbicide dissipation in the soil and herbicide adsorption to soil affects both plant availability and overall efficacy. Thus, a better understanding of aminocyclopyrachlor, aminopyralid, and clopyralid soil behavior was sought through field and laboratory experiments. In the field experiment, all three herbicides were applied at 1.12 kg ai ha^{-1} to bare soil and six 30 cm core samples were taken over a year to determine the dissipation rates of each herbicide and to observe any herbicide movement in the profile. In the laboratory experiment, six North American soils with varying soil properties were fortified with each of the three herbicides at a concentration of 1 μg g^{-1} and spiked with radiolabeled herbicide to determine soil adsorption. Results of the field experiment indicate that all three herbicides dissipate at similar rates under field conditions with soil half-lives of 32.5, 28.9 and 26.6 d for aminocyclopyrachlor, aminopyralid, and clopyralid, respectively. Aminocyclopyrachlor and aminopyralid were also observed to stay in the upper portion of the profile, while clopyralid displayed some mobility in the profile. Results of the laboratory experiment indicate that aminocyclopyrachlor would have the highest potential for soil adsorption, followed by aminopyralid, and clopyralid which has the least potential for soil binding with average K_d values across the six soils of 0.503, 0.378, and 0.236 mL g^{-1}, respectively. Soil adsorption of the herbicides was generally correlated with soil organic matter (OM) or texture, but not with pH. In general, the results of these experiments agreed with previously published research and shed new light on aminocyclopyrachlor soil behavior.

Desirable Reclamation and Restoration Species Seedling Response to Aminocyclopyrachlor. Holden J. Hergert*, Brian A. Mealor, Andrew R. Kniss, Rachel D. Mealor; University of Wyoming, Laramie, WY (095)

Aminocyclopyrachlor is registered for non-crop applications. One potential future use of aminocyclopyrachlor is weed management in reclamation and restoration. A greenhouse study was conducted in 2010 and repeated in 2011 to investigate the seedling response of 27 species accessions or cultivars and 2 exotic weeds, Russian thistle and downy brome, to aminocyclopyrachlor. Aminocyclopyrachlor was applied at rates of 10, 20, 40, 80, 160, and 320 g ha^{-1} 30 days after planting when grasses reached the 3 to 5 leaf stage and forbs and shrubs were less than 5 cm in height. Each treatment contained 7 replicates per study and all treatments included a nonionic surfactant at 0.25% v v^{-1}. Herbicide treatments were applied in a spray chamber delivering 187 L ha^{-1} at 276 kPa. A four parameter log-logistic model was used to estimate the dry weight reduction in response to aminocyclopyrachlor rate. Russian thistle biomass was reduced 90% at 105 g ha^{-1}. At the same rate, reduction in grass biomass ranged from 0 to 43%. Variation in growth reduction by aminocyclopyrachlor was observed among genera, species, and even among accessions within a species. At 105 g ha^{-1}, growth of all flax and sagebrush species was reduced ≥74%. If aminocyclopyrachlor were used in a reclamation or restoration situation for postemergence control of Russian thistle, most of the grasses in this experiment appear to be fairly tolerant; whereas the selected sagebrush and flax species were highly susceptible at this early growth stage even at low rates.

GF-2791 - A New Herbicide Containing Aminopyralid and Clopyralid for Honey Mesquite Control in Southwestern Rangelands. Daniel Chad Cummings*[1], Vernon Langston[2], Pat Burch[3], Vanelle F. Peterson[4]; [1]Dow AgroSciences LLC, Perry, OK, [2]Dow AgroSciences LLC, The Woodlands, TX, [3]Dow AgroSciences LLC, Christiansburg, VA, [4]Dow AgroSciences, Mulino, OR (096)

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 (280 g ae/ha) and clopyralid (280 g ae/ha) has been the industry standard for chemical control of honey mesquite. GF-2791, containing 276 g ae clopyralid olamine salt/L + 60 g ae aminopyralid potassium salt/L 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 20 research trials conducted from 2009 through 2011, aerial applications of GF-2791 at 2.4 L/ha (equivalent to 560 g ae clopyralid/ha + 120 ae aminopyralid/ha) gave 78% control of honey mesquite at about one year after application, compared to 66% with the current standard of 280 g ae/ha triclopyr + 280 g ae/ha clopyralid. A wide spectrum of common undesirable woody species including, black brush, cat claw mimosa, twisted acacia, and locust were also controlled. The addition of 280 g ae/ha of triclopyr ester increased the spectrum of the woody species controlled. GF-2791 is a new standard herbicide formulation that provides improved control of honey mesquite in North America.

Influence of Aminopyralid, Clopyralid, Metsulfuron, and Picloram Application Timing on Grass Establishment. Cameron Douglass*[1], Scott J. Nissen[1], Joseph D. Vassios[1], Corey V. Ransom[2], Vanelle F. Peterson[3]; [1]Colorado State University, Fort Collins, CO, [2]Utah State University, Logan, UT, [3]Dow AgroSciences, Mulino, OR (097)

The integration of chemical weed control with the establishment of competitive and functional plant communities is one successful strategy for long-term management of rangeland and pasture ecosystems. Native species and grasses in particular, are often seen as being especially desirable because they serve as forage and are also appropriate ecologically. However, there is insufficient empirical data on the impacts of residues from commonly used rangeland and pasture herbicides on seeded grasses. Our prior work has focused on the interaction of herbicide (aminopyralid and aminocyclopyrachlor) application timing relative to seedling growth, and found that seedling grasses are very sensitive to post herbicide treatments. On the other hand, all grasses were tolerant to pre-plant herbicide applications, and particularly those done the spring before seeding. Fall pre-plant applications resulted in some injury the following growing season, but did not significantly impact stand establishment and by the second year grass biomass was equivalent to hand-weeded control plots. So, this study was initiated to further examine the impacts of application timing of a wider selection of commonly used herbicides on native grass establishment. Picloram, aminopyralid, clopyralid, aminopyralid plus clopyralid, and aminopyralid plus metsulfuron methyl were applied pre-plant in spring and fall 2009 to a prepared seedbed. During the subsequent winter, six cool season native grasses (basin wildrye, big bluegrass, bluebunch wheatgrass, Siberian wheatgrass, slender wheatgrass, and western wheatgrass) were seeded perpendicular to the herbicide treatments. Grass biomass and growth parameters for each species have been determined annually at the end of 2010 and 2011 growing seasons. One year after treatment individual species responses to herbicides varied considerably, though Siberian wheatgrass was more consistently tolerant to all tested products. The only treatment that universally reduced seedling grass establishment was the fall pre-plant application of aminopyralid plus metsulfuron methyl. Two years after treatment neither herbicides nor application timings negatively impacted grass productivity. While all six grass species responded positively the second growing season, biomass of basin wildrye and western wheatgrass were substantially higher than the untreated control. Taken as a whole, these data confirm our earlier research indicating that pre-plant applications of herbicides made either the spring or fall prior to grass seeding can be successfully used to promote the establishment of native grasses while also controlling susceptible perennial weed species.

Managing Canada Thistle Invasion in Constructed Grasslands with Aminopyralid and Fire. Greta G. Gramig*, Amy C. Ganguli; North Dakota State University, Fargo, ND (098)

A field experiment was established during the summer of 2010 on constructed grasslands in Fargo, ND. Aminopyralid and prescribed fire were applied to control Canada thistle (*Cirsium arvense* L.) and to shift community composition toward native C_4 grass species. A completely randomized design comprised three treatments (control, aminopyralid-alone, aminopyralid + fire) and four replications. At peak summer biomass in 2011, Canada thistle stem density and canopy cover for all species were assessed in 18-0.25 m^2 quadrats in each 9x9 m plot. Grass species data were aggregated into two functional groups: non-native cool-season C_3 grasses and native warm-season c4 grasses. MANOVA was conducted to control for experiment-wise type 1 error rate for univariate comparisons among mean cover estimates for Canada thistle, C_3 grasses, and C_4 grasses. Wilks' Lambda statistic was highly significant. Subsequently, univariate ANOVAs showed that Canada thistle stem density decreased in the treated plots compared to the controls, but thistle density did not differ between aminopyralid-alone and aminopyralid +fire. Similarly, Canada thistle cover was substantially reduced in the treated plots compared to the controls, but did not differ between aminopyralid-alone and herbicide+fire. Cover of C_3 grasses increased in the aminopyralid-only plots compared to the control. Cover of C_4 grasses did not differ among any treatments, including the control. Aminopyralid-alone and aminopyralid + fire were equally effective for Canada thistle control, but aminopyralid-alone encouraged a shift to greater C_3 grass cover. Cover of C_4 grasses was not increased by fire. However, an additional planned spring 2012 burn may encourage greater C_4 grass cover.

Indaziflam - A New Herbicide for the U.S. Industrial Vegetation Market. Hans C. Olsen*[1], David Spak[2]; [1]Bayer CropScience, Wildomar, CA, [2]Bayer CropScience, RTP, NC (099)

Indaziflam is a newly registered herbicide for pre-emergent control of annual grasses and broadleaf weeds in areas such as roadsides, industrial sites and railroads. Indaziflam is a cellulose biosynthesis inhibitor (CBI), and represents a novel mode of action for resistance management and long-term residual activity. Indaziflam provides broad-spectrum control of over 75 weed species, including grasses, broadleaf weeds and annual sedges. Research trials have shown the long-term performance of indaziflam tank mixes on tough 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 bromes (*Bromus* spp.), wild barleys (*Hordeum* spp.), medusahead (*Taeniatherum caput-medusae*) and sprangletop (*Leptochloa* spp.).

Implementation of IPM Strategies on a Remote, Insipient Infestation of Spotted Knapweed in Fremont County, WY. John (Lars) L. Baker*[1], Kimberly K. Johnson[1], Mike Wille[2], Nancy A. Webber[1]; [1]Fremont County Weed and Pest, Lander, WY, [2]Fremont County Weed and Pest Control District, Riverton, WY (153)

A case study of discovery, inventory, biological control, chemical control, and grazing managment on an isolated inaccessable infestation of Spotted knapweed over a ten year span of time in northern Fremont County, Wyoming

Russian Knapweed Control and Grass Establishment in Response to Tillage and Herbicide Applications. Scott J. Nissen*[1], Corey V. Ransom[2], Vanelle F. Peterson[3], Joseph D. Vassios[1], Cameron Douglass[1]; [1]Colorado State University, Fort Collins, CO, [2]Utah State University, Logan, UT, [3]Dow AgroSciences, Mulino, OR (154)

Russian knapweed is an invasive, herbaceous perennial that is well adapted to many semi-arid regions of the Western US. It is drought tolerant and once established has the potential to produce dense monotypic populations. Due to competition for limited resources and allelopathic exudates from the root system Russian knapweed can often out compete native grasses. Field sites with dense Russian knapweed infestations were established in Colorado (CO) and Utah (UT) to evaluate the impact of tillage and herbicide treatments on the establishment of five native and one non-native perennial grass. The experimental was a strip, split plot design where tillage was the main effect, herbicide treatment was the sub-plot and grass species was the sub-sub-plot. The tillage treatment consisted of discing followed by roller-harrow. The herbicide treatments were; control, aminopyralid (3 and 7 oz prod/ac), clopyralid (16 oz prod/ac), aminopyralid plus clopyralid (3 + 9.3 oz prod/ac), picloram (32 oz prod/ac), and aminocyclopyrachlor (2.5 dry oz prod/ac). Herbicides were applied in September 2009 and grasses were seeded in December 2009 (UT) or April 2010 (CO). The planted native species were slender wheatgrass, basin wildrye, bluebunch wheatgrass, big bluegrass, and western wheatgrass. The non-native species was Siberian wheatgrass. The two sites differed in rainfall patterns during the course of the experiment. Rainfall was close to average in Colorado both years, while the Utah site was extremely dry in 2010 and wetter than normal in 2011. At the Colorado site north of Fort Collins, Russian knapweed control was 100% across all herbicides 2 YAT and tillage had no impact on Russian knapweed control or grass establishment. All grasses established well compared to the untreated control, with the exception of big bluegrass. Even aminopyralid at 3 oz prod/ac provide 100% control 2 YAT when combined with competition from seeded grasses. At the Utah site, the lack of adequate rainfall in 2010 resulted in no grass establishment the year after seeding; however, grasses did establish in 2011. Tillage had a significant impact on Russian knapweed control at the Utah site. All herbicide treatments provided acceptable control when combined with pre-plant tillage, but aminopyralid at 3 oz and clopyralid failed to provide acceptable control under no-till conditions. While there were significant environmental differences (rainfall patterns) between these two field sites, the bottom line is that we were able to establish grasses in sites that had been dominated by Russian knapweed. There are a number of herbicide options that would allow land managers to tailor a management program that included grass establishment. These data suggest that under dry conditions picloram might be a better option than clopyralid or low rates of aminopyralid. In areas with sufficient rainfall aminopyralid at 3 oz prod/ac provided excellent Russian knapweed control and rapid grass establishment.

Monitoring and Simulating the Spatial Distribution Change of Invasive Plant Species Using Geospatial Information Technologies. Sunil Narumalani[1], Qingfeng (Gene) Guan[2], Stephen L. Young*[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Univeristy of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, North Platte, NE (155)

Advanced geospatial information technologies, including remote sensing, geographic information systems, and Global Positioning Systems, provide efficient means to acquire and manage information/data about species and the climatic/environmental conditions that potentially affect the invasion process. Invasive plant species are one of the biggest threats to the environment. The occurrence of non-native common reed (*Phragmites australis*) in the main tributary (Platte River) of Nebraska has a direct effect on the availability of water for agriculture and roosting sites for migratory and indigenous avian species. Reduced water flow from invasive plant species infestations has been estimated to be near 50% in some locations. Extensive knowledge of the complex relationships among species (i.e., coexistence and competition), and between species and the environment and an assessment of management strategies using models is lacking. Our objectives were to identify distributions and predict movements of non-native common reed in the Platte River. For two years, we analyzed plant communities in the study areas and compared mapped populations over years and by treatments (e.g., sprayed, mowed, or cultivated). We found that non-native common reed had changed significantly between 2006 and 2010. In addition, non-native common reed populations were most reduced in the treated areas. Modeling has indicated that the most susceptible areas for continued infestation are those furthest from the main river channel. This information will help inform practitioners on the potential for designing management plans and implementing control strategies.

Status of Biological Control Projects on Yellow Starthistle, Russian Thistle, Scotch Thistle, Cape-Ivy and French Broom. Lincoln Smith*; USDA-ARS, Albany, CA (156)

The USDA-ARS quarantine laboratory in Albany, CA, in cooperation with foreign scientists, is currently developing classical biological control agents for five species of invasive alien terrestrial weeds. Host specificity testing of the yellow starthistle rosette weevil, *Ceratapion basicorne*, indicates that it does not attack safflower under field conditions and that it has low preference for bachelor's button. Host specificity tests are being conducted on a weevil, *Larinus filiformis*, that attacks seedheads. The eriophyid mite, *Aceria salsolae*, which stunts Russian-thistle, can attack six closely related species of *Salsola* and sometimes multiply on *Bassia hyssopifolia* and *Bassia scoparia* in no-choice laboratory experiments. A stem-boring seed-feeding caterpillar, *Gymnancyla canella*, is being evaluated for specificity. For Scotch thistle control, three weevils (*Larinus latus*, *Trichosirocalus briesei* and *Lixus cardui*) that have been released in Australia are being evaluated for risk to native thistles (*Cirsium* spp.). A petition has been submitted to USDA-APHIS requesting permission to release two agents of Cape ivy: a gall-forming fly, *Parafreutreta regalis*, and a stem-boring moth, *Digitivalva delaireae*. For French broom, a psyllid, *Arytinnis hakani*, that is killing plants in Australia is being evaluated for risk to native lupines.

Control of Mesquite-Pricklypear Complex with Aerial Herbicide Applications. William L. Hatler*, Charles R. Hart; Texas AgriLife Extension Service, Stephenville, TX (157)

Two of the most noxious and difficult to control species on southwestern rangelands, mesquite and pricklypear, often occupy the same environment. Control of pricklypear in this complex has been difficult due to physical obstruction of broadcast chemical applications by mesquite foliage, creating the need for separate applications on both species. This project was designed to look at application techniques for treating both mesquite and pricklypear with a single aerial application. Herbicide applications by helicopter, which allow precision applications with high total spray volume and large droplet size, have historically been done almost exclusively in forestry settings. We test the use of this technology on the mesquite-pricklypear complex to allow for spray droplet penetration through the mesquite canopy, resulting in increased coverage and greater control of pricklypear and mesquite with a single application. Aerial herbicide applications were made in 2003-2008 comparing tank mixes of Tordon 22K or Surmount with Reclaim and Remedy at variable total spray volumes. The helicopter spray boom was equipped with either large droplet Accuflo nozzles, small droplet CP nozzles or an alternating combination of the two. Results indicate that applications of the tank mix of Surmount, Reclaim and Remedy at a total spray volume of 15 gallons per acre with the combination of Accuflo and CP nozzles provide an optimum level of apparent mesquite and pricklypear mortality.

Testing Control Options for Western Salsify on Conservation Reserve Program Lands in Montana. Jane Mangold*; Montana State University, Bozeman, MT (158)

Western salsify (*Tragopogon dubius*) has recently formed dense stands in rangeland and Conservation Reserve Program (CRP) lands in northern Montana. My objective was to test the effects of various herbicide treatments and mowing on western salsify and associated vegetation in CRP lands. In spring 2010, six herbicide and one mowing treatments were applied at three sites with varying densities of western salsify. Herbicide treatments included combinations of glyphosate, 2,4-D, dicamba, and/or metsulfuron applied when western salsify was either in the rosette or bolting stage. Mowing was applied at the bolting stage. Western salsify rosettes and flowering plants and annual and perennial grass density and biomass were sampled in August 2010 and 2011. Data were analyzed using a mixed model analysis of variance. Herbicide treatments reduced western salsify and increased perennial grass only at the highest density (34 plants/m^2) site. When dicamba (140 g a.i./ha) plus 2,4-D (333 g a.i./ha) was applied at the rosette stage, western salsify flowering plant density and biomass were reduced to zero and perennial grass biomass increased by 108% in 2010. In 2011 western salsify flowering plant density was lower across all herbicide treatments compared to the mowed and non-treated plots. Western salsify rosette density decreased across treatments from 2010 to 2011, but remained high in the non-treated control (40 plants/m^2). Annual grass density increased by up to 400% compared to the non-treated control when dicamba, 2,4-D, and metsulfuron were combined and applied at the bolting stage. Timing of application appeared to be important because treatments applied during the rosette stage generally outperformed similar herbicide applications during bolting. Mowing did not control western salsify. Results suggest dicamba plus 2,4-D applied at the rosette stage can provide effective control of western salsify and increase perennial grasses without stimulating annual grasses.

Suppressing Downy Brome Following Wildfires. Charlie D. Clements*[1], Daniel Harmon[2]; [1]USDA, Reno, NV, [2]USDA-ARS, Reno, NV (159)

Downy brome, more widely known as cheatgrass, has invaded millions of hectares of rangelands throughout the Intermountain West. Downy brome provides a early maturing, fine-textured fuel that has increased the chance, rate, season and spread of wildfires. In July 2006, a wildfire burned a xeric Wyoming big sagebrush community in northern Nevada. We implemented an experiment to test the importance of 1) timing of restoration/rehabilitation efforts, 2) mechanical weed control, and 3) plant species potential to be artificially seeded as well its' ability to suppress downy brome. Sixty 20m x 60m plots were established, in which 30 plots were seeded in the fall of 2006 and the remaining 30 plots seeded in the fall of 2007. Half of each plot was disced to test this mechanical weed control practice of downy brome. The 2006 plots were disced in August of 2006, while the 2007 plots were disced in May 2007 and summer fallowed. The seeded treatments were A) 'Hycrest' crested wheatgrass, B) Sherman big bluegrass, C) Bottlebrush squirreltail, and D) a mixture of these species with Indian ricegrass, Wyoming big sagebrush, 'Immigrant' forage kochia and 'Ladak' alfalfa. Discing did decrease the germination density in the seed bank 300.5/m² down to 88.6/m² in the 2006 plots and 382.1/m² down to 182.2/m² in the 2007 plots. There were no significant differences when comparing seeded species survival in the disced –vs- undisced plots though.. The 2006 seeded treatments A) crested wheatgrass and D) mix were most successful at establishing, 9.3/m² and 9.7/m² compared to B0 Sherman big bluegrass, .75/m², and C) squirreltail, 1.1/m², respectfully. Establish (two year old plants) seeded treatments A) crested wheatgrass and D) mix, significantly reduced downy brome densities, 6.2/m² and 7.5/m² compared to 126.1/m² for big bluegrass and 175.6/m² for squirreltail. Added downy brome suppression was also recorded for those plots seeded the first fall following the wildfire (2006) as increased success of seeded species was experienced.

Efficacy Trials for Total Vegetation Control in the Pacific Northwest. Harvey A. Holt*[1], Galen M. Wright[2], Joshua Sharpes[3]; [1]Green Systems Analytics, LLC, Seattle, WA, [2]Washington Forestry Consultants, Inc., Olympia, WA, [3]Washington Forestry Consultants Inc, Olympia, WA (160)

Herbicide tests were established in Washington in 2011 to assess their potential for total vegetation control. Consequently, most of the test sites were located on or around railroads and roadside. Treatments were applied in April with a backpack sprayer equipped with off-center type nozzles to treat approximately a 15-foot swath. Treatments were applied at the rate of 30 gallons per acre in 2L mixes. A randomized complete block with four replicates was the standard experimental design. Unless otherwise specified, all treatments contained 1-2 lb glyphosate and 1/4% NIS.

The primary weed species at the BNSF yard at Auburn, WA, was witchgrass late in the growing season. After 110 days treatments resulting in more than 90% bare ground included (all rates are per acre): 1. flumioxazin @ 4 oz + sulfometuron methyl @ 1.6 oz + metsulfuron methyl @ 0.45 oz + bromacil @ 1.6 lb; 2. flumioxazin @ 5 oz + bromacil @ 2.4 lb; 3. aminocyclopyrachlor @ 4 oz + bromacil @ 3.2 lb; 4. V-10233 @ 8 oz or 10 oz (flumioxazin 33.5%, pyroxasulfone 42.5%); 5. V-10233 @ 10 oz + prodiamine @ 2.5 lb.

The line-of-road treatments on the Chelatchie Prairie railroad near Yacolt, WA, were to control an array of broadleaf weeds such as fringed willowherb, marestail, and wild carrot. Treatments resulting in more than 90% bare ground 144 DAT included: 1. sulfometuron methyl @ 3 oz; 2. indaziflam @ 1 oz + sulfometuron methyl @ 3 oz; 3. Viewpoint @ 13 oz (aminocyclopyrachlor 22.8%, imazapyr 31.6%, metsulfuron methyl 7.3%) + 1% MSO; 4. V-10233 @ 10 oz; 5. V-10233 @ 10 oz + prodiamine @ 2.5 lb; 6. aminopyralid @ 1.75 oz + topramezone @ 1.4 oz + prodiamine @ 2 lb; 7. aminopyralid @ 1.75 oz + topramezone @ 1.4 oz + sulfometuron methyl @ 2.25 oz.

A herbicide test to control kochia (major species) and Russian thistle (minor species) was established on the Yakima Central railroad near Harrah, WA. At 159 DAT, treatments resulting in more than 90% bare ground included: 1. indaziflam @ 1 oz + Perspective @ 4.75 oz or 7.5 oz (aminocyclopyrachlor 39.5%, chlorsulfuron 15.8%); 2. aminocyclopyrachlor @ 2 oz + rimsulfuron @ 0.75 oz; 3. aminocyclopyrachlor @ 2 oz + bromacil @ 1.6 lb

A herbicide test was established on a UP siding in Kennewick, WA, where the primary species was Russian thistle. There were only three replicates at this site. At 157 DAT, treatments providing more than 90% bare ground included: 1. flumioxazin @ 5 oz + sulfometuron @ 2.25 oz + metsulfuron @ 0.6 oz + picloram @ 4 oz + 1/4% MSO; 2. indaziflam @ 1 oz + Perspective @ 4.75 oz or 7.5 oz; 3. aminocyclopyrachlor @ 3 oz + rimsulfuron @ 0.75 oz; 4. aminocyclopyrachlor @ 2 oz + bromacil @ 1.6 lb; 5. aminopyralid @ 1.75 oz + topramezone @ 1.4 oz + prodiamine @ 2 lb; 6. aminopyralid @ 1.75 oz + topramezone @ 1.4 oz + sulfometuron methyl @ 2.25 oz; 7. topramezone @ 1.4 oz + prodiamine @ 1.5 lb.

A herbicide test was established on a roadside near Wallula, WA, to control an array of weeds including gray rabbitbrush, yellow starthistle, and prickly lettuce. At 182 DAT, treatments resulting in more than 90% bare ground included: 1. Viewpoint @ 13 oz or 16 oz or 20 oz + 1% MSO; 2. aminopyralid @ 1.75 oz + topramezone @ 1.4 oz + prodiamine @ 2 lb; 3. topramezone @ 1.4 oz + prodiamine @ 1.5 lb.

Toward Herbicidal Control of Buffelgrass. John H. Brock*; Brock Habitat Restoration and Invasive Plant Management, Tempe, AZ (161)

Herbicide trials for the control of buffelgrass (*Pennisetum cilare*) were conducted at Arizona State University Tempe in 2008, 2009 and 2010. The first two trials were broadcast sprayed. In 2010 the plants were sprayed to "canopy" wet. Some of the herbicides applied in 2008 and 2009 initially looked promising, but within about a year, the majority of the buffelgrass plants had returned to normal growth status. In September 2010, herbicides that previously showed some effectiveness for buffelgrass control, were applied in a 2 % herbicide solution sprayed to a foliage wet condition, with 1 % seed oil as a surfactant. Fourteen months after the 2010 treatment, several herbicides are showing excellent buffelgrass canopy mortality. Those herbicides include; glyphosate, imazapyr, nicosulfuron, sulfometuron, and a combination of nicosulfuron plus sulfometuron. Nicosulfuron and the treatment combining nicosulfuron plus sulfometuron had scores of 100 % canopy mortality, compared to 89 % mortality from glyphosate. Monitoring in 2012 of the 2010 treatments will be made to ascertain if the buffelgrass plants initiate crown sprouting, as has been observed in earlier studies. Future tests should be made to Sonoran desert vegetation invaded by the buffelgrass so that of herbicide selectivity to the non-target native plant community can be measured.

Efficacy of Glyphosate and Imazapic Mixtures for Postemergence Control of Buffelgrass. Travis M. Bean*[1], William B. McCloskey[1], Grant Casady[2]; [1]University of Arizona, Tucson, AZ, [2]Whitworth University, Spokane, WA (162)

Buffelgrass (*Pennisetum ciliare*) is a perennial African bunchgrass that aggressively outcompetes native Sonoran Desert species for water and nutrients and initiates a grass-fire cycle that results in ecosystem replacement. Various herbicides have been tested for efficacy on buffelgrass but only glyphosate has been able to kill mature plants in a single application. However, glyphosate has no soil activity and repeated treatments in successive years are required to reduce the buffelgrass soil seed bank and achieve lasting control. Our objectives were to determine if imazapic can reduce the need to repeat herbicide treatments by providing preemergence control of buffelgrass and if imazapic-glyphosate mixtures can improve the postemergence control of buffelgrass. We used a full-factorial experimental design to evaluate mortality of buffelgrass plants sprayed with imazapic, glyphosate or combinations of the herbicides and to evaluate buffelgrass seedling densities following treatment. Imazapic enhanced glyphosate effectiveness for post emergence buffelgrass control, but seedling emergence in the study area was insufficient to evaluate pre emergence effects.

Biology and Management of Hare Barley in Cool-Season Grass Pastures. Andrew G. Hulting*, Jessica L. Haavisto, Gene Pirelli; Oregon State University, Corvallis, OR (163)

Hare barley (*Hordeum murinum* ssp. *leporinum*) is a cool season annual grass that invades pastures and range areas around the world. A documented weed management issue in several Oregon counties, hare barley may infest several thousand acres in western Oregon. Studies were conducted to investigate the biology and develop management options for hare barley in cool season, established perennial grass pastures. Field and laboratory studies were initiated in the fall of 2008 to generate this information for hare barley management. Experiments were conducted to evaluate herbicide treatments applied before and after hare barley emergence in perennial grass pastures. Multi-year applications of a labeled pasture herbicide, aminopyralid, and non-pasture labeled herbicides, imazamox and imazamox + MCPA ester, were the only treatments that consistently resulted in a high level of hare barley control with acceptable crop safety. A laboratory experiment was initiated to develop a growing degree day model to understand when viable seed is produced in hare barley. We determined that viable seed set depends on cumulative growing degree days (GDD) regardless of the location from which the seeds were collected. The majority of hare barley seed becomes viable after accumulating approximately 2300 GDD. This result indicates that individual pasture owners and hay producers can monitor growing degree days in their respective farming locations and base their management strategies for controlling hare barley and for preventing the spread of hare barley to other locations prior to viable seed production.

Utlizing Herbicide Treatments for Ventenata and Medusahead Encroachment in a Central Oregon Native Bunchgrass System. Fara A. Brummer*[1], Marvin D. Butler[2], Rhonda B. Simmons[2]; [1]Oregon State University Extension, Warm Springs, OR, [2]Oregon State University, Madras, OR (164)

Medusahead (*Taenetherium caput-medusae*) and Ventenata (*Ventenata dubia*) are aggressive annual weeds that are rapidly degrading range and wild lands of the Pacific Northwest. A compromised forage base for livestock and wildlife, increased risk for wildfire, erosion, and displacement of perennial grasses are consequences of these introduced species. Plot trials for their control were established in central Oregon at Warm Springs, in a rangeland area with clay dominated soil, where native bunchgrasses still remained despite encroachment by medusahead and ventenata. Four different herbicides were applied in the fall of 2008 to 10-ft by 25-ft plots replicated four times. Herbicides and rates were as follows: 0.09 lb ai/A of imazapic, 0.09 lb ai/A of imazapic + 0.18 lb ai/A of glyphosate, 0.06 lb ai/A of rimsulfuron, and 0.02 lb ai/A of sulfometuron + 0.01 lb ai/A of chlorsulfuron. Herbicide treatments also included a silicon surfactant at 0.25 percent v/v. Application was done using a CO2-pressurized hand-held boom sprayer outfitted with TeeJet 8002 nozzles on a 9-ft boom operated at 40 psi, with 20 gal water

/acre applied. Herbicide efficacy and bunchgrass response were evaluated every year in the early summer following treatments. All four herbicides provided 100 percent control of both medusahead and ventenata in the year following application. In 2010, two years after application, residual efficacy for the four herbicides dropped, with control rates of 60% to 95% for medusahead and 60% to 81% for ventenata. None of the bunchgrasses appeared negatively affected by the herbicide applications.

PROJECT 2: WEEDS OF HORTICULTURAL CROPS

Why Common Lambsquarters May Become a Problem Weed in Idaho Potatoes. Pamela Hutchinson*; University of Idaho, Aberdeen, ID (100)

Common lambsquarters (*Chenopodium album* L.) is a weed often found in Pacific Northwest potato production fields. Dimethenamid-p, EPTC, flumioxazin, fomesafen, and rimsulfuron - herbicides used in potatoes to control hairy nightshade (*Solanum sarrachoides* Sendt.) and other nightshade weeds, do not always provide adequate, season-long common lambsquarters control. In addition, this weed can be somewhat tolerant of glyphosate used on Roundup Ready sugar beet or corn, crops now being grown in rotation with potatoes. Hence, common lambsquarters may become more dominant in potato production areas compared with occurrence in current weed spectrums. Tank-mixing and rotating to herbicides with different modes of action are practices which have long been included in weed management recommendations for potato cropping systems, and more recently, have been touted as critical for preventing or delaying the development of herbicide resistant weed populations. In light of the herbicide choices mentioned, additional emphasis also should placed on including appropriate tank-mix partners which control common lambsquarters in potatoes, and combining glyphosate with herbicides which can do the same in Roundup Ready crops grown in potato rotations.

Potato Daughter Tuber Response to Aminopyralid. Kevin B. Kelley*, Lloyd C. Haderlie; AgraServ, Inc., American Falls, ID (101)

Auxinic herbicides that have become available over the last few years are very effective on several broadleaf weeds. One of these, aminopyralid, is commonly used in range and pastures. However, off-target injury to broadleaf crops can be troublesome, and injury by aminopyralid to potatoes prompted this research. Potatoes were evaluated for their sensitivity to aminopyralid compared to picloram, dicamba, and clopyralid under several off-target scenarios: fall soil-applied carryover, spring preplant drift, in-season response to early and mid-season drift, and late-season drift before harvest. Aminopyralid caused injury and yield losses of potatoes the year of application (2010) at rates similar to or lower than picloram (paper number 93 - 2011 WSWS annual meeting). The potential for aminopyralid to be carried over in seed potatoes and cause injury and yield loss the following year (2011) was evaluated. The timing of the exposure had an effect on the level of injury and the potential for yield loss. Aminopyralid applied to soil the fall (2009) before planting potatoes had the least effect on potato growth (both the year of and the following year) with some injury but no yield loss at the rates tested from daughter tubers planted in 2011. Aminopyralid applied to soil soon before planting potatoes resulted in injury and yield losses at the lowest rates with 0.44 g ai/ha (0.5% of a use rate) causing yield losses the year of application and a reduction in quality the following year. Aminopyralid applied in-season at 4.4 g ai/ha (5% of a use rate) resulted in injury and yield losses. Aminopyralid applied in-season at 0.44 g ai/ha caused foliar injury but no yield loss the year of application, and did not affect the potatoes from the seed grown out the following year. Aminopyralid applied soon before harvest at 4.4 g ai/ha also caused yield loss in potatoes planted the following season. Much higher rates of dicamba and clopyralid were required to cause injury. Picloram caused injury and yield losses at rates similar to aminopyralid. However, in some scenarios, aminopyralid caused greater damage than picloram at similar rates. As newer herbicides are developed, evaluating their effect on sensitive crops can determine which crops are most sensitive. This would assist growers and applicators know when to take extra precautions to avoid losses caused by off-target movement.

Management of Weeds in Processing Onions Grown in Northeast California. Rob G. Wilson*[1], Steve B. Orloff[2]; [1]University of California, Tulelake, CA, [2]University of California, Yreka, CA (102)

High weed populations in processing onions decrease yield, reduce onion stand density, and cause problems at harvest. Research was conducted at the Intermountain Research and Extension Center in Tulelake, CA during 2009 to 2011 to evaluate the efficacy and crop safety of pre- and postemergence herbicides in processing onions. Treatments included broadcast preemergence herbicides applied at planting and the loop onion growth stage, postemergence herbicides broadcast applied starting at the 1.5 leaf onion growth stage, and the combination of preemergence and postemergence herbicides. The efficacy of chemigation applications was evaluated in separate trials using a small-plot chemigation system. These trials indicated the best weed control resulted from treatments that combined preemergence herbicides with postemergence applications of oxyfluorfen applied at the 1.5 leaf onion growth stage followed by oxyfluorfen + bromoxynil applied at the 2.5 leaf onion growth stage. The most efficacious preemergence herbicide treatments with minimum onion injury and yield loss on multiple soil types included: DCPA applied at planting, DCPA + ethofumesate at 0.5 lb ai/A applied at planting, and pendimethalin at 0.7 lb ai/A applied at the loop stage. Treatments that included preemergence application of ethofumesate at 1 lb ai/A + pendimethalin at 0.7 lb ai/A applied at the loop stage and oxyfluorfen + bromoxynil + dimethenamid-p applied at the 2.5 leaf stage provided excellent weed control, but they decreased onion stand and onion yield compared to the control.

Announcing the Existence of Cyperus esculentus var. heermannii in Eastern Oregon. Joel Felix*[1], Kevin V. Osborne[2]; [1]Oregon State University, Ontario, OR, [2]Oregon State University, Nyssa, OR (103)

Yellow nutsedge (*Cyperus esculentus* L.) is a troublesome weed with broad infraspecific variation across the world. There are five recognized varieties within *Cyperus esculentus*, namely var. *esculentus*, var. *Sativus*, var. *leptostachyus*, var. *macrostachyus*, and var. *heermannii*. The later four varieties occur in the Americas as well as in Europe and North America. Variety *esculentus* dominates in Africa and southern Europe and var. *leptostachyus* is widely distributed in the United States. Variety *Sativus* is cultivated in some parts of Africa, Europe, China, and South and North America. Variety *heermannii* is described as being rare and only existing in California, Utah, Florida, and Mexico. We report the existence of var. *heermannii* in eastern

Oregon in the region known as the Treasure Valley. The Treasure valley is also heavily infested with var. *leptostachyus,* that was in all of the fields surveyed. The five varieties are mainly differentiated by the inflorescences and tuber size. The survey was conducted during summer 2011 in the fields east and west of highway 201 from 43° 46' 03.31" N, -117° 05' 51.39" W (elevation 726 m asl) to 44° 14' 41.98" N, -116° 59' 39.89" W (elevation 683 m asl). *Cyperus ecsulentus* var. *heermanni* was found in fields planted to onion (*Allium cepa*), sugar beet (*Beta vulgaris*), and pinto beans (*Phaseolus vulgaris*). Ten plants were randomly sampled from each of 10 fields arbitrarily chosen for the survey. Each plant was measured for culm length from the ground to the base of the inflorescence, number of leaves per plant, and the length of the longest leaf. Inflorescences were evaluated for the number of bracts, bract length, the number of rays, and the number of spikelets per ray. The average culm length, number of leaves per plant, and the longest leaf were 48 cm, 7, and 47 cm, respectively. The average number of bracts, bract length, and the number of rays per inflorescence were 12, 19 cm, and 8, respectively. The average ray length was 12 cm, with an average of 31 spikelets per ray. The average dry weights for the leaves, culm, bracts, rays, and roots per plant were 1.1, 1.3, 0.4, 1.5, and 1.2 g, respectively. Additional research is underway to characterize var. *heermannii* for the time of emergence, flowering date, tuber production, and germination under the Treasure Valley conditions.

The Challenge of Chicory as a Crop and a Weed. Don W. Morishita*, Donald L. Shouse; University of Idaho, Twin Falls, ID (104)

Chicory (*Cicorhium intybus* L.), a short-lived perennial plant, is gaining popularity in the food processing industry because of inulin produced in the root. In the seedling stage, chicory is small and susceptible to early weed interference. Studies were conducted in southern Idaho to: 1) evaluate currently registered and non-registered herbicides for weed control in chicory; 2) evaluate herbicide combinations for volunteer chicory control in field corn and spring wheat; and 3) investigate root re-growth potential to find better ways to control it. Herbicides evaluated for weed control in chicory included trifluralin (applied PPI), rimsulfuron:thifensulfuron (2:1 ratio), flumetsulam, imazamox, and triflusulfuron (applied postemergence); and cycloate, dimethenamid-P, EPTC, pendimethalin, and *s*-metolachlor applied in combination with rimsulfuron:thifensulfuron. Of these herbicides, trifluralin, rimsulfuron:thifensulfuron, dimethenamid-P, and *s*-metolachlor have been the most effective controlling common lambsquarters, redroot pigweed, kochia, annual sowthistle, hairy nightshade and green foxtail. Trifluralin, imazamox and triflusulfuron are currently registered for use in chicory. Volunteer chicory control in field corn and spring wheat has not been very successful. Herbicides evaluated in wheat have included clopyralid:2,4-D(1:7.64 ratio), fluroxypyr:clopyralid (1:1.1 ratio), thifensulfuron:tribenuron (1:1 ratio), florasulam:fluroxypyr:pyroxsulam (1:57.9:6 ratio), pyrasulfotole:bromoxynil (1:4.9 ratio), fluroxypyr. All of these herbicides, except florasulam: fluroxypyr:pyroxsulam controlled volunteer chicory 75 to 85% until about mid-July. By harvest, volunteer chicory control was unacceptable and grain yields averaged only 75 to 80 bu/A. In field corn, herbicides evaluated included glyphosate + mesotrione + atrazine, glyphosate + clopyralid:2,4-D, glyphosate + fluroxypyr:clopyralid, glyphosate + diflufenzopyr, glyphosate + thifensulfuron + atrazine, and glyphosate + thifensulfuron + atrazine + fluroxypyr. Glyphosate + diflufenzopyr, glyphosate + clopyralid:2,4-D, and glyphosate + fluroxypyr:clopyralid controlled chicory 81 to 83% 29 days after application, but corn yields were only 41 to 57 bu/A. Chicory root re-growth studies showed that chicory roots cut into 5 cm lengths could produce many new shoots and roots. Root burial studies showed that shoots could emerge from whole roots buried 30 cm below soil surface. Roots buried 60 cm below soil surface produced shoots, but had only grown about 15 cm. Additional studies are continuing to better understand chicory reproductive potential from buried root pieces.

Evaluating Methyl Bromide Alternatives for Commercial Vegetable Production: From Small-Plot to On-Farm Trials. Lynn M. Sosnoskie*[1], Alfred S. Culpepper[1], Theodore M. Webster[2]; [1]University of Georgia, Tifton, GA, [2]USDA-ARS, Tifton, GA (105)

In Georgia, the loss of MeBr directly impacts the production and profitability of several fruiting vegetables [specifically, pepper (*Capsicum annuum* L.), eggplant (*Solanum melogena* L.), and tomato (*Lycopersicum esculentum* Mill)) and cucurbits (specifically, squash [yellow (*Cucurbita pepo* L.)], melons [watermelon (*Citrullus lanatus* (Thunb.) Matsum and Nakai) and cantaloupe (*Cucumis melo* L.)], and cucumbers (*Cucumis sativus* L.). Combined, these crops have a farm gate value of more than $400 million. Between 2004 and 2008, we evaluated the effects of MB, methyl iodide (MIDAS), Telone II plus chloropicrin (T2+Pic), Telone II plus chloropicrin in rotation with MB (T2+Pic/MB), Vapam (metam sodium), Telone II plus chloropicrin plus Vapam (3-Way), and Telone C35 (T-C35), with and without herbicides, on weed densities in spring planted bell pepper. Weed pressure (nutsedges, annual grasses and pigweeds) was significantly influenced by fumigant, herbicide and the interaction between the main effects. Nutsedges were present at the beginning of the study at a density of less than 1 plant per meter squared. By 2008, nutsedge densities in the Vapam, T-C35, NF, and T2+Pic treatments averaged between 1.5 and 13.4 plants per meter squared (up to 134,000 plants per hectare). The use of herbicides (clomazone, *S*-metolachlor and napropamide) reduced nutsedge numbers in these plots more than 46% as compared to a non-fumigated, non herbicide control. Like the nutsedges, crabgrass and pigweed densities were also greatest in the T-C35, NF, T2+Pic plots when herbicides were not applied. Nutsedge, crabgrass, and pigweed populations did not increase over time in the MB, MIDAS, T2+Pic/MB, and 3-Way systems. In 2007, we conducted a companion study to determine if MIDAS, dimethyl disulfide (DMDS), and the 3-Way are economic and effective alternatives to MB with respect to weed control in large, on-farm pepper production trials. The study was conducted on three commercial farms located in Colquitt, Echols, and Tift Counties in GA during the spring of 2007. Treatments were replicated 4 times at each site. Plots ranged from 0.05 to 0.17 ha in size. Pepper height, pepper stand and weed emergence were evaluated throughout the season. Fruit were harvested according to grower practices and processed through commercial packing houses. Pepper stands and heights did not differ between treatments. Nutsedges and livid amaranth were the predominant weeds in the study. There were no differences in weed control among fumigant treatments at the Colquitt County farm; compared to a check plot, all fumigants reduced weed populations by 99%. Nutsedge and livid amaranth densities were significantly greater in the DMDS (18 to 85 plants/ha) treatment as compared to the MB (1 to 24 plants/ha) standard at the Echols County and Tift County sites. The MIDAS and 3-Way treatments did not differ from the MB standard with respect to weed control at both sites. Yield differences were only noted at the Tift County farm. The mean number of boxes of Jumbo fruit produced (over 4 harvests) in the DMDS treatment was reduced, statistically, by 4% relative to the MB standard; the reduction in yield was attributed to weed competition. Although labeled for use on peppers in 47 states, the current price of MIDAS makes it cost prohibitive for GA growers. DMDS was registered for use in plasticulture production by the EPA in 2010. Efforts from this and other studies have shown that a DMDS system must include herbicides and must be applied under a high barrier mulch to provide weed control and yields similar to MB or 3-Way systems. The 3-way system has been the most readily adopted MB alternative in Georgia; in 2010, the 3-Way was applied on over 70% of Georgia's fumigated acreage.

Testing of Herbicide Combinations for Use in Newly-Planted Strawberry. Timothy W. Miller*, Carl R. Libbey; Washington State University, Mount Vernon, WA (106)

Strawberries are produced in matted-row perennial culture in the Pacific Northwest, with first-year strawberries not harvested for fruit. Several herbicide combinations were tested for efficacy and crop safety in newly-planted strawberry at the WSU Northwestern Washington Research and Extension Center near Mount Vernon. Strawberries were transplanted in early late spring 2009, 2010, and 2011 with herbicides applied preemergence (PRE) to weeds immediately after transplanting each year, and certain products also applied postemergence (POST) to strawberry and weed foliage at 1 month after transplanting. In 2009, no treatment caused more than 10% crop injury. Weed control initially was very good, but few combinations were providing adequate weed control by the end of the season. Herbicide treatments did not significantly affect strawberry plant survival. Vegetative growth parameters showed that herbicide treatments were generally safe, although strawberry leaf area was reduced by nearly 50% for pendimethalin + flumioxazin (PRE) and flumioxazin + pendimethalin (PRE + POST). Crop injury in 2010 with sulfentrazone + oxyfluorfen was 29% in late June and still 14% by late July. Flumioxazin followed by pendimethalin or sulfentrazone injured strawberry 18 and 20%, respectively, by June 29 and 14 and 11% by July 29. V-10233 also caused injury through mid-season, with 25 and 19% injury at the June and July ratings, respectively. Other products causing 10 to 19% injury by June 29 were rated at <10% injury by July 29. Weed control was >89% for most products through July, although oxyfluorfen + dimethenamid-p, s-metolachlor, or isoxaben was poor by September. V-10233 appeared to reduce strawberry stand by September, as did pendimethalin + flumioxazin and sulfentrazone + oxyfluorfen. Leaf area per plant in September was reduced 57% by V-10233 compared to hand weeded strawberries; isoxaben, flumioxazin followed by pendimethalin or sulfentrazone, and oxyfluorfen + dimethenamid or sulfentrazone also reduced leaf area. In 2011, crop injury was near zero at one month after treatment. Weed control in July exceeded 85% with 12 of the 19 treatments, but only pendimethalin + sulfentrazone or flumioxazin were still providing adequate control by September. V-10233, isoxaben, penoxulam + sulfentrazone, and indaziflam were safe for newly-planted strawberry, but only V-10233 was still providing good weed control by September.

Post-Dispersal Seed Predation by Carabid Beetles in Vegetable Row Crop Rotations. Ed Peachey*[1], Jessica M. Green[2]; [1]Oregon State University, 97331, OR, [2]Oregon State University, Corvallis, OR (107)

Post-dispersal weed seed predation by carabid beetles may reduce weed seed banks and possibly recruitment in annual cropping systems. Carabid activity-density (AD) was monitored in irrigated row-crop systems over four years in conventional, conservation tillage, and organic systems of the Pacific Northwest. *Pterostichus melanarius* was the primary carabid beetle captured and accounted for over 80% of the total sampled community. Seed predation potential of carabids beetles was assessed by measuring seed loss from seed receptacles that excluded mammals and other herbivores, and by visual and stable isotope analysis of gut contents of the primary species present. In general, weed seed loss tracked with carabid beetle AD, but visual and stable isotope analysis of the gut of *P. melanarius* (the most abundant species) indicated that weeds seeds were a small portion of the diet. The effects of tillage intensity and insecticide use on both carabid beetle populations and weed seedling recruitment were measured over 4 years in replicated experiments. Activity-density of *P. melanarius* (the primary carabid beetle present) did not differ with tillage system or insecticide use during the first two years of the experiment, but was greatest in strip-tilled plots that had been sprayed with insecticide in the third year of the crop rotation. Weed seedling recruitment in spring (from a pulse of weeds seeds sown into plots in the fall) was greater for both hairy nightshade and wild proso millet when insecticides were not applied, indicating that carabid beetles and other soil biota influenced weed recruitment. A final study documented that removal of weed seed from seed receptacles increased linearly with increasing *P. melanarius* density. However, *Pterostichus melanarius* did not consume weed seed immediately after contact. Weed seeds were buried a short distance after removal from seed receptacles.

Control of Crabgrass and Field Bindweed with Consumer Formulations of Quinclorac and Phenoxies. Joseph R. Scoresby*[1], Paul Scoresby[2]; [1]Green Light Chemical, Mosinee, WI, [2]Shiess & Associates, Ucon, ID (108)

The loss of MSMA for post emergence crabgrass control leaves limited alternates for homeowners. The remaining chemistry is either quinclorac or fenoxyprop. Quinclorac is available in several formulations offered by several companies for homeowners to choose from. Most formulations are combinations with phenoxies. Crabgrass control is not equal between formulations. A study conducted in California shows formulations with higher quinclorac quantity will give higher crabgrass control. Quinclorac also controls several broadleaf weeds including field bindweed, *Convolvulus arvensis*. Field bindweed has been noted as one of the 10 worst weeds in the world. It is a problem in agriculture crops, landscapes and home lawns. It is a weed that can be especially challenging for homeowners. Formulations of quinclorac with phenoxies should provide superior control of field bindweed than phenoxies alone. Studies were conducted in Idaho to test new homeowner formulations of phenoxies with quinclorac to control field bindweed. Results of this research show combinations of phenoxies with quinclorac can provide good field bindweed control. Combinations with quinclorac clearly provide improved field bindweed control over phenoxies alone. The two formulations tested are marketed as Crabgrass Killer Plus* and Quincept.

Effect of Application Timing on Efficacy of Indaziflam. Seth Gersdorf*[1], Darren Unland[2], Steven R. King[3]; [1]Bayer CropScience, Sacramento, CA, [2]Bayer CropScience, Research Triangle Park, NC, [3]Bayer CropScience, Huntley, MT (109)

Indaziflam is the active ingredient in the new herbicide Alion from Bayer CropScience. In April 2011 the EPA granted federal registration of Alion for weed control use in many perennial fruit and tree nut crops. It has been previously shown that indaziflam generally provides little activity on weeds that have already emerged from the soil at the time of application. Similar to other soil residual herbicides, moisture is necessary for incorporating indaziflam into the soil where it is active on weeds. Trials conducted during the development of Alion have demonstrated that the timing of application and an activating rain or irrigation are important for the performance of indaziflam. Application timing will vary by region and grower preferences and is flexible as long as activating moisture occurs in a timely manner.

PROJECT 3: WEEDS OF AGRONOMIC CROPS

Pyroxsulam - A Five-Year Overview of Weed Control Research Across U.S. Winter Wheat.
Roger E. Gast*[1], Larry C. Walton[2], Daniel Chad Cummings[3], Joseph P. Yenish[4], Harvey Yoshida[5], Jonathon A. Huff[6], Brian D. Olson[7], Marvin E. Schultz[1]; [1]Dow AgroSciences, Indianapolis, IN, [2]Dow AgroSciences, Tupelo, MS, [3]Dow AgroSciences LLC, Perry, OK, [4]Dow AgroSciences, Billings, MT, [5]Dow AgroSciences, Richland, WA, [6]Dow AgroSciences, Herrin, IL, [7]Dow AgroSciences, Geneva, NY (110)

Pyroxsulam herbicide, a member of the triazolopyrimidine sulfonamide chemical family, is a postemergence grass and broadleaf herbicide developed by Dow AgroSciences for use in spring and winter wheat. It is an acetolactate synthase (ALS)-inhibiting herbicide and can be applied postemergence (fall or spring) to actively growing winter wheat from 3 leaf to tiller stage, for control of grass weeds from 2 leaf to 2 tiller stage and broadleaf weeds up to 2 inches tall or 2 inches in diameter. The current U.S. formulation, PowerFlex®, is selective in winter wheat, spring wheat (including durum), rye and triticale, but is not selective in barley, oats, rice, maize or broadleaf crops.

Dow AgroSciences has conducted over 300 internal and external field research trials in winter wheat regions with PowerFlex® over the last five seasons (2006 to 2011), representing most geographies. An in-depth evaluation was conducted on the effect of application timing, compared to key commercial standards, on the efficacy of major weeds and the resulting impact on wheat yields. Herbicide applications were made either in the fall or spring at the appropriate timeframe for each geography. The key grass and broadleaf weeds evaluated included cheat (*Bromus secalinus*), downy brome (*Bromus tectorum*), henbit (*Laminum amplexicaule*) and Italian ryegrass (*Lolium perenne ssp. multiflorium*). Efficacy data were collected on many other broadleaf weeds naturally occurring in these trials.

The experimental design in all trials was a randomized complete block with 3 or 4 replications. Most plot sizes ranged from approximately 5 to 20 ft wide by 20 to 40 ft. in length. Treatments were applied with either a CO2 backpack or small plot tractor sprayer calibrated to deliver 10 to 15 GPA.

PowerFlex® herbicide at 18.4 g ai/ha (0.016 lbs ai/A) provides control of cheat, downy brome, non ALS-resistant Italian ryegrass and henbit when applied in the fall or spring, comparable or superior to other commercial standards. Winter wheat yields, averaged across trials containing the same key weed species, were increased by either a fall or spring application of PowerFlex® compared to the untreated weedy check with all key weeds tested. PowerFlex® provided the widest spectrum of broadleaf weed control compared to other ALS standards. Winter wheat injury was minimal with PowerFlex®.

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PowerFlex is not registered for sale or use in all states. Contact your state pesticide regulatory agency to determine if a product is registered for sale or use in your state. Always read and follow label directions.

Rotational Crop Safety with Pyroxsulam in California and Arizona Wheat. Jesse M. Richardson*[1], Roger E. Gast[2], Byron B. Sleugh[3], Marc Fisher[4], Deb Shatley[5], Barry Tickes[6], Steve B. Orloff[7]; [1]Dow AgroSciences, Hesperia, CA, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Clovis, CA, [4]Dow AgroSciences LLC, Fresno, CA, [5]Dow AgroSciences, Lincoln, CA, [6]University of Arizona, Yuma, AZ, [7]University of California, Yreka, CA (111)

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. Field studies were conducted in 2010 and 2011 with pyroxsulam in three distinct growing regions; desert, central valley, and intermountain zones. Experiments were designed to evaluate the impact of pyroxsulam soil residues, from an application to wheat, on potential rotational crops. Rotational crops included corn, sorghum, blackeyed cowpea, tomato, sudangrass, cotton, cantaloupe, lettuce, onion, alfalfa, broccoli, potato, barley and tall fescue.

Herbicide treatments in the studies included 1, 2 and 4X label rates of pyroxsulam and mesosulforon (1X = 15 g a.i./ha for both), and 1 and 2X rates of chlorsulfuron (1X = 17.5 g a.i./ha). Herbicides were applied postemergence to wheat and the crop was subsequently harvested, with an application-to-planting interval of 90 days. Injury was assessed up to 70 days after planting the rotational crops. Little or no injury was observed with pyroxsulam up to the 2X rate on all tested crops except tomato, onion and alfalfa. Only minor injury of these crops was observed where the 15 g a.i./ha label rate was applied. Pyroxsulam can be used in California and Arizona wheat production systems that require short rotation intervals, with safety at normal planting intervals to most common crops in these cropping systems. Pyroxsulam will be sold in California and Arizona under the trade name Simplicity™ herbicide.

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State restrictions on the sale and use of Simplicity™ apply. Consult the label prior to purchase or use for full details. Always read and follow label directions.

Downy Brome and Winter Wheat Response to Pre-plant Applications of Propoxycarbazone-sodium and Pyroxsulam. David A. Claypool*, Andrew R. Kniss; University of Wyoming, Laramie, WY (112)

A field study was conducted at the Sustainable Agriculture Research and Extension Center near Lingle, Wyoming, in 2010-2011 to evaluate preemergence applications of propoxycarbazone-sodium and pyroxsulam for downy brome control and crop safety in winter wheat. Hard red winter wheat ('Genou') was drilled in 7.5-inch rows at a rate of 60 lbs/A on September 17, 2010. Propoxycarbazone-sodium was applied at rates of 0.42 and 0.63 ai/A either PRE, Fall POST, or Spring POST. Pyroxsulam was applied at a rate of 0.337 ai/A at the same time. When propoxycarbazone was applied at 0.42 oz ai/A, wheat injury was similar between PRE and Fall POST application timings. Injury from PRE applications of propoxycarbazone increased when the rate was increased to 0.63 oz ai/A. Pyroxsulam applied PRE resulted in significantly greater wheat injury (68%) compared to either fall or spring POST applications. Treatments that included a fall application tended to provide greater downy brome control compared with single applications made PRE or in the spring.

Introduction to Pyrasulfotole Plus Thiencarbazone-methyl Plus Bromoxynil Plus Mefenpyr-diethyl - A New Herbicide for Grass and Broadleaf Weed Control in Northern Plains Cereals. Dean W. Maruska*[1], Kevin B. Thorsness[2], Steven R. King[3], Mike C. Smith[2], Bradley E. Ruden[4], Mary D. Paulsgrove[5], Mark A. Wrucke[6]; [1]Bayer CropScience, Warren, MN, [2]Bayer CropScience, Fargo, ND, [3]Bayer CropScience, Huntley, MT, [4]Bayer CropScience, Bruce, SD, [5]Bayer CropScience, Raleigh, NC, [6]Bayer CropScience, Farmington, MN (113)

Huskie Complete™ herbicide is a new postemergence grass and broadleaf herbicide that has been developed by Bayer CropScience for use in spring wheat, durum wheat, 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 from 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 stage of growth depending on weed species.

Huskie Complete will be 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. Huskie Complete has been tested on spring wheat, durum wheat, 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.

Pyrasulfotole Plus Bromoxynil for Broadleaf Weed Control in Grain Sorghum. Charles P. Hicks*[1], Greg Hudec[2], Russ Perkins[3]; [1]Bayer CropScience, Fort Collins, CO, [2]Bayer CropScience, Manhatten, KS, [3]Bayer CropScience, Lubbock, TX (114)

Broadleaf weed control in grain sorghum continues to be challenging with limited pesticide options available. Huskie, a combination of active ingredients bromoxynil and pyrasulfatole, has been labeled for post emergence control and broadleaf weeds in wheat, barley, oats, rye, and triticale. In 2011, Huskie received federal registration for applications in grain sorghum. Huskie is a new herbicide tool for sorghum growers and contains both HPPD and PS II mode of action active ingredients. Fortunately, this herbicide combination also has the potential to control various groups of herbicide resistant weeds (triazine, ALS, and glyphosate). Huskie provides control of the toughest broadleaf weeds including Kochia, Russian thistle, Devil's Claw, Puncturevine, Palmer amaranth, waterhemp, and other pigweed species. Some transitory leaf burn to grain sorghum has occurred following an application of Huskie. New growth is not affected and recovery is quick and complete. Huskie may be applied to actively growing sorghum between the 3 leaf stage of growth to a maximum height of 12 inches and use rates of 12.8-16 ounces of Huskie per acre are recommended. Huskie is a relatively new herbicide combination that has the potential to provide effective postemergence weed control of problematic weeds in grain sorghum.

Saflufenacil Use in Cool-season Grasses Grown for Seed. Daniel W. Curtis*, Andrew G. Hulting, Carol Mallory-Smith, Kyle C. Roerig; Oregon State University, Corvallis, OR (115)

Studies were conducted with saflufenacil to evaluate injury to perennial ryegrass and tall fescue grown for seed and to identify activity on weed species either alone or in combination with other herbicides. Trials were conducted in commercial grass seed fields and at the Oregon State University Hyslop Research Farm near Corvallis, OR. The first study, initiated in a newly-seeded stand of perennial ryegrass, included evaluation of saflufenacil for control of diuron-resistant annual bluegrass, Italian ryegrass and California brome. Saflufenacil was applied at 25 g ai/ha alone and in combination with metribuzin, mesotrione and ethofumesate. Saflufenacil applications provided no control of any of the grass species, but did not decrease perennial ryegrass seed yields. Saflufenacil was applied to an established stand of perennial ryegrass at 25 g ai/ha alone and in combinations with pyroxasulfone. Saflufenacil did not increase the control of diuron-resistant annual bluegrass provided by pyroxasulfone. The saflufenacil applications did not affect grass seed yields. Two studies initiated to evaluate broadleaf weed control with saflufenacil in new plantings of perennial ryegrass were conducted during the 2009-2010 and 2010-2011 growing seasons. In 2009, saflufenacil was applied at 25 g ai/ha to 1 tiller perennial ryegrass. In 2010, saflufenacil was applied at 100 g ai/ha preemergence and at 25g ai/ha post emergence to 1 tiller perennial ryegrass. The post emergence applications provided 100% control of broadleaf weed species present which included lesser-seeded bittercress, shepherd’s purse, ivy-leaf speedwell and sticky chickweed. A study conducted in the spring of 2011 included applications of saflufenacil at 25 g ai/ha to 2 leaf spring-planted tall fescue applied alone and in combination with mesotrione. Saflufenacil provided 90% control of the initial flush of sharppoint fluvellin, but did not control later emerging sharppoint fluvellin. The combination of mesotrione and saflufenacil provided 80% control of later emerging sharppoint fluvellin. Neither saflufenacil nor mesotrione provided effective control of the erect knotweed. Results of these studies suggest that saflufenacil will provide effective control of several broadleaf species in perennial ryegrass and tall fescue being grown for seed.

Pyroxasulfone Interaction with Plants. Eric P. Westra*[1], Dale L. Shaner[2], Philip Westra[3]; [1]Colorado State University, Fort Collins, CO, [2]USDA, Fort Collins, CO, [3]Colorado State University, Ft. Collins, CO (116)

A field trial was established during the summer of 2011 in Northern Colorado to evaluate the crop response of multiple species over time by planting crops into a range of pyroxasulfone rates five times over a five month period. The objectives of the study were to a) evaluate crop tolerance of multiple species to increasing rates of soil-applied pyroxasulfone, b) Evaluate crop response of species planted into dissipating levels of pyroxasulfone over time, and c) evaluate control of indigenous weed species. Plots were established at the Colorado State University Horticultural Research Station located just North of Fort Collins Colorado. The soil type was a Nunn clay loam with 2.2% organic matter. Based on previous soil sorption research, this soil type had a sorption coefficient of .838 L/kg which ranked 17th out of 25 soils (ranking 1=most binding). Previous dissipation studies at this field site resulted in an average dissipation half-life of 30.8 days for the two years in which dissipation was evaluated. Plots were sprayed with a CO_2 pressurized backpack sprayer at 187 L/ha on May 27th 2011. Pyroxasulfone was soil-applied at rate of 300, 150, 75, 37.5 g ai/ha and set up in a randomized design along with an untreated check. Herbicide treatments were three meters wide by 45 meters long and oriented from north to south. Thirteen different species were planted on a monthly bases for a total of 5 planting from 5-27 to 10-27. Crop species were planted east to west across herbicide treatments in a block for each time point. For each time point, crops were seeded with a ribbed-belt push seeder in rows spaced 30cm apart. Plots were irrigated with an over-head linear on a consistent basis to maintain plant available water. Species that grew included sunflowers (*Helianthus annuus*), corn (*Zea mays*), sorghum (*Sorghum bicolor*), dry beans (*Phaseolus vulgaris*) and soy beans (*Glycine max*). Individual plantings were harvested approximately seventy days after planting and data was collected for stand counts, heights and fresh weights in order to compare species tolerance to increasing rates of pyroxasulfone both initially and over time. Preliminary results indicate that for the first three plantings where adequate biomass was produced for analysis, corn (*Zea mays*), sunflowers (*Helianthus annuss*) and soy beans (*Glycine max*) were the three most tolerant species, while dry beans (*Phaseolus vulgaris*) were classified as moderate, and sorghum (*Sorghum bicolor*) appeared to be the most sensitive of the species tested. Preliminary data also suggests that crop injury was the most significant in the early plantings, and tended to decrease overtime as residual levels of pyroxasulfone decreased in the soil, although crop injury was most severe in the second planting due to movement and location of pyroxasulfone in the soil profile.

Searching for Improved Lentil Tolerance to PPO Inhibitor Herbicides. Ken L. Sapsford*[1], Eric N. Johnson[2], Albert Vandenberg[3]; [1]University of Saskatchewan, Saskatoon, SK, [2]Agriculture and Agri-Food Canada, Scott, SK, [3]University of Saskatchewan, Saskatoon, Mexico (117)

Sulfentrazone, a soil applied, Group 14 (PPO inhibitor) herbicide registered in Canada in 2010, is very effective for control of kochia in pea, flax, chickpea and sunflower. Lentil is sensitive to sulfentrazone but we hypothesize that it may be possible to identify and develop Group 14 resistant lentil germplasm since tolerance exists in other grain legume genera. In 2008 we evaluated 4 lentil lines to 4 sulfentrazone rates and found wide variability in tolerance; from 0 to 68% visual injury and 31% to 82% yield reductions compared to the untreated check. In 2009 we screened 32 lentil lines for sulfentrazone tolerance and selected 7 of the most tolerant lines for replicated trials in 2010-11 at two Saskatchewan locations. Our most and least tolerant lines have been CDC Improve and CDC Impala, respectively.

Progress in Managing Herbicide Resistant Weeds in Lentil. Eric N. Johnson*; Agriculture and Agri-Food Canada, Scott, SK (118)

Broadleaf weed control in lentil (*Lens culinaris* L.) can be challenging. The introduction of Clearfield lentil into Western Canada has helped managed broadleaf weeds; however, ALS resistance is prevalent in kochia [*Kochia scoparia* (L.) Schrad.] and wild mustard (*Sinapis arvensis* L.). Alternatives are needed to manage these problematic weeds. Two studies funded through the Pulse Cluster will be reported on. The first study evaluated fall and spring applied flumioxazin for its weed control efficacy and lentil tolerance. Studies were conducted at Scott, Saskatoon, and Rosetown, SK. The Rosetown site had late season flooding; therefore, only some visual injury ratings could be obtained. Flumioxazin was applied in late fall and spring pre-seed at rates of 71, 107, 140, 214, and 428 g ai ha^{-1}. CDC Improve lentil was seeded at all locations. Visual injury to lentil was minimal at both Scott and Saskatoon with all treatments. At Rosetown, visual injury was unacceptable at spring applied rates ≥ 214 g ai ha^{-1}. At Scott, spring application resulted in slightly higher visual control ratings of kochia but a rate of 214 g ai ha^{-1} was required to provide >75% control, independent of timing. Visual control ratings of wild mustard were similar for fall and spring application with 214 g ai ha^{-1} required to provide > 80% control. Fall or spring applications of 140 g ai ha^{-1} provided >75% control of common lambsquarters (*Chenopodium album* L.). At Saskatoon, all rates of fall applied flumioxazin provided excellent visual control of winter annual weeds such as stinkweed (*Thlapsi arvense* L.), and narrow-leaved hawksbeard (*Crepis tectorum* L.) prior to spring burn-off treatments. In-crop weed densities were low; however, there was a trend for lower wild buckwheat biomass with the flumioxazin treatments. Fall treatments resulted in lower redroot pigweed (*Amaranthus retroflexus* L.) biomass than spring treatments with a fall applied rate of 71 g ai ha^{-1} providing a 95% reduction in biomass. A second study evaluated fluthiacet-methyl applied post-emergence in CDC Improve lentil at rates of 2, 4, 6, and 8 g ai ha^{-1}, as well as metribuzin at 125 g ai ha^{-1}, and a tank-mix of metribuzin and fluthiacet at rates of 125 and 2 g ai ha^{-1}, respectively. Studies were conducted at both Scott and Saskatoon. Initial chlorosis from fluthiacet-methyl and the metribuzin / fluthiacet-methyl tank-mix was evident at both locations, with injury ratings as high as 25% recorded. The chlorosis was transient and no injury was recorded near crop maturity. Lentil yields were higher than the untreated check due to positive weed control effects. At Scott, fluthiacet-methyl alone reduced kochia biomass by 70 to 90%. Metribuzin and the metribuzin / fluthiacet-methyl tank-mix reduced kochia biomass by 50% and 92%, respectively indicating some additivity. Wild mustard control with fluthiacet-methyl was erratic and the metribuzin / fluthiacet-methyl tank-mix did not provide higher levels of wild mustard control than metribuzin alone. At Saskatoon, wild mustard suppression was provided at 2 to 3 g ai ha^{-1} with control recorded at higher rates. Adding fluthiacet-methyl to metribuzin did not improve control of wild mustard. Results for kochia were similar to Scott.

Performance of Novel Broadleaf Herbicides. Gregory K. Dahl*[1], Joe V. Gednalske[2], Lillian C. Magidow[3], Eric P. Spandl[3]; [1]Winfield Solutions LLC, St. Paul, MN, [2]Winfield Solutions LLC, River Falls, WI, [3]Winfield Solutions, LLC., St. Paul, MN (119)

Winfield Solutions, LLC. has developed three new herbicides, AGH-09008, AGH-09035, and AGH 08032. AGH-09008 is a novel 2,4-D acid herbicide formulation. AGH-09008 will be marketed by Winfield Solutions, LLC. as Rugged™ herbicide. Generally, 2,4-D esters provided similar or greater weed control than AGH-09008 and AGH-09008 provided greater weed control than 2,4-D dimethyl amine. The compatibility and performance of AGH09008 with K-salt glyphosate herbicides was similar to that of 2,4-D esters and better than 2,4-D dimethyl amine. AGH 09008 performed well when UAN was the spray carrier. AGH-09008 was more compatible than 2,4-D dimethyl amine in mixtures with other herbicides, fertilizers and other tank mix products. Tomatoes showed significant growth regulator type injury when placed in volatility testing chambers with 2,4-D ester formulations. The appearance of tomatoes tested with AGH-09008 and 2,4-D amine were similar to tomatoes that were in not exposed to 2,4-D. AGH-09035 and AGH-08032 are broad-spectrum broadleaf herbicides for use in small grains. AGH-09035 and AGH-08032 are marketed by Winfield Solutions, LLC. as WELD™ herbicide and Carnivore™ herbicide, respectively. AGH-09035 contains fluoroxypyr, clopyralid and MCPA ester. AGH-08032 contains fluoroxypyr, bromoxynil and MCPA ester. AGH-09035 and AGH-08032 can be applied at 1 to 1.5 pints per acre to broadleaf weeds up to four inches tall. AGH-09035 and AGH-08032 provided excellent control of many weeds including kochia, wild buckwheat, common lambsquarters, smartweeds and wild mustard. Both herbicides were compatible with many grass herbicides used in small grains. They were also compatible with many adjuvants, insecticides, and some fungicides and micronutrients.

Broadleaf Weed Control in Field Corn with Preemergence Followed by Sequential Postemergence Herbicides. Richard N. Arnold*, Michael K. O'Neill, Kevin A. Lombard; New Mexico State University ASC, Farmington, NM (120)

Research plots were established on May 10, 2011, at New Mexico State University's Agricultural Science Center at Farmington, New Mexico, to evaluate the response of field corn (var. Pioneer PO231HR) 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 10, field corn was planted with flexi-planters equipped with disk openers. Preemergence treatments were applied on May 11 and were immediately incorporated with approximately 0.75 in of sprinkler applied water. Sequential postemergence treatments were applied on June 13 when field corn was in the 4th 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 13 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 Zidua, Sharpen and G-Max Lite at 1.3, 0.6, 21.2 oz ai/A gave poor control of Russian thistle. The addition of Status applied as a sequential postemergence treatment at 1.52 oz ai/A increased Russian thistle control approximately 20 to 50%.

Herbicide Programs for Kochia Management Revisited. Vipan Kumar*[1], Prashant Jha[2], Nicholas Reichard[2]; [1]Student, Huntley, MT, [2]Montana State University, Huntley, MT (121)

Kochia (*Kochia scoparia* L.) is one of the most troublesome weeds in agronomic crops in the northern and western United States. The severity of the problem is due to evolution of kochia biotypes resistant to one or more herbicide chemistries including glyphosate. Glyphosate-resistant kochia biotypes have been found in Kansas, Nebraska, and Alberta (Canada), and expected to spread further in the northwestern U.S. There is a need for development of alternative herbicide programs for control of herbicide-resistant kochia biotypes. Field experiments were conducted at the MSU Southern Agricultural Research Center, Huntley, MT, in 2011, to evaluate preemergence (PRE) and postemergence herbicide options for kochia control in a fallow field with a natural infestation of kochia. Herbicides were applied with a hand-held boom calibrated to deliver 94 L ha^{-1} at 276 kPa. All POST treatments were applied to 8- to 10-cm kochia plants. Experiments were conducted in a randomized complete block design with 4 replications. Control with acetochlor + atrazine applied PRE at 1.685 kg/ha was 100% at 30 DAA, and was superior to all other PRE treatments, except sulfentrazone (0.212 kg/ha) and flumioxazin (0.013 kg/ha). Control from PRE applications of isoxaflutole (0.091 kg/ha), dicamba (0.567 kg/ha) plus 2, 4-D (0.260 kg/ha), and dicamba plus diflufenzopyr (0.024 kg/ha) plus 2, 4-D, and acetochlor (0.731 kg/ha) were inadequate, and ranged from 32 to 46% at 30 DAA. Saflufenacil + dimethenamid at 0.74 kg/ha and dicamba (0.283 kg/ha) plus 2,4-D (0.260 kg/ha) applied PRE provided poor (≤ 15%) control of kochia. 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 (0.851 kg/ha) plus atrazine (0.567 kg/ha) provided effective control of kochia, which averaged 94% 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), mesotrione (0.106 kg/ha) plus atrazine (0.283 kg/ha), topramezone (0.016 kg/ha) plus atrazine averaged 84%. Control from tembotrione (0.093 kg/ha) applied alone or with atrazine (0.283 kg/ha) and saflufenacil (0.025 kg/ha) plus atrazine (0.425 kg/ha) averaged 70%, which was lower than all other POST products, except glyphosate. In conclusion, PRE herbicides including acetochlor + atrazine, sulfentrazone and flumioxazin, and POST herbicides including fluroxypyr + bromoxynil, pyrasulfutole + bromoxynil, carfentrazone-ethyl + 2,4-D, paraquat + atrazine were effective for kochia control, and could be utilized as a possible alternative to glyphosate for managing glyphosate-resistant kochia.

Herbicide Programs for Control of Volunteer Glyphosate-Resistant Canola in Glyphosate-Resistant Sugarbeet. Prashant Jha*[1], Vipan Kumar[2], Nicholas Reichard[1]; [1]Montana State University, Huntley, MT, [2]Student, Huntley, MT (122)

Field experiments were conducted at the Southern Agricultural Research Center in Huntley, MT, in 2011, to evaluate herbicide programs for volunteer glyphosate-resistant canola control in glyphosate-resistant sugar beet. Glyphosate-resistant canola was broadcast in the field just prior to sugar beet planting and a uniform density of 5 to 7 canola plants m^{-2} was obtained. Glyphosate-resistant sugar beet variety "BTS 36RR50 Pro 200" was planted on April 20 at a seeding rate of 119,500 seeds ha^{-1} in 61-cm wide rows. Treatments were arranged in a randomized complete block design with four replications. Herbicides were applied as a single POST application at the 2-leaf stage of sugar beet or a sequential POST application at the 2-leaf followed by (fb) 6-leaf stage of sugar beet (10-14 days after the 2-leaf application), with or without PRE. Single POST treatments included triflusulfuron methyl (Upbeet®) applied alone at 17.5 g ai ha^{-1} (half rate) or at 35 g ai ha^{-1} (full rate). Sequential POST treatments included triflusulfuron at half or full rate applied alone, in combination with ethofumesate (Nortron SC®) at 140 g ai ha^{-1}, or in combination with phenmedipham + desmedipham + ethofumesate (Progress®) at 44.73 g ai ha^{-1}. Additional treatments included ethofumesate applied as PRE at 4200 g ai ha^{-1} fb the sequential POST treatment of triflusulfuron at half or full rate, and ethofumesate applied alone at 140 g ai ha^{-1} as a sequential POST. A non-treated check and a hand-weeded control were also included for comparison, with a total of 13 treatments. All triflusulfuron treatments included methylated seed oil (MSO) at 1.5 % v/v. All treatments were applied with glyphosate at 840 g ae ha^{-1} with 2% w/w of ammonium sulfate (AMS). Herbicides were applied with a hand-held boom calibrated to deliver 94 L ha^{-1} at 276 kPa. Sugar beet injury and canola control were visually rated at 7, 14 and 21 days after each application on a scale of 0 (no injury or control) to100 (complete control or plant death). Weed control data at 21 d after the last application (DAA) were used for analysis. Sugar beet root and sucrose yields were recorded at harvest. Data were subjected to ANOVA using PROC MIXED in SAS. Means were separated using Fisher's protected LSD test at $\alpha = 0.05$. None of the herbicides caused any injury to sugar beet. Volunteer canola control with ethofumesate (4200 g ai ha^{-1}) applied PRE fb a sequential POST application of triflusulfuron methyl (at half or full rate) was 91% at 21 DAA, which was equivalent to the hand-weeded treatment. Canola control did not differ between half and full rates of triflusulfuron methyl. A single POST application of triflusulfuron provided lower control than a sequential POST treatment. There was no additional advantage of tank-mixing ethofumesate or phenmedipham + desmedipham + ethofumesate with triflusulfuron. POST applications of ethofumesate alone did not provide any control of volunteer canola. Canola biomass in sequential POST treatments containing triflusulfuron averaged 80% lower than single POST treatments of triflusulfuron. Furthermore, canola seed production was almost 10-fold less in sequential compared to single triflusulfuron treatments. Nontreated volunteer canola plants produced almost 7000 seeds m^{-2}. Among all triflusulfuron-based treatments, single POST treatments yielded lower than the hand-weeded plots. Sugar beet yields in ethofumesate (POST) alone and nontreated check treatments averaged 40,320 kg ha^{-1} of root and 4,480 kg ha^{-1} of sucrose, which were almost two-fold lower than the yields obtained in hand-weeded plots. In conclusion, POST applications of triflusulfuron methyl at rates ≥ 17.5 g ai ha^{-1} at 2-leaf fb 6-leaf stage of sugar beet prevented volunteer glyphosate-resistant canola interference and yield reductions in glyphosate-resistant sugar beet; however, addition of ethofumesate PRE to the sequential triflusulfuron POST program was needed to prevent volunteer canola seed bank replenishment.

Weed Management in Alfalfa to Avoid Evolution of Glyphosate-Resistant Weeds: Grower Survey and Initial Field Results. Steve B. Orloff*[1], Robert G. Wilson[2], Daniel H. Putnam[3]; [1]University of California, Yreka, CA, [2]University of Nebraska-Lincoln, Scottsbluff, NE, [3]University of California, Davis, CA (123)

A survey was conducted to evaluate grower experience and attitudes toward glyphosate-tolerant (GT) alfalfa now that there have been more than 10 years of research experience and 6 years of grower experience with the crop. Of the 113 grower respondents who had grown GT alfalfa, 91% were either satisfied, very pleased, or indicated the technology far exceeded expectations. Eight growers responded that they were disappointed, and two extremely disappointed. Forty-one percent of respondents indicated a concern for glyphosate-resistant weeds as a consequence of use of the technology, with only 25% indicating that it is not a concern and 34% unsure. Research was conducted in Tulelake, CA and Scottsbluff, NE to evaluate the effectiveness and crop injury from several herbicide treatments to develop a resistance management program in seedling GT alfalfa. Treatments included glyphosate alone and in combination with saflufenacil, imazamox, imazethapyr, clethodim, 2,4-DB, pendimethalin, bromoxynil and acetochlor and a non-glyphosate standard treatment consisting of imazamox and clethodim . Some of the herbicide combinations injured the alfalfa, but only saflufenacil caused greater than 25% injury in both trials, a commercially unacceptable level. Almost all herbicide combinations with glyphosate resulted in nearly complete control of the weeds present in Tulelake (SOLNI, AMARE, SOBID) and in Scottsbluff (CHEAL, SOLNI, ERACN, POROL, AMARE). Alfalfa yield was significantly lower in the untreated control plots at the Tulelake site. Some of the herbicide treatments had numerically lower yield than glyphosate alone treatment but the difference was not statistically significant. The study demonstrated that there are several herbicides that can be tank mixed with glyphosate for complete weed control with minimal alfalfa injury in a resistance management program.

Reductions in Corn Leaf Area Induced by Drought Stress and Level of Irrigation Impacts Weed Control. Randall S. Currie*[1], Jennifer L. Jester[2], Norman Klocke[2]; [1]Kansas State Univ., Garden City, KS, [2]Kansas State univ., Garden City, KS (124)

In 2011, a severe drought reduced corn production in a long-term experiment to measure the dose response relationship of irrigation and corn grain yield. Corn biomass and leaf area was reduced as irrigation decreased causing late season Palmer amaranth growth. Corn was grown in three locations, where the objective was to maintain weed free conditions. For the 5 years prior to 2011, weed control was pursued with aggressive herbicide tank mixes. In 2011, corn first received a pre-emergence application of glyphosate, atrazine, isoxaflutole, dimethenamid and saflufenacil at 1, 1.7, 0.031, 0.78 and 0.08 lbs ai/A; followed by postemergence application of fluroxypyr, glyphosate, S-metolachlor, and tembotrione at 0.13, 1, 1.43, and 0.082 lbs/A. Additional post-emergence applications of glyphosate at 0.75 lbs/A were applied, as needed, to maintain weed-free conditions at canopy closure. The treatments, replicated four times, were 100, 84, 71, 55, 42, and 30% of what locally-derived models predicted for non-rate limited irrigation. As a result, the net irrigation amounts were 18, 14, 10, 7, 4, 1 inches/A across irrigation treatments, which resulted in 25, 20,16,13,11, and 7 inches of total water use per acre (evapotranspiration). Total water use was based on soil water measurements up to 8 feet, total in season rainfall and total net irrigation. Corn populations for each treatment were 9,500, 22,000, 24,500, 27,000, 29,500, and 32,000 plants/A, increasing as the irrigation level increased. These populations were based on previous models for the level of irrigation to be applied. Corn leaf area index (LAI) was measured as described in Weed Tech .2008.22:448-452. Palmer amaranth biomass samples were taken at corn harvest. The fully irrigated corn yielded from 178 to 203 bu/A. Grain yield decreased linearly at all locations to a minimum of 0 to 3.5 bu when irrigated with less than 30% of full irrigation requirements. Palmer amaranth biomass was from 9 to 38 lb/A in fully irrigated corn. Palmer amaranth biomass increased from 1.5 to 4 fold as irrigation decreased to 60% of full irrigation. At all three locations, when irrigation was less than 50% of full irrigation requirements, Palmer amaranth biomass increased from 6 to 31 fold compared to fully irrigated corn. However, when irrigation was below 30% of full irrigation requirements, Palmer amaranth biomass was 51 to 82 lbs/A. Although corn populations were reduced to match reduced irrigation levels, it was not possible to reduce crop water stress enough to prevent corn leaf loss due to drought. Severe reduction in the corn canopy allowed late season Palmer amaranth to emerge. In previous studies, simple linear models of corn LAI reduced by hail, predicted corn yield loss well with R square values well above 0.94. (See Weed Tech . . . 2008.22:448-452.) Simple linear models of LAI were also predictive of corn yield loss in this study with R square values greater than 0.99. The reader is advised to use this data with caution. Although based on two locations, regressions of only 3 points were used. It should be considered only as a starting point for future research. Although the previous work had shown strong linear relationship with corn LAI influenced by hail injury and Palmer amaranth biomass, no relation ship could be shown using this limited data set for corn injured by drought stress. When corn was irrigated with more than 60% of full irrigation, it was able to compete with Palmer amaranth. Between irrigation levels of 30 and 50%, Palmer amaranth was able to utilize the remaining water better than the corn. When irrigation was below 30%, drought severely reduced both weed and crop growth.

Herbicide Resistant Italian Ryegrass: Any Options Left? Carol Mallory-Smith*, Andrew G. Hulting, Daniel W. Curtis, Kyle C. Roerig, Mingyang Liu; Oregon State University, Corvallis, OR (125)

There have been an increasing number of Italian ryegrass (*Lolium multiflorum*) populations, in the Pacific Northwest and, in particular, the Willamette Valley, which have resistance to more than one herbicide. Cross- or multiple-resistance is limiting control of Italian ryegrass in many different crops including wheat, clover, Christmas trees, and orchards. For example, a population from a Christmas tree plantation is resistant to at least three different chemical groups: 2, 5, and 9. A different population from a field that has been in continuous wheat is resistant to all chemical classes of ACCase inhibiting herbicides, to ALS inhibiting herbicides and to diuron. Four other populations are resistant to flufenacet and ACCase inhibiting herbicides. Eight populations collected in orchards are resistant to glyphosate and glufosinate. A different population from a wheat field is resistant to glufosinate but not to glyphosate. The obligate outcrossing nature of Italian ryegrass means that if the gene responsible for resistance is carried in the pollen (paternal parent) the resistance will spread more widely and quickly than if it is only carried on the pollen receptor (maternal plant). Therefore, it is also critical to identify the resistance mechanisms and inheritance of the resistance trait to inform management decisions. Resistance to the herbicide atrazine is likely only carried by the maternal plant while resistance to sulfometuron is due to a point mutation and will be carried by both the paternal and maternal plant. Preliminary studies on inheritance of resistance in the populations with resistance to glyphosate and glufosinate indicate that the traits may be controlled by more than gene. In the population with only glufosinate resistance, the trait is due to a point mutation and likely will be inherited as a single gene. If resistance is controlled by more than one gene or if the trait is not a dominant trait then the spread of resistance may be reduced. These differences in inheritance and spread via pollen provide opportunities to develop management recommendations based on how quickly a population may increase or decrease; however, recommendations become very complicated under these scenarios because they differ for each population. Rotation of herbicide mechanisms of action has not prevented multiple-resistance in this species which should serve as a warning for other species where resistance frequently evolves.

Fitness Costs of Multiple Herbicide Resistant Wild Oat? Erik A. Lehnhoff*, Fabian Menalled, Barbera Keith, William Dyer; Montana State University, Bozeman, MT (126)

Herbicides resistance is a worldwide concern affecting crop production. A solution to manage herbicide resistance has historically been to switch to an herbicide with a different mode of action, but this approach may not be effective if the biotype is resistant to multiple herbicide modes of action, termed multiple herbicide resistance (MHR). The resource allocation theory predicts a fitness cost to for herbicide resistance as plants divert resources from growth and reproduction toward defense. We investigated two herbicide resistance wild oat (*Avena fatua*) biotypes in Montana, USA, and found that they were MHR, with one biotype resistant to difenzoquat (membrane disruptor), imazamethabenz (ALS inhibitor) and flucarbazone (ALS inhibitor) and the second biotype resistant to those as well as paraquat (membrane disruptor) and tralkoxydim (ACCase inhibitor). Growth experiments were done under different nitrogen application rates with the MHR biotypes and two herbicide susceptible (HS) biotypes to assess fitness costs. The MHR biotypes did not have lower relative growth rates, produce less biomass, or allocate biomass differently to above- or below-ground tissues than the HS biotypes. Also, photosynthesis, stomatal conductance and transpiration were not lower in MHR than HS biotypes. HS biotypes ultimately produced more tillers and seeds than MHR biotypess, but the MHR biotypes initiated and completed seed production earlier than the HS biotypes. Our results do not indicate a fitness cost to individuals for herbicide resistance, but differences in seed production may indicate a fitness cost at the population level.

Glyphosate Resistance in Several Kochia Populations in Kansas. Amar S. Godar*[1], Phillip W. Stahlman[2], Johanna A. Dille[1], Philip Westra[3]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS, [3]Colorado State University, Ft. Collins, CO (165)

Four glyphosate-resistant kochia (*Kochia scoparia*) populations were confirmed in western Kansas in 2007. Complaints of poor kochia control with glyphosate in the region continued to increase in the following years. We collected seed from kochia plants suspected of resistance to glyphosate in eight fields throughout western Kansas in 2010 and conducted greenhouse and laboratory experiments to confirm and quantify the level of glyphosate resistance in each population. In whole plant bioassay, a series of glyphosate rates ranging from 0.04 to 5.4 kg ae ha^{-1} were applied on 15-cm tall plants. A known glyphosate susceptible biotype from Ellis Co. KS was used as a control and the experiment included six replications. Mortality and biomass reduction were determined 21 d after glyphosate treatment. Based on the LD_{50} (50% mortality) and GR_{50} (50% biomass reduction) values, the suspected kochia biotypes were four- to eight-times and four- to ten-times more resistant to glyphosate, respectively, compared to the susceptible biotype. An *In-Vivo* shikimate assay was performed by treating 4-mm leaf discs from fully expanded young leaves with 200µM glyphosate and incubating for 16 h under continuous light. The assay included 8 plants from each population and was done in duplicate. The susceptible individuals accumulated at least three times more shikimic acid than did the suspected glyphosate-resistant individuals. This study confirms eight additional glyphosate-resistant kochia populations indicating wide-spread presence of glyphosate resistance in kochia throughout western Kansas. Increased awareness and prompt implementation of herbicide resistance management practices are required to mediate the problem.

Herbicide Options for Glyphosate-Resistant Kochia Control. Andrew R. Kniss*[1], Phillip W. Stahlman[2], Patrick W. Geier[2], Robert G. Wilson[3], Gustavo M. Sbatella[4], Philip Westra[5], Richard M. Cole[6], Jeffrey M. Tichota[7]; [1]University of Wyoming, Laramie, WY, [2]Kansas State

University, Hays, KS, [3]University of Nebraska-Lincoln, Scottsbluff, NE, [4]Oregon State University, Madras, OR, [5]Colorado State University, Ft. Collins, CO, [6]Monsanto, St. Louis, MO, [7]Monsanto, Centennial, CO (166)

Field studies were initiated at 5 locations in Kansas, Nebraska, Colorado, Wyoming, and South Dakota in 2011 as part of a regional effort to determine best management practices for glyphosate-resistant kochia. Three herbicide treatments were chosen for each of five major crops grown in this region. Treatments were developed with a goal of controlling kochia without the use of glyphosate. A glyphosate treatment and an untreated check were also included for a total of 17 treatments. At each site, the trial was established in the absence of crop competition so that all herbicides could be evaluated in a single trial. Kochia control was estimated visually 3 to 4 weeks following the final herbicide application. Kochia biomass was then collected from 1 m^2 of each plot to evaluate biomass reduction. Kochia control with glyphosate was lowest at the Kansas field site in both years, averaging 57 and 14% in 2010 and 2011, respectively. Kochia control with glyphosate at all other sites ranged from 85 to 100%. When locations and years were combined for analysis, herbicide treatments registered for use in corn controlled kochia at least 98%, and no differences were observed among corn herbicide treatments. Herbicide treatments registered for use in soybean, wheat, and fallow controlled kochia 78 to 96%. Two herbicide programs registered for use in soybean provided greater than 90% control; sulfentrazone plus imazethapyr PRE followed by fluthiacet-methyl POST provided 91% kochia control, while S-metolochlor plus metribuzin PRE followed by lactofen POST controlled kochia 96%. Dicamba provided 92% control of kochia, greater than any other fallow treatment. For wheat treatments, pyrasulfatole plus bromoxynil provided 86% and fluroxypyr plus bromoxynil provided 85% kochia control. Sugarbeet herbicide programs controlled kochia 30 to 41%. Adding triflusulfuron to sugarbeet treatments increased kochia control by 11%. Corn herbicide treatments reduced kochia biomass by 96%, soybean, wheat, and fallow herbicide treatments reduced kochia biomass 80 to 85%, and sugarbeet herbicide treatments reduced kochia biomass by 32%. Control of glyphosate resistant kochia will be best achieved with corn herbicide programs compared with other crops.

Weed Control with Corn Herbicides that Allow Rotation to Dry Bean and Sugarbeet. Jared C. Unverzagt*, Andrew R. Kniss; University of Wyoming, Laramie, WY (167)

Herbicide options in corn in the High Plains are limited in crop rotations containing dry edible bean and sugarbeet. A field study was conducted in 2011 to evaluate corn herbicide programs that: (1) are effective on the weed spectrum in the High Plains; (2) allow rotation to both dry edible bean and sugarbeet the following season; and (3) utilize multiple modes of action for herbicide resistance management. Corn was planted on May 6 at 84,000 seeds ha^{-1} in 76 cm rows. Plots were 3 m by 9 m and arranged in a two-factor factorial 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 + dimethenamid-P at 70 and 612 g ai ha^{-1} respectively, acetachlor 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 + dicamba at 56 and 140 g ai ha^{-1}. Visual control ratings were taken at 5, 8, and 16 weeks after planting, and corn was harvested on Oct 24. PRE herbicides resulted in few significant differences in either weed control or yield when combined with a POST. Glyphosate and dicamba plus diflufenzopyr provided significantly greater control of broadleaf weeds and greater yield than glufosinate regardless of PRE herbicide treatment. Glyphosate and glufosinate provided significantly greater grass control when compared to dicamba plus diflufenzopyr treatments.

Influence of Different Levels of Corn Stover on Preemergence and Postemergence Herbicide Performance in Dry Beans. Robert G. Wilson*[1], Gustavo M. Sbatella[2]; [1]University of Nebraska-Lincoln, Scottsbluff, NE, [2]Oregon State University, Madras, OR (168)

Field experiments were conducted in 2010 and 2011 near Scottsbluff, Nebraska to measure the influence of different levels of corn stover on preemergence and postemergence herbicide performance in dry beans. In early May corn stocks were shredded and in late May glyphosate was utilized to kill existing weeds. The experimental design was a split block with main blocks consisting of three levels of tillage: rototilling once plus roller harrow, rototilling twice plus roller harrow, and no-till. Subplots consisted of either five herbicides applied preemergence or two herbicide treatments applied postemergence. Dry beans, 'Great Northern Orion' were planted with a no-till planter equipped with row cleaners the first week of June. The amount of tillage before dry bean planting influenced crop stand, early season injury from herbicides, dry bean seed yield, and weed density. Dry bean stand was greatest and crop injury from herbicides reduced in areas that were not tilled before planting compared to areas that were rototilled twice. Toothed spurge density was reduced with no tillage while kochia density increased with tillage. Dry bean vigor was reduced from preemergence treatment with halosulfuron (Permit) while crop density was reduced from flumioxazin (Valor) and injury increased with increases in tillage. A preemergence application of pendimethalin (Prowl) reduced weed density by 78% while a postemergence treatment with imazamox plus bentazon (Raptor plus Basagran) reduced weed density 88%. The greatest reduction in weed density (95%) occurred when flumioxazin was applied preemergence with no-tillage before planting.

Development of a New Herbicide Resistance Trait in Wheat. Michael Ostlie*[1], Philip Westra[2], Dale L. Shaner[3], Scott Haley[1]; [1]Colorado State University, Fort Collins, CO, [2]Colorado State University, Ft. Collins, CO, [3]USDA, Fort Collins, CO (169)

While herbicide resistant crops have become common in many agricultural systems, wheat has had few introductions of this technology. Quizalofop resistant wheat accessions were identified in herbicide screening studies of mutagenized plants. A series of experiments were designed to phenotypically and genotypically characterize this resistance mechanism. These 18 accessions were found to have a 1.5 to 7.5 fold increase in quizalofop tolerance over non-mutant wheat. DNA sequencing revealed a novel C to T substitution resulting in a change from alanine to valine in acetyl co-enzyme A carboxylase (ACCase) at position 2004 based on *Alopecurus myosuroides* notation. This mutation was discovered multiple times on each of the three homologous wheat chromosomes among the accessions studied. The mutations on the A, B, or D genome performed equally well in whole plant response. Enzyme activity of plants containing the A, B, or D genome mutations revealed a 4 to 10 fold increase in tolerance to quizalofop. Whole plant and enzyme assays were conducted on plants which contain a mixture of wild-type and mutant ACCase, indicating the potential for increasing the level of resistance in the future. Discovery of the new point mutations has provided an opportunity to develop new wheat varieties resistant to quizalofop.

Estimating the Frequency and Impact of Transgene Introgression from Wheat and Jointed Goatgrass. Craig T. Beil*[1], Philip Westra[2], Pat Byrne[3], Dale L. Shaner[4], Scott Haley[1]; [1]Colorado State University, Fort Collins, CO, [2]Colorado State University, Ft. Collins, CO, [3]Co-Advisor, Fort Collins, CO, [4]USDA, Fort Collins, CO (170)

Transgenic crops have been approved and have seen commercial success in some markets while in other markets they remain in the development stage, not yet approved. As transgenic crops begin to lift the constraints of environmental factors on crop production in the western U.S., crop developers will request deregulation of wheat (*Triticum aestivum* L.) lines with transgenes in the near future.

Successful release of transgenic crops in regions with related wild species involves careful monitoring, understanding, and risk assessment of gene flow. The long term goals of these series of studies are to develop the capability to predict the frequency and impact of introgression of transgenes from wheat to jointed goatgrass (*Aegilops cylindrica* Host.). Estimates of landscape-level gene flow from wheat to jointed goatgrass in the Central Great Plains took advantage of imazamox-resistant 'Above' wheat to estimate field level hybridization. Rates of subsequent backcrossing of the hybrids to jointed goatgrass were also estimated in field studies.

Because jointed goatgrass lacks the A- and B- genome, it has been suggested that the risk of gene flow from transgenic wheat to jointed goatgrass can be reduced by inserting transgenes into wheat chromosomes of these two genomes. However, there are several mechanisms for A- and B- genome chromosomes to become stably introgressed into jointed goatgrass.

The scope of this project lies in determining the germination frequency and fertility of backcross generations of wheat x jointed goatgrass. Cytogenetic experiments with backcross generations will extend our understanding of the mechanisms of gene transfer from wheat to jointed goatgrass.

Italian Ryegrass Control in Winter Wheat with 1- and 2-Pass Herbicide Programs. Joe Armstrong*; Oklahoma State University, Stillwater, OK (171)

Italian ryegrass (*Lolium multiflorum*) is an especially important weed problem in Oklahoma wheat production due to the widespread presence of ALS-resistant populations. To investigate additional herbicide options for Italian ryegrass control in winter wheat, field trials were conducted to compare one- and two-pass herbicide programs, postemergence (POST) only and early-POST followed by POST, for Italian ryegrass control and grain yield. At both trial locations, the greatest Italian ryegrass control was achieved with pinoxaden applied POST (≥98%) and metribuzin + flufenacet applied early-POST followed by pinoxaden applied POST (99%). Season-long Italian ryegrass control for a single early-POST application of metribuzin + flufenacet ranged from 64 to 84%, depending on use rate. Despite the excellent control with a single POST application of pinoxaden, yields for this treatment were lower than for an early-POST application of metribuzin + flufenacet. At both locations, wheat yields when metribuzin + flufenacet was applied as an early-POST treatment, whether or not a follow-up treatment was applied, were at least 10% greater compared to a single POST application of pinoxaden. Results from these trials indicate that early-season weed competition has the greatest effect on winter wheat yields. To maximize both yield and Italian ryegrass control, the most effective option is a two-pass program consisting of metribuzin + flufenacet followed by pinoxaden. Furthermore, a two-pass herbicide program allows for the use of additional herbicide modes of action to prevent the development of pinoxaden- and ACCase-resistant Italian ryegrass in Oklahoma.

Management Strategies for Transition from Conservation Reserve Program to Crop Production. Shawn P. Wetterau*; Washington State University, Pullman, WA (172)

Experiments were conducted in Eastern Washington and neighboring Idaho (Colfax, St. John, and Winona, WA; Gifford, ID) in 2010 and one location (Moro, OR) in 2011 to compare rate and timing of glyphosate and tank mix partners (premix of clopyralid + fluroxypyr, 2,4-D ester, and 2,4-D amine) for removal and control of perennial grasses and weeds in Conservation Reserve Program (CRP) land. In 2010, glyphosate application experiments indicate that a mixture of glyphosate + clopyralid + fluroxypyr is the most effective treatment for perennial grass and weed control in CRP. In 2011, control of sheep fescue (*Festuca ovina* L.) at the Moro, OR, site was 88% or less regardless of glyphosate rate, timing, or mix partner. The most effective control was observed with sequential applications of glyphosate at high rates. A separate experiment evaluating the undercutter sweep + glyphosate, disking + glyphosate, and glyphosate without tillage was conducted at the three Eastern Washington sites (Colfax, St. John, and Winona, WA). In the undercutter sweep trials, increasing the intensity of the tillage caused a release of species not present in the no-till treatments. In particular, common lambsquarters (*Chenopodium album*), redroot pigweed (*Amaranthus retroflexus*), mustard spp. (*Crusiferae spp*.), and nightshade spp. (*Solanum spp*.) were observed in treatments that included tillage.

The Effects of Crop Rotation and Terrain Attributes on the Weed Seed Bank. Rachel Unger*[1], Mark E. Swanson[1], Ian C. Burke[1], David R. Huggins[2], Eric R. Gallandt[3], Stewart Higgins[1]; [1]Washington State University, Pullman, WA, [2]USDA-ARS, Pullman, WA, [3]University of Maine, Orono, ME (173)

Understanding how crop rotation and terrain influence the weed seed bank may help identify field-related factors that contribute to increased or decreased weed pressure. A no-till, multi-year cropping systems study with six different three year rotations of spring wheat – winter wheat – alternative crop rotation (winter or spring plantings of barley, triticale, canola, or pea) was initiated in 2001 at the Washington State University Cook Agronomy Farm near Pullman, WA. Soil cores were taken in 1999 and 2010 from 369 geo-referenced locations across the farm to analyze the weed seed bank. Samples were exhaustively germinated and germination was recorded weekly by species over the course of the study. The data were analyzed using Poisson generalized linear model (GLM) and zero-inflated Poisson regression model. In 2010, the wild oat population had decreased to the point that statistical analysis was not possible. Crop rotations could not be analyzed in the 2010 zero-inflated Poisson regression due to reduced weed populations. In 1999 and 2010, mayweed chamomile was negatively correlated with elevation, slope, and transformed aspect when analyzed using Poisson GLM. In 2010, spring barley, canola, and wheat were negatively correlated with mayweed chamomile. In 1999 and 2010, global irradiation and slope were negatively correlated with common lambsquarters, while elevation and wetness index were positively correlated. In 2010, spring barley, canola, and pea were negatively correlated with common lambsquarters. In 1999 and 2010, elevation was negatively correlated with mayweed chamomile when analyzed using zero-inflated Poisson regression. In 1999, slope and global irradiation were negatively correlated with common lambsquarters.

PROJECT 4: TEACHING AND TECHNOLOGY TRANSFER

Herbicide Resistance Education from WSSA - A Critical Step in Proactive Management.
Jill Schroeder*[1], Wes Everman[2], Les Glasgow[3], Lynn Ingegneri[4], David Shaw[5], John Soteres[6], Jeff Stachler[7], Francois Tardif[8]; [1]New Mexico State University, Las Cruces, NM, [2]Michigan State University, Lansing, MI, [3]Syngenta Crop Protection, Greensboro, NC, [4]consultant, Ft. Collins, CO, [5]Mississippi State University, Starkville, MS, [6]Monsanto Company, St. Louis, MO, [7]North Dakota State University and University of Minnesota, Fargo, ND, [8]University of Guelph, Guelph, ON (174)

Herbicide resistance education and training have been identified as critical paths toward advancing the adoption of proactive best management practices to delay and mitigate the evolution of herbicide-resistant weeds. In September 2011, the Weed Science Society of America (WSSA) introduced a training program designed to educate certified crop advisors, agronomists, pesticide retailers and applicators, growers, students, and other interested parties on the topic of herbicide resistance in weeds. A peer reviewed, five-lesson curriculum is currently available at the Society's web page via web-based training and PowerPoint slides. Topics include: (1) An introduction to herbicide resistance in weeds (2) How do herbicides work? (3) What is herbicide resistance? (4) How do I scout for and identify herbicide resistance in weeds? and (5) How do I manage resistance? The lessons are unique among herbicide resistance training materials in that, for the first time, the WSSA presents a unified message on the causes of herbicide resistance and offers several strategies for identifying and mitigating herbicide resistance in weeds. The lessons contain the most up-to-date definitions for use in the field, including those for low- and high-level resistance, a video on how to scout for herbicide-resistant weeds, and an emphasis on proactive management. The lessons utilize animations to showcase these important points. A Spanish-language version has been also produced. Greater than 600 downloads of the English version and 15 downloads of the Spanish version were documented between October 1, 2011 and February 16, 2012.

The Development and Adoption of the Ecofallow and Ecofarming Cropping Systems.
Robert N. Klein*; University of Nebraska, North Platte, NE (175)

First what is Ecofallow and Ecofarming? Planting corn, sorghum or soybeans into untilled weed-free wheat stubble that is 10 months old is an acceptable practice in the Central Great Plains. In Nebraska, this system is known as ecofallow. Ecofarming and ecofallow are systems of no-till or reduced tillage. Ecofarming is defined as a system of controlling weeds and managing crop residues throughout a crop rotation with minimum use of tillage so as to reduce soil erosion and production costs while increasing weed control, water infiltration, moisture conservation and crop yield. Prior to the mid 70's much of western Nebraska dryland farmland was in a winter wheat-fallow rotation. As many as nine tillage operations were used in the 14 to 15 month fallow period to control weeds and prepare a seedbed for the next winter wheat crop. The fallow period is to store water for the following winter wheat crop but water storage efficiency with fallow periods using tillage usually averages only about 22%. Tillage also leaves the soil susceptible to erosion from wind and water. Ecofallow and ecofarming also called no-till can greatly improve the water storage efficiency of both the ecofallow period (wheat harvest to spring row crop planting) and the pre-wheat fallow period (row crop to winter wheat seeding). These practices which maintain much of the crop residue protect the soil from wind and water erosion. This paper will discuss what it takes to make these cropping systems successful.

Mobile Apps and Weeds. A Potential Useful Tool or Just a New Gadget? Gustavo M. Sbatella*; Oregon State University, Madras, OR (176)

The capabilities of portable devices, such as cell phones, in transmitting and providing access to information have drastically improved in recent years. Part of this improvement can be attributed to the use of Apps. Apps is the abbreviation for application. These applications are software designed and developed for use on portable devices. Apps enhance the features of portable devices by providing additional functionalities and utilities. A diverse range of activities have the potential of benefiting from this improvement in technology, including weed management programs. Currently there are several options offered that can be applied in weed management, but the most frequent support offered for this purpose is facilitating plant identification. This feature is sometimes accompanied by the possibility to report the location of a weed as well to load pictures of the species. Invasive species programs seem to have been taken advantage of these capabilities, particularly the ability to report the geographical location of the weeds. There are also options for use in agricultural crops. In these cases the application offers the possibility to identify and map the location of the plants, suggest control measures and also contact a specialist when facing a specific problem. There are several challenges facing these applications, such as limited cell phone signal reception in remote areas or inaccurate reports of weed species due to incorrect plant identification when applications are used by the general public. Nevertheless, due to the popular use of cell phones capable to provide a wide range of utilities, mobile apps have the potential to become a helpful tool for weed control.

PROJECT 5: BASIC BIOLOGY AND ECOLOGY

Fitness Associated with EPSPS Gene Amplification in Glyphosate Resistant Palmer Amaranth. Darci A. Giacomini*[1], Sarah M. Ward[1], Philip Westra[2]; [1]Colorado State University, Fort Collins, CO, [2]Colorado State University, Ft. Collins, CO (127)

In the six years since its discovery in 2005 (Culpepper et al., 2006), glyphosate resistant Palmer amaranth has become a major problem for many farmers in multiple states. A major mechanism of resistance in Georgia populations is due to amplification of the 5-enolpyruvylshikimate-3-phosphate synthase (*EPSPS*) gene throughout the genome, with some resistant plants encoding and expressing more than 100 *EPSPS* genes. Such high numbers of *EPSPS* genes and protein production could result in a fitness cost to resistant plants, due to (1) metabolic cost of overproduction of this enzyme, (2) disruption of other genes after insertion of the *EPSPS* gene, or (3) possible disruption of enzymatic pathways downstream of the shikimate reaction. A greenhouse experiment was set up to test for growth and reproduction differences between glyphosate susceptible and resistant Palmer amaranth plants. Measurements included growth rates, plant height/volume, final biomass, photosynthesis rates, inflorescence length, pollen viability, and seed set. There were no significant fitness costs for plants with the resistance trait detected in this study, though more research needed in this area, specifically testing the plants in a competitive environment and in a field-based study.

Gene Amplification of EPSP Synthase in Glyphosate Resistant Kochia scoparia. Andrew T. Wiersma*[1], Stephen T. Chisholm[1], Amar S. Godar[2], Phillip W. Stahlman[3], Jan Leach[1], Philip Westra[4]; [1]Colorado State University, Fort Collins, CO, [2]Kansas State University, Manhattan, KS, [3]Kansas State University, Hays, KS, [4]Colorado State University, Ft. Collins, CO (128)

Since the first identification of glyphosate resistant *Kochia scoparia* in 2007, concerns about glyphosate efficacy have mounted in the central Great Plains. Until recently, the mechanism of glyphosate resistance in *K. scoparia* had yet to be determined. Experiments were done on plants from Kansas, Colorado, North Dakota, and South Dakota to determine the mechanism of resistance. Screening for resistance was done using an overhead track sprayer and shikimate accumulation leaf disk assays. The *EPSPS* target site was sequenced. Quantitative PCR was used to measure *EPSPS* copy numbers and transcription, and immunoblots were done to quantify EPSPS protein accumulation. No proline 106 mutation was found in glyphosate susceptible or resistant individuals. Glyphosate susceptible plants had a single *EPSPS* gene copy (relative to *ALS*), while the relative *EPSPS* gene copy numbers ranged between ~3 and 9 in glyphosate resistant individuals. Increased relative *EPSPS* gene copy numbers also correlated with reduced shikimate accumulation in leaf disks treated with 100 uM glyphosate. Based on the correlation of relative *EPSPS* genomic copy number to relative *EPSPS* transcript abundance, amplified *EPSPS* gene copies are effectively transcribed. Compared to glyphosate susceptible plants, EPSPS protein accumulates to a greater extent in glyphosate resistant plants with increased genomic copy number. Following these results, increased EPSPS expression appears to be responsible for glyphosate resistance in *K. scoparia*. Given that *K. scoparia* is already a problematic weed in western states, removal of glyphosate as a viable option for control could significantly impact western US cropping systems.

Using Molecular Techniques to Understand Glyphosate Resistance in Palmer Amaranth, Kochia, Giant Ragweed, and Common Lambsquarter. Philip Westra*[1], Todd Gaines[2], Jan Leach[3], Stephen T. Chisholm[3], Andrew T. Wiersma[3], Darci A. Giacomini[3], Chris Preston[4]; [1]Colorado State University, Ft. Collins, CO, [2]University of Western Australia, Perth, Australia, [3]Colorado State University, Fort Collins, CO, [4]University of Adelaide, Adelaide, Australia (129)

Molecular techniques are increasingly being applied to key weed science research projects including determination of the mechanisms of glyphosate resistance in multiple weed species. Once successful primers have been constructed for the EPSPS gene in a plant, the gene can be removed, cleaned up, and sent off for sequencing. This DNA sequencing is frequently used to look for known mutations that confer modest glyphosate resistance such as the Proline 106 mutation. Once this amount of molecular testing has been successful, Q-PCR can be used to determine gene copy number. If an increase in EPSPS gene copy number is detected, additional molecular research is used to determine if the amount of EPSPS enzyme protein produced correlates with the gene copy number. New generation deep sequencing coupled with advanced bioinformatics can then be used to construct DNA sequence surrounding amplified genes to begin to probe possible genetic mobile elements that may facilitate gene amplification under the stress imposed by glyphosate selection pressure. In addition, where protein specific antibodies have been developed, fairly precise estimations of protein production can be correlated with enzyme level and enzyme activity. In the specific case of kochia (*Kochia scoparia*), advanced molecular research at Colorado State University on multiple accessions from KS, CO, NE, SD, and ND where glyphosate resistance was suspected, no Proline 106 mutation was detected in any of the lines. However, QPCR results showed that gene amplification occurs in all of these "resistant" populations with the increased copy number generally in the range of 4 to 9 fold. This appears to be enough to provide kochia survival at lethal field rates. Some kochia plants survive glyphosate rates as high as 6 lb/acre in the greenhouse. Using an EPSPS specific antibody shows that EPSPS protein level correlates well with increased gene copy number. Although increased copy numbers are modes in kochia, they appear to be sufficient to allow kochia survival and reproduction when sprayed with a commercial recommended level of glyphosate.

Mechanism of Resistance to Glyphosate in Palmer Amaranth (*Amaranthus palmeri*) Populations from New Mexico. Mohsen Mohseni-Moghadam*, Jamshid Ashigh, Jill Schroeder; New Mexico State University, Las Cruces, NM (130)

Two populations of Palmer amaranth from New Mexico have been confirmed to be resistant to glyphosate. The objective of this study was to determine the molecular basis of resistance in resistant Palmer amaranth populations. The results of partial cDNA sequencing of *EPSPS* indicated that none of the populations had a point mutation that coded for a substitution at position 106 of the EPSPS enzyme. Quantitative RT-PCR analysis indicated that the genomes of resistant plants contained from 2-fold to 8-fold more copies of the *EPSPS* compared to that of susceptible plants. Quantitative RT-PCR on cDNA also revealed positive correlation between the relative *EPSPS* expression and the relative copy number of genomic *EPSPS* in those plants. *In vivo* shikimate accumulation assay with excised leaf tissues of resistant and susceptible plants, 8 h after treatment with water or glypghosate at 400 g ai ha^{-1}, indicated that only susceptible plants accumulated shikimate after glyphosate treatment. Results suggest that the *EPSPS* gene amplification is the molecular basis of glyphosate resistance in these resistant populations of Palmer amaranth from New Mexico.

Comparison of the Eco-Efficiency of Conventional and Glyphosate-Resistant Sugarbeet Production. Andrew R. Kniss, Carl W. Coburn*; University of Wyoming, Laramie, WY (131)

The rapid adoption of glyphosate-resistant sugarbeets has largely displaced conventional sugarbeet production. Eco-efficiency analysis allows the comparison of production systems by quantifying the level of output per unit of input. A study was conducted to compare the eco-efficiency of herbicide treatments in conventional and glyphosate-resistant sugarbeet production. Using herbicide environmental impact and yield data from six studies located in multiple growing regions in the U.S., a partial eco-efficiency analysis was performed on conventional and glyphosate-resistant systems. Greater values of eco-efficiency lower environmental impact per unit of sugar production. The average eco-efficiency of all glyphosate treatments was 16% less than the average of all conventional treatments including micro-rates (P=0.066). Micro-rate treatments of conventional herbicides resulted in an eco-efficiency value 1.5 and 1.4 times greater than the average of all glyphosate and conventional treatments, respectively (P=0.046 and P=0.017). Micro-rate treatments provided the maximum eco-efficiency in each study. Inclusion of a preemergence herbicide in conventional and micro-rate treatments reduced eco-efficiency values below that of glyphosate treatments. Future comparisons will include additional herbicide studies, as well as compare tillage and other inputs that differ between conventional and glyphosate-resistant sugarbeet production systems.

Compensatory Growth in Palmer Amaranth: Effects on Weed Seed Production and Crop Yield. Lynn M. Sosnoskie*[1], Alfred S. Culpepper[1], Timothy L. Grey[1], Theodore M. Webster[2]; [1]University of Georgia, Tifton, GA, [2]USDA-ARS, Tifton, GA (132)

Palmer amaranth is a highly competitive weed of field corn, peanut, soybean and, especially, cotton. Biotypes resistant to glyphosate have been confirmed in nearly every agronomic county in GA. Growers, extension agents, and university research personnel have observed instances where: 1) previously pulled Palmer amaranth plants have re-rooted and become reestablished in a field and 2) plants that have been cut back (using hoes or machetes) have re-sprouted from dormant buds and resumed normal growth. Plants that escape removal can flower and produce progeny that could severely impact the following year's crop. The objective of this study was to evaluate the potential of Palmer amaranth to grow and develop following defoliation occurring during a simulated hand-weeding failure. This study was conducted in Tifton, Ty Ty, and Plains, GA in 2011. A density of ten Palmer amaranth plants per plot were established in the center two rows of each experimental unit (five plants per row, four row plots). Plots were maintained weed free, except for the selected Palmer amaranth, by hand-weeding. At the start of Palmer amaranth flowering (June to August), plots were randomly assigned to one of four defoliation treatments: 1) no defoliation [Intact], 2) removal of all stem and leaf tissue to the soil line [Soil], 3) removal of all stem and leaf tissue to a height of one inch above the soil line [1"], and 4) removal of all stem and leaf tissue to a height of six inches above the soil line [6"]. Plant heights were recorded regularly throughout the growing season. Floral tissues from female plants (inflorescences and seed) were harvested when seeds were 50 to 75% mature, but before plant senescence. Tissue was air dried in a greenhouse and the seed from each plant sieved through18, 20, 35, and 40 mesh screens. Following the removal of all chaff, total seed mass and number were determined. Cotton was harvested from the center two rows of each plot and yield determined. Averaged across all sites, Palmer amaranth plants were approximately 55 inches in height when the defoliation treatments were initiated. By six weeks after cutting (WAC), the intact plants were, on average, almost 85 inches tall. Averaged over all locations, plants cut back to the soil line, and 1" and 6" above the soil line were, approximately, one, 25, and 50 inches in height 6 WAC. Palmer amaranths that were allowed to grow and develop normally produced an average of 394,000 seeds/plant; plants cut back to the soil line, and 1" and 6" above the soil line produced an average of 22,000, 36,000, and 129,000 seeds/plant, respectively. Average cotton yield was between 2,500 and 3,000 lb/A in plots where Palmer amaranths had been physically defoliated at the time of flowering; cotton yields of 1,500 lb/A were recovered from plots where Palmer amaranth plants were left intact. Results from this field study show that Palmer amaranth plants cut back (all stem and leaf tissue removed) to one and six inches above the soil line are able to successfully regrow and achieve reproductive maturity. Although the defoliated plants never achieved the same size as their intact counterparts, they were still able to produce significant amounts seed. Current control recommendations urge cotton growers to remove Palmer amaranth plants escaping early season control measures by hand to try and reduce the size of the residual seedbank. Growers need to be aware that ineffectual salvage attempts could negate efforts designed to manage the size of Palmer amaranth populations in the field.

Characterizing Shade-Avoidance Responses in Sugarbeet. Louise Lorent*[1], David A. Claypool[1], Ryan Rapp[2], Jared C. Unverzagt[1], Andrew R. Kniss[1]; [1]University of Wyoming, Laramie, WY, [2]University of Nebraska, Concord, NE (133)

Low red:far red light ratio reflected from neighboring vegetation can be detected by plants and can trigger irreversible physiological changes known as shade-avoidance responses. These responses are suspected to determine the onset of crop-weed interaction before competition for resources occurs, and have been documented to cause yield loss in corn and soybean. Because of the biennial character and growth type of a sugarbeet, the outcome of shade-avoidance responses in this crop could be different. A pot experiment was conducted under non-limiting resource conditions using common lambsquarters as a model weed species. Sugarbeet was either grown surrounded by weeds or by bare soil. Common lambsquarters was removed at different timings between cotyledon and twelve true-leaf stages of sugarbeet development. Sugarbeet was harvested at 100 days after emergence. Timing of weed removal had no effect on root weight at harvest (P=0.9). Parameters significant in explaining variation in root weight included leaf biomass, root diameter and length, leaf mean length and canopy angle. Further studies are needed to evaluate the impact of shade avoidance responses on these parameters.

Herbicide Absorption and Translocation in Eurasian Watermilfoil. Scott J. Nissen*, Joseph D. Vassios; Colorado State University, Fort Collins, CO (135)

Eurasian watermilfoil (*Myriophyllum spicatum*) (EWM) is a submersed, invasive species that occurs across much of the United States. One of the more common control strategies for EWM is the use of systemic herbicides like triclopyr (Renovate®). Ongoing research has focused on evaluating triclopyr absorption and translocation in EWM using ^{14}C-triclopyr. Rooted plants were treated with 1 ppm triclopyr plus radiolabeled herbicide and triclopyr absorption and shoot to root translocation were determined. Additional experiments evaluated translocation from roots to shoots following root exposure. For both studies, plants were harvested over a 192-hour time course. EWM absorbed more triclopyr then would have been predicted based on parameters like log K_{ow}; however, translocation to roots following shoot exposure was limited to only 2.6% of the absorbed herbicide. Triclopyr absorption by EWM roots was low, but there was accumulation 1.6 times the external concentration. Approximately 25% of absorbed triclopyr translocated to shoots 192 HAT. This information provided the bases for evaluating triclopyr absorption and transloction following a granular triclopyr application. Granules were formulated with cold and radiolabelled triclopyr in a manner similar to Renovate OTF and applied to large, well-established, multi-stemmed EWM plants in 11 L cylindrical tanks. There was no significant difference in foliar accumulation between the two formulations; however, the amount of radiolabel accumulating in plant roots increased 6-fold with the granular formulation. For long-term control or for applications in areas with high water exchange, increasing root accumulation could improve control.

Absorption and Translocation of Aminocyclopyrachlor in Black Walnut. Nevin Lawrence*, Shawn P. Wetterau, Jared L. Bell, Ian C. Burke; Washington State University, Pullman, WA (136)

Aminocyclopyrachlor is a new synthetic auxin herbicide for control of broadleaf weeds in non-agronomic areas. Absorption and translocation of aminocyclopyrachlor in the tree species black walnut (Juglan nigra) was evaluated utilizing 14C radiolabeled formulations of aminocyclopyrachlor. The study design included three herbicide formulations and two application methods. Basally-applied treatments included an emsulsifiable concentrate of the ester (DPX-KJM44EC) and an oil soluble liquid of the acid (DPX-MAT28OL). The acid (DPX-MAT28) was applied foliarly. Basal applications were applied onto plant stems with a 10 µL herbicide mixture containing bark oil, non-radiolabeled herbicide at 250 g ai L-1 and radiolabeled herbicide (22.56 kBq). Foliar applications were made by covering a leaf and applying a non-radiolabeled herbicide mixture at 210 g ai ha-1 DPX-MAT28 and nonionic surfactant at 25% v v-1. Covered leaves were treated with radiolabeled herbicide (29.29 kBq). Plants were harvested at 2, 8, 24, and 72 HAT and divided into plant parts: roots, area above and area below the treated section. Parts were dried, weighed, subsampled were necessary, oxidized and the radioactivity quantified. The greatest absorption of herbicide occurred with the DPX-KJM44EC formulation with 66% of applied radiolabeled herbicide being recovered 72 HAT. DPX-MAT28OL absorption was 52% 72 HAT. The foliarly applied DPX-MAT28 reached maximum absorption 8 HAT with 9% applied aminocyclopyrachlor absorbed. Translocation of applied material out of the treated portion was 18.4% for DPX-KJM44EC, 15.2% for DPX-MAT28OL, and 2.5% for DPX-MAT28 72 HAT. In black walnut, basal applications have increased absorption and translocation out of the treated section.

The Biology of Dittrichia graveolens: A Foundation for Developing Management Strategies. Rachel N. Brownsey*[1], Joseph M. DiTomaso[2], Guy B. Kyser[2]; [1]UC Davis, Red Bluff, CA, [2]University of California, Davis, CA (137)

Dittrichia graveolens (L.) Greuter (stinkwort; Asteraceae) is a rapidly expanding and poorly studied annual invasive plant that is becoming a focus of resource managers in California. *D. graveolens* establishes in disturbed areas and has effective dispersal due to an abundance of pappus-bearing, wind dispersed seeds. Potential for *D. graveolens* invasion in wildland ecosystems is not well understood at present; a better characterization of biology and life history traits is needed to assess this potential. We focused our initial research on the germination and growth phases of the *D. graveolens* life cycle to understand its capacity for establishment and growth under a variety of environmental conditions. Germination in response to temperature was tested in the lab using a temperature table. Field experiments were carried out to assess germination and growth in response to seasonal cycles. In the greenhouse, germination and growth were observed for four light environments (100, 50, 27, and 9% light). Preliminary results indicate that there is no primary seed dormancy, and germination occurs with the first rainfalls of the season and throughout the winter and early spring. Additionally, germination occurs at a wide range of constant temperatures (12°-35°C), and is not inhibited by shade. Subsequent studies show that plant growth is limited by low light conditions, and that phenology of flowering is influenced by photoperiod. These studies are the first step in describing the biology and life history traits of *D. graveolens* and will improve our ability to predict its range expansion and develop effective, well-timed management strategies.

The USA National Phenology Network: A Platform for Education, Research and Decision-making in a Changing World. Jake F. Weltzin*; U.S. Geological Survey, Tucson, AZ (138)

The USA National Phenology Network (USA-NPN; www.usanpn.org), established in 2007, is a national science and monitoring initiative focused on phenology as a tool to understand how plants, animals and landscapes respond to climatic variability and change. Core functions of the National Coordinating Office (NCO) of USA-NPN are to provide a national information management system including databases, develop and implement internationally standardized phenology monitoring protocols, create partnerships with a variety of organizations including field stations for implementation, facilitate research and the development of decision support tools, and promote education and outreach activities related to phenology and climate change. This presentation will describe programs, tools and materials developed by USA-NPN to facilitate science, management and education related to phenology of plants, animals and landscapes within protected areas at local, regional and national scales. Example tools and materials include databases, user interfaces, web services, support materials for partnership development, communication, education and outreach. Particular emphasis will be placed on the on-line integrated animal and plant monitoring program, *Nature's Notebook*, which provides standardized protocols for phenological status monitoring and data management for over 500 animal and plant species.

EDUCATION & REGULATORY SECTION

Communicating Weed Impacts Through a Weed Awareness Campaign. Roger Batt*; Idaho Weed Awareness Campaign, Meridian, ID (139)

The Idaho Weed Awareness Campaign, or IWAC, was created in 2001 by the efforts of the Idaho Weed Coordinating Committee. Its mission is to create public awareness and education to help the people of Idaho understand the economic and environmental impacts of invasive weeds and support the implementation of all aspects of integrated weed management. Our main goal is to encourage Idahoans to help develop and participate in invasive weed eradication and management programs, and to assist in preventing the spread of invasive weeds.

By focusing on a central theme of Idaho's Most Wanted "Noxious Weeds," IWAC has created an ongoing Community Outreach Program, utilizing Television, Radio and Newspaper ads. IWAC has also developed an "Invasive Weeds Toolkit" educational program which is being distributed to Elementary and Middle Schools in Idaho. IWAC also created a web site to distribute information to the public. It is updated regularly to provide attractive and educational interactive multimedia content and it also allows for people to network and discuss opportunities for awareness. A highlight of this website is our "Virtual Field Guide" where you can visit 360 degree panorama images, video and multimedia, and a "Reference Library" providing information about each of Idaho's noxious weeds.

Sharing Impacts Using Social Media – Practical Solutions for Everyday Use. Jim Lindstrom*; Washington State University, Spokane, WA (140)

Today, everyone from teenagers to seniors are using social media to communicate about the issues important to them. Most educationally based organizations are also using social media to tell their stories to a target audiences.

Why should we do this? Using FaceBook as an example, as of September 2011 there are more 750 million active users of which 50% log on to their Facebook page in any given day. People spend over 700 billion minutes per month on Facebook. In addition "more than 2.5 million websites have integrated with Facebook, including over 80 of comScore's U.S. Top 100 websites and over half of comScore's Global Top 100 websites."

This session explores methods to maximize your impact with audiences by wisely choosing the social media method to meet your goals and to track usage of those social media sites by your clientele. The ultimate goal is successfully utilizing social media to communicate effectively with your clientele.

Non-Market Costs of Weeds Within a Weed Planning Tool: Communicating Importance of Weed Management. Tyron Venn*, Matthew Wibbenmeyer; University of Montana, Missoula, MT (141)

Communicating the benefits of weed treatment programs is challenging because most benefits are avoided damages associated with delaying or preventing the spread of weeds to uninvaded landscapes. Furthermore, most avoided damages relate to resources that are not marketed, including wildlife habitat, water quality and air quality. To date, limited economic research has been performed to estimate these non-market benefits. This paper presents findings from a choice experiment that estimated several non-market damage costs of weeds in the Interior Northwest of the United States, and highlights the opportunities and challenges to incorporating them into a weed treatment planning tool to support economically efficient management and improve communication of the social benefits of weed control.

Program Impacts: Strategies for Effective Evaluation Using Surveys. Stephanie Kane*; University of Idaho, Moscow, ID (142)

In the past several years, funding agencies (e.g. USDA, NSF) have encouraged or outright required interdisciplinary approaches to address complex problems, including in agriculture. This trend requires integrating data from multiple disciplines, e.g. agronomy, entomology, economics, and sociology. In addition, research and extension projects of all sizes are facing increasing requirements to evaluate program efficacy and document impacts. Both situations (working in an interdisciplinary framework and effective program evaluation) require a coordinated and well-thought out data collection effort. The purpose of this talk is to outline a framework for conducting these types of studies, with an emphasis on using survey methods in an interdisciplinary manner to understand the multiple dimensions that promote or inhibit change in a system and drive research impacts. Several recent examples will be presented to illustrate the framework.

CAST Reports Threats to Soil Conservation Gains from Herbicide-Resistant Weeds. Robert G. Wilson*; University of Nebraska-Lincoln, Scottsbluff, NE (143)

Growers and scientists have long recognized both beneficial and detrimental aspects of tillage. In some situations tillage operations promote soil loss, adversely affect surface water quality, and negatively impact soil productivity. Weed Management is a primary reason for tillage, and until the development of highly effective herbicides, tillage was not optional. Furthermore, with the development of herbicide-resistant (HR) crops, particularly glyphosate-resistant (GR) crops, herbicides such as glyphosate minimized the need for tillage as a weed control tactic; the resulting crop production systems have been primary enablers for the success of U.S. Department of Agriculture Natural Resource Soil Conservation programs. When any single herbicide mechanism of action is used repeatedly without alternative management tactics, however, selection pressure becomes intense for plants that are tolerant or resistant to that herbicide. The unintended consequence of the predominance of GR crops on the agricultural landscape has been intense selection pressure for the development of GR weeds. There is now a large and growing threat to soil conservation gains because of the dire need in some situations to manage these resistant weeds through any means necessary, including tillage. In some instances, tillage is one of the few effective options to manage particular HR weeds. For example, Palmer Amaranth has become the dominant weed problem in southeastern U.S. cotton production because of evolved resistance to glyphosate. Inversion tillage was clearly demonstrated to be an effective tool in helping the management of this weed. Creative research programs have been developed that meet conservation compliance requirements and at the same time judiciously use tillage as an element for management of this species. Further research is critically needed in instances when few or no other options are available to ensure the economic viability of farming operations while addressing long-term soil quality concerns.

Refining Your Ask: How Do We Communicate the Importance of Weeds to Legislators?
John D. Cantlon*; DuPont Land management, Lakewood, CO (144)

The art of communicating a need to policy makers is best served by using a technique called an ASK. This technique allows for a very focused delivery of a need or concept to enable the support, expansion or termination of policy. Often, experts in their field, can be quickly overlooked by the inability to sharply and clearly define their request in a few seconds. This session will define an ASK, demonstrate it's usefulness and provide insight into the preliminary and follow up requirements to change policy with targeted legislators on a state and federal level. The session will draw up critical elements in creating a critical mass of support on weed issues and outline the current ASKs put forth with Western Governors, State Legislators, State Department of Agriculture Directors and Congress.

SYMPOSIUM: Tree and Vine Weed Control: New Issues and Opportunities in the U.S.

Managing Glyphosate-resistant Weeds in California Orchards and Vineyards. Brad Hanson*[1], Anil Shrestha[2], Kurt J. Hembree[3], Steve Wright[4], John A. Roncoroni[5]; [1]Univ. of California, Davis, Davis, CA, [2]California Fresno State University, Fresno, CA, [3]UCCE, Fresno, CA, [4]UCCE, Tulare, CA, [5]UCCE, Napa, CA (145)

Herbicide-resistant weeds have become a serious management issue in central and coastal California fruit tree, nut tree, and vineyard production systems. Recent decreases in the price of glyphosate, increasing fuel costs, and trends to reduced use of preemergence herbicides for regulatory, economic, or performance-related reasons have substantially increased the use of glyphosate in these cropping systems. The first case of glyphosate resistance in California, rigid ryegrass in Sacramento Valley orchards, was reported in 1998. In recent years, four additional glyphosate-resistant species (Italian ryegrass, horseweed, hairy fleabane, and junglerice) have become established in various production regions in the state. University research and extension efforts currently focus on four major areas: 1) documenting and characterizing existing populations and evaluating mechanisms of resistance; 2) evaluating and demonstrating alternative chemical control measures such as rotating modes of action, tankmix partners, and residual herbicides; 3) testing and demonstrating application technologies designed to reduce off target herbicide issues while increasing efficacy of available herbicides; and 4) educating growers and advisors about current and potential herbicide-resistant species and developing recommendations suitable for the numerous and diverse tree and vine productions systems that extend throughout the state. While some tree and vine systems have a number of registered herbicides as well as mechanical weed control options, other systems have more limited options due to the number of available herbicides, crop safety issues, or environmental concerns related to erosion and water and air quality. Developing techniques to minimize further selection and spread of glyphosate-resistant weeds in California tree and vine production systems is critical to ensure that herbicides with favorable economic and environmental qualities, such as glyphosate, remain available and useful for these systems and may require significant changes in grower attitudes and weed management practices.

Weed Control in Young Orchards, Special Problems and Solutions. Timothy J. Smith*; Washington State University, Wenatchee, WA (146)

Orchard managers must balance the risk of herbicide damage to young orchard trees against the certain damage caused by excessive weed competition and irrigation efficiency disruption. Labels restrict most residual herbicides until the second or third year of orchard establishment. In the early years of orchard establishment, growers are compelled to control weeds by relatively frequent application of post-emergent contact or systemic herbicides. Many continue this practice well beyond the time restrictions on residual herbicide labels. In 2010 and 2011, trials were carried out starting in second season apples and cherries in an effort to evaluate safety, efficacy and best application timing of various residual herbicides. Treatments included indaziflam + glyphosate (1.75, 2.5 or 3.25 fl oz ai + 1.88 lb ae), rimsulfuron + pendimethalin + glyphosate (1 oz ai + 2.85 lb ai + 1.88 lb ae), or penoxsulam + oxyfluorfen + glyphosate (0.031 lb. ai + 1.48 lb ai + 1.88 lb ae), or penoxsulam + oxyfluorfen + glyphosate (0.062 lb ai + 2.95 lb ai + 1.88 lb ae.) These treatments were applied in spring 2010; then in fall 2010, the same treatments were applied on one half of each replicate. In spring of 2011, the same rates were applied to the half untreated in fall 2010. Visual estimates of weed control were collected and populations were characterized on percentage of ground cover, and on a numerical scale relative to degree of practical weed control, based upon when a prudent manager would likely choose to respray the treatment. Tree trunks were measured to monitor for possible growth suppression. Generally, the higher rates of the treatments performed very well in 2010, the second year of tree growth. In 2011, the weed control was season-long (April to October) in the 2.5 or 3.25 fl oz indaziflam + glyphosate, the rimsulfuron + pendimethalin + glyphosate, and the higher rate of penoxsulam + oxyfluorfen + glyphosate. By fall 2011, those treatments treated in spring 2010 and 2011 were superior to those treated in spring and fall 2010. No tree growth effects or other symptoms were documented. Costs of the more effective residual herbicides applied once per season in the spring were estimated to be similar to total costs of four applications of glyphosate.

Weed Control and Resistance Management in Florida Citrus. Steve Futch*; University of Florida, Gainesville, FL (147)

Weed management in Florida citrus is an essential component of the total citrus production program and comprises approximately 12% of the annual production cost. Citrus growers utilize a combination of vegetation management practices including but not limited to, cultural, preventative, mechanical and chemical methods. The objectives of citrus weed management programs are to suppress and control weeds to a level that they do not cause damage to the tree, impact yield, or impede grove and harvesting operations. The herbicide selected for weed control in Florida citrus operations varies depending on: 1) application site (tree age, cultivar, soil type, location within the state and specific county restrictions); 2) weed species present or anticipated; 3) stage of weed growth; and, 4) season of the year. Utilized herbicides are divided into two main groups, soil-applied preemergence and foliar-applied postemergence products. Commonly used preemergence herbicides include: bromacil, diuron, indaziflam, norflurazon, pendimethalin, and simazine. The most frequently used postemergence herbicide is glyphosate. Other postemergence products include 2,4-D, carfentrazone-ethyl, fluazifop-P-butyl, paraquat, saflufenacil, and sethoxydim. Few weeds in Florida citrus groves have been identified as truly resistant to currently used products. However, some species are showing the need to increase herbicide rates or mixing a combination of post products of different chemical classes to maintain acceptable control. Herbicide boom design and features allow for precise and uniform application of selected products and in a manner that avoids contact with the tree canopy. Equipment is capable of delivering herbicide product or products via a shielded boom controlled by electronic sensors varying application based upon tree size or other predetermined factors.

Preemergence Herbicides and Weed Management in Southwestern Pecans. William B. McCloskey*[1], Jill Schroeder[2], Jesse M. Richardson[3]; [1]University of Arizona, Tucson, AZ, [2]New Mexico State University, Las Cruces, NM, [3]Dow AgroSciences, Hesperia, CA (148)

Arizona and New Mexico pecan growers rely heavily on postemergence glyphosate applications for weed management and need to diversify the herbicide mechanisms of action they use to mitigate the development of herbicide resistant weeds. Preemergence herbicide applications are a common way to diversify weed management programs to include additional mechanisms of action. Studies were initiated in Red Rock, AZ and Dona Ana, NM to evaluate a new preemergence herbicide, penoxsulam, alone, in combination with oxyfluorfen or isoxaben, or in combination with both of these herbicides and to compare penoxsulam and penoxsulam tank-mixtures with other herbicides (e.g. pendimethalin+flumixoazin). Plots with one pecan tree measuring 6.1 m x 9.1 m (AZ) or 4 m x 3 m (NM) were arranged in either a randomized complete block (AZ) or completely random (NM) design. Herbicides were applied with CO_2 pressurized backpack sprayers using a 6 nozzle (AZ) or 4 nozzle (NM) booms equipped with flat fan nozzles calibrated to deliver 188 L/ha (20.1 GPA, AZ) or 234 L/ha (25 GPA, NM). Treatments were applied in spring 2010 and again in 2011 on the same plots. The comparison treatment was glyphosate applied at the cooperating grower's use rate (1.7 kg/ha). Three times per season, generally in June, August and October or November, the weeds emerging in the plots were counted after which glyphosate was applied to kill all emerged weeds. In the Arizona experiment in August 2010 (110 DAT), penoxsulam applied at 16 and 31 g/ha provided 18 and 28 percent control of annual broadleaves (mostly tumble pigweed and Wright groundcherry) and 7 and 14 percent control of annual grasses (primarily junglerice and red sprangletop). In contrast, the premix of penoxsulam and oxyfluorfen (16 and 31 g/ha penoxsulam with 0.85 and 1.7 kg/ha oxyfluorfen in the Pindar GT formulation) provided 73 and 87 percent control of broadleaves and 89 and 93 percent control of grasses at the low and high rates, respectively, 110 DAT. The commercial standard, pendimethalin+flumioxazin at 3.2 kg/ha + 0.215 kg/ha, provided 76 and 96 percent control of annual broadleaves and grasses, respectively. Flumioxazin at 043 kg/ha and rimsulfuron at 0.07 kg/ha provided 76 and 36 percent control, of broadleaves, respectively and 12 and 28 percent control of grasses, respectively. Thus, the results indicated that penoxsulam, flumioxazin and rimsulfuron were not stand alone herbicides under the conditions present in southwestern pecan orchards and need to be mixed with other residual herbicides. Similar results were obtained in 2011 except that the grass control obtained with the pendimethalin+flumioxazin at 3.2 kg/ha + 0.215 kg/ha treatment was not as good at 30 and 26 percent control at 87 and 162 DAT, respectively. All of the herbicide treatments declined in efficacy over the course of the season; the premix of penoxsulam and oxyfluorfen (16 and 31 g/ha penoxsulam with 0.85 and 1.7 kg/ha oxyfluorfen in the Pindar GT formulation) provided 34 and 67 percent control of broadleaves and 53 and 79 percent control of grasses at the low and high rates, respectively, 192 DAT in contrast to the results above at 110 DAT. Herbicide efficacy declined more rapidly in the New Mexico experiments where the trees were smaller, produced less shade and were less competitive with the weeds. None of the herbicide treatments in Arizona resulted in phytotoxicity symptoms in the pecan foliage and did not affect trunk diameter growth measured 0.5 m above the soil line. Similar results were obtained in New Mexico but because the trees were smaller, trunk diameter growth varied more and a few treatments had slower growth. However, this slower growth appeared to be related to initial size of tree (i.e., trunk diameter) and other factors and not a result of the herbicide treatments.

Weed Control and Resistance Management in NM Pecan Orchards. Mohsen Mohseni-Moghadam, Jamshid Ashigh*, Jill Schroeder; New Mexico State University, Las Cruces, NM (149)

Alternative mechanism of actions herbicides have been previously shown to provide acceptable control of glyphosate-resistant Palmer amaranth populations from New Mexico. However, the major obstacle in employing alternative herbicides by the growers has been the possibility of increased weed management costs. The objectives of this study were to identify the efficacy and cost of alternative mechanisms of action herbicides for season-long weed management in pecan orchards. Field studies were conducted in 2010 and 2011 with oxyfluorfen, flumioxazin, oxyfluorfen plus pendimethalin, flumioxazin plus pendimethalin, and pendimethalin plus glyphosate in Rincon New Mexico. The cost of each herbicide was obtained from local retail companies and the application cost ha^{-1} was obtained from several commercial applicators and was estimated at US. \$42 ha^{-1}. Herbicides were applied at their recommended field rates and, in both years, season-long weed control was achieved with oxyfluorfen plus pendimethalin and flumioxazin plus pendimethalin treatments. However, additional applications of glyphosate were required to achieve acceptable season-long weed control with oxyfluorfen, flumioxazin, and pendimethalin plus glyphosate. These results indicated that the pecuniary benefit of season-long weed management with glyphosate, in pecan orchards, was comparable to some of the tested alternative herbicides.

The Effect of Adjuvants and Spray Volume on Saflufenacil Activity on Conyza species. Ben Duesterhaus*[1], Curtis R. Rainbolt[2]; [1]BASF Corporation, Oakdale, CA, [2]BASF Corporation, Fresno, CA (150)

Saflufenacil, a PPO Inhibitor (WSSA Group 14 Herbicide), is active on a number of broadleaf weeds as a contact post emergent and rate dependent pre-emergent treatment. The saflufenacil molecule is a slightly acidic (pKa – 4.5), polar molecule with pH dependent water solubility. Due to the molecular size of 500.9g and chemical properties, plant uptake for effective post emergent weed control is a challenge. Adjuvants, spray volume and coverage are factors involved in efficient uptake of contact herbicides, like saflufenacil. In 2011, six small plot replicated trials were established in orchards to determine the effects adjuvants and spray volume have on saflufenacil, applied in combination with glyphosate, for control of emerged hairy fleabane (*Conyza bonariensis*). The trials concluded optimum weed control was obtained with 1%MSO v/v at 30 gallon per acre spray volume, and the least effective treatment was with 1% v/v COC 15 gallon per acre spray volume. These trials and previous development work indicate the most effective adjuvant option for saflufenacil is 1%MSO v/v. Further, these trials indicate 30 gallon spray volumes are numerically more effective than the 15 gallon spray volume.

Resistance Management with Bayer CropScience Herbicides in Tree Crops. Monte D. Anderson*[1], Darren Unland[2]; [1]Bayer CropScience, Spangle, WA, [2]Bayer CropScience, Research Triangle Park, NC (151)

Glufosinate has been registered for postemergence use in several tree crops since the mid 1990's. It is a Group 10 non-selective herbicide with limited translocation that provides fast burndown of weeds. Indaziflam is a Group 29 preemergence herbicide that was registered in 2011. It provides long lasting residual control of both monocot and dicot weeds in a wide range of tree crops. In a world where glyphosate has been utilized heavily over a long period of time, glufosinate represents an underutilized herbicide option, especially with the advent of numerous glyphosate resistant weeds. Many of the weeds with glyphosate resistance are inherently sensitive to glufosinate, especially broadleaf species. Indaziflam represents a mode of action with little or no previous use in perennial crops. A common solution to glyphosate resistance development in transgenic crops is heavier reliance on preemergence herbicides, which is a solution that needs to be adopted more in perennial crops. The length of residual from indaziflam will reduce the frequency of postemergence herbicide use. Both glufosinate and indaziflam offer alternative mode of action and resistance options that will improve weed management in tree crops.

Dow AgroSciences Weed Control Programs and Strategies in Tree Crops. Deb Shatley*[1], Richard K. Mann[2], Barat Bisabri[3], James Mueller[4], Jesse M. Richardson[5], Byron B. Sleugh[6]; [1]Dow AgroSciences, Lincoln, CA, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences LLC, Orinda, CA, [4]Dow AgroSciences LLC, Brentwood, CA, [5]Dow AgroSciences, Hesperia, CA, [6]Dow AgroSciences, Clovis, CA (152)

Growers and their advisors have generally utilized two approaches to chemical weed control in perennial crops, a post-emergence herbicide regime also known as “see and spray” and a program approach consisting of herbicides with residual activity with or without post-emergence herbicides for season-long weed control. Glyphosate became the mainstay for weed control in California orchards when the price began to decrease. Affordable pricing and reliable control contributed to the prolonged use of glyphosate until scientists confirmed the development of glyphosate-resistant weed species in California. Growers then began the search for an alternate to glyphosate with a different mode of action and residual partners in an effort to mitigate the increase in resistant weed biotypes.

The Dow AgroSciences weed control strategy in tree crops is a program approach utilizing Dow AgroSciences herbicides and tank-mix options. The Dow AgroSciences program revolves around the use of penoxsulam + oxyfluorfen (Pindar™GT), oxyfluorfen (GoalTender® or Goal®2XL) or isoxaben (Trellis™). These products can be used as a standalone treatment or tank-mixed with a post-emergence herbicide for added burn down weed control or grass residual herbicide to broaden weed control spectrum.

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SYMPOSIUM: Ecology and Management of Downy Brome (Bromus tectorum) in the West: What Can the Past Tell Us About the Future?

Downy Brome Management in Great Basin Cropland - Past, Present, and Future. Ralph E. Whitesides*, Corey V. Ransom; Utah State University, Logan, UT (177)

Historical anecdotes indicate that *Bromus tectorum* has been known by many common names. Perhaps the most commonly used are bronco grass, cheat, downy chess, downy brome, June grass, six weeks grass, and nodding brome. To residents of the Great Basin, downy brome has been lifesaving vegetation to the cattle rancher when no other forage was available, it has robbed wheat farmers of profitable grain crops, served as the main source of food for introduced chukar partridge, and has been the fuel that supported an increase in frequency and intensity of wildfire.

Downy brome was first reported in New York and Pennsylvania in 1861 and was reported throughout the remainder of the United States by 1928. By the turn of the century, during the late 1800's and the early 1900's it was recognized as a potentially serious introduced weed that could be problematic in agronomic crops. Most notably the weedy nature of the grass was recognized in wheat and alfalfa. During the three decades from 1900 to 1930 observations were made about the competitive nature of the plant and some initial weed biology work helped identify growth habit and life cycle. Although downy brome was spreading rapidly on over utilized grazing lands and rangelands during this period normal cultural control practices associated with agronomic crop production appeared to have slowed it's advance into cropland. During the 1930's and 1940's weed management research was initiated and preliminary work was conducted with herbicides such as 2,4-D (reported to be ineffective in control) and IPC and C-IPC. In the 1950's and 1960's a majority of downy brome management work in cropland was conducted using newly developed herbicide chemistry such as carbamates, triazines, and ureas. Although new herbicides were being developed almost all downy brome control activities with herbicides involved preemergence application and photosynthesis inhibiting chemicals. By the 1970's and 1980's new herbicide chemistry was implemented and chemical fallow and no-till applications were incorporated into downy brome management in wheat. EPTC as a preemergence soil incorporated treatment became an alfalfa standard. In alfalfa selective "graminicides" became available and postemergence control of downy brome became possible.

In the present day, (1990 – 2012) downy brome control has moved to a more integrated management program. Use of tillage and cultural crop management has been implemented along with herbicides. Herbicides in use for downy brome control in crops still include preemergence herbicides but ALS and ACCase inhibitors have provided additional opportunities for selective postemergence control in small grains (wheat) as well as alfalfa. There is continued emphasis on herbicides for downy brome control but there is a large increase in evaluating the relationship between crop management and herbicide use. There continues to be use of ALS herbicide chemistry with increased interest in timing, especially fall and spring applications, and mixtures of herbicides (active ingredients) and combinations with adjuvants. Herbicide tolerant wheat and herbicide resistant alfalfa has provided another approach to selective downy brome management.

In the future, understanding downy brome ecology, especially growth and development is critical to success. There will be an increase in weed biology research, more emphasis on cultural practices (including tillage), increased additions to crop traits for herbicide tolerance, and more emphasis on biological control.

Ecological Factors Influencing the Outcome of Downy Brome Control in Semi-Arid Wildlands. Thomas A. Monaco*; USDA, Logan, UT (178)

Bromus tectorum, commonly known downy brome, occurs on over 23 million hectares in the western U.S. Since its introduction in the mid 1800's it has spread through agricultural practices and grazing, and by the 1920s it had spread to most of its current range in the Great Basin wherever perennial cover was disturbed. As a naturalized annual grass, it has altered ecosystem structure and function, leading to the loss of plant and obligate wildlife species due to changes in wildfire disturbance regimes. Managing shrublands degraded by downy brome has often employed seeding exotic, grazing tolerant forage grasses to stablize lands and support ecosystem productivity. However, since the 1980s, restoring native species has been emphasized, presenting a much more complex management scenario to prevent the spread of downy brome and the reoccurrence of destructive wildfires. Here, I present an overview of the ecological factors that influence the outcome of downy brome control in semi-arid wildlands of the Great Basin. I will illustrate key contrasts between traditional and contemporary management strategies that call for systematic reduction of seed bank densities and interventions to alter ecosystem processes such that native species may be restored to invaded wildlands.

Managing Downy Brome in Canyon Grasslands and Sagebrush Steppe. Timothy Prather*; University of Idaho, Moscow, ID (179)

Downy brome residence in the Northwest extends from sagebrush grasslands to canyon grasslands, upland prairies and into managed pastures. Downy brome dominance within a portion of each of these plant community types often is attributed to historic management that injured the perennial plant communities and allowed entry by annual grasses like downy brome. Our sagebrush grasslands may be one exception, in part, because of the continuous fuel load that creates fires across large landscapes that encroach on better condition communities. In perennial grasslands, downy brome does not appreciably increase after fire, with the annual and perennial grass ratios remaining equivalent before and after fire. The rooting profile of downy brome is well known and several studies have demonstrated resources in shallow soil depths acquired by downy brome. Soil borne resources at deeper soil depths, however, are either not used or acquired by other invasive plant species. Perennials still present in plant communities with soil depths deeper than the rooting depth of downy brome can expand with control of downy brome. Plant communities with perennials still present may expand as seedlings have a chance to establish; some studies in canyon grasslands have documented 20% to 50% increases (combination of increased stature and recruitment) even if only broadleaf weeds are controlled. Control of annual grasses in addition to broadleaf invasive plants would enhance recovery of resident perennial species. For example, control of downy brome In canyon grasslands with imazapic (1.5 oz ae/A) applied as a preemergent or delayed until downy brome plants produced tillers provided 70% control and grass biomass has a 3 fold increase in perennial grass biomass. Perennial grasses can be established; particularly when site conditions allow equipment to drill and establishment is enhanced when annual grasses are controlled since seedling perennial grasses are disadvantaged compared to downy brome seedling densities. With late winter seeding, even a glyphosate application at or just prior to seeding has allowed for successful grass establishment. In situations where seeds cannot be drilled, much of the seed can be lost to seed predation, anywhere from 40% to 80% is possible so covering with a mulch or trampled into the soil using livestock can both aid in success of establishment and reduce exposure to predation. Understanding longer-term precipitation patterns can further increase the chance for success by planting during an increasing precipitation cycle rather than one that is decreasing towards drought. Annual grasses such as downy brome change ecosystem function through changes to resource availability, modifying fire return intervals, and stifling perennial grass establishment. Changes to system function strengthen the argument for managing annual grasses to reduce their influence and to move towards perennial systems that are more productive than annual grasslands and provide for greater plant and animal diversity.

Downy Brome Plant Growth and Herbicide Resistance Modeling. Daniel Ball*; Oregon State University, Pendleton, OR (180)

Downy brome (*Bromus tectorum* L.) is a major detriment to winter wheat production systems in the Pacific northwest (PNW) and Great Plains regions of the U.S. In the PNW, recent significant production changes have occurred with tillage-based cultivation systems transitioning to no-till production. These no-till systems rely heavily on glyphosate for downy brome control in fallow, and have a nearly sole reliance on ALS inhibitor herbicide use in the wheat crop. Sole reliance on these herbicide chemistries necessitates judicious use to slow the development of herbicide resistant weeds, including downy brome. Prevention of seed production in downy brome during fallow periods is necessary to help control this annual grass weed. An ability to predict the time for downy brome seed production can facilitate timing of glyphosate applications in fallow to prevent seed production. The growth rate of downy brome is linear with respect to growing degree-days (GDD) accumulation. If historical GDD information is available for a location, then growth rate and seed set of downy brome can be predicted. However, this predictive model has certain limitations related to saturation of vernalization. In another simulation exercise, development of ALS inhibitor herbicide resistant weed populations in wheat has been modeled under different resistance management scenarios. The evolution for herbicide-resistant downy brome in several PNW instances has been estimated with some accuracy by this empirical herbicide-resistance modeling approach. The potential implications for downy brome seed set, and herbicide-resistance simulation modeling will be discussed.

Impacts of and a Novel Control Strategy for Annual Bromes. Matt Rinella*; USDA-Agricultural Research Service, Miles City, MT (181)

Cheatgrass impacts differ widely between Great Basin and northern Great Plains grasslands, with the difference likely owing to differences between the plant communities of the two regions. Cheatgrass is generally considered more problematic in the Great Basin, so information pertaining to its impacts and management is more complete for that region than for the Great Plains. However, concerns are growing about cheatgrass in the Great Plains, and information about this weed's impacts and management is gradually accumulating for the region. I will use long-term data to guide a discussion on population dynamics of cheatgrass in the northern Great Plains in addition to reviewing the literature on this weed's impacts in the region. I will also discuss groundbreaking herbicide research that may provide a new alternative for controlling cheatgrass and other invasive annual grasses. In collaboration with others, I found that picloram, aminopyralid and select other growth regulator herbicides reduced cheatgrass, Japanese brome and medusahead seed production to nearly zero in the field and/or greenhouse when the chemicals were applied at particular growth stages. The short lifespan of invasive annual grass seeds (~1-2 years) suggests growth regulator herbicides could be used to deplete annual grass soil seed banks. Growth regulators are already widely used to control invasive broadleaf weeds, such as spotted knapweed and leafy spurge. It should be possible to time growth regulator applications to simultaneously target broadleaf weeds and the invasive annual grasses that often dominate the understory beneath broadleaf weeds while leaving native perennial grasses unharmed.

Keeping Cheatgrass Honest: Assessing the Role of Biological and Environmental Stressors in Mediating the Ecological Role of Cheatgrass in Cropping Systems. Fabian Menalled*; Montana State University, Bozeman, MT (182)

Cheatgrass (*Bromus tectorum*) is an exotic winter annual grass considered to be one of the most problematic weeds in crop and non-crop habitats throughout the western United States. Although cheatgrass has been present in Montana and the northern Great Plains for some time, it has received more attention recently as producers and land managers express concern over its apparent increase and perceived impacts. While much research has been conducted on the direct impacts of cheatgrass on crop yield and quality, less knowledge exists on the role of abiotic conditions (e.g. resource availability) and biological stressors (e.g. plant pathogens) in mediating the ecological significance of cheatgrass invasions across agricultural systems. We combined growth chamber, greenhouse, and field studies to assess the role of biological and environmental stressors in mediating the ecological role of cheatgrass in cropping systems. More specifically, we have investigated the effects of resource availability, crop and weed density, and generalist pathogens (*Wheat streak mosaic virus* and pink snow mold, *Microdochium nivale*) on competitive relationships between winter wheat (*Triticum aestivum*) and cheatgrass. We found that while *Wheat streak mosaic virus* impacted interactions between cheatgrass and winter wheat, nitrogen availability modified that relationship. Specifically we observed that at high N fertilization rates, infection reduced crop weed suppression. Also, results indicated that cheatgrass could increase crop winterkill. Winter wheat mortality in weed-infested areas was up to 50 percent higher than in the weed-free controls. The impacts of cheatgrass on winterkill appear to be mediated by enhancing pink snow mold survivorship and spread. Overall, our results expand previous research on the competitive impacts of cheatgrass and highlight the importance of understanding the biotic and abiotic contexts that conditions the impact and consequences of biological invasions, a necessary step to develop ecologically based management programs.

Systems in Transition: Integrated Management of Annual Brome at the Intersection of Great Plains Grasslands and Sagebrush Steppe. Brian A. Mealor*; University of Wyoming, Laramie, WY (183)

Annual *Bromus* species are perhaps the most ubiquitous and problematic weedy species of western rangelands. Although the focus on ecological impacts of downy brome has largely centered on Great Basin systems, the impacts of downy brome are more broad-reaching. The establishment and spread of downy brome east of the Rockies is not a recent occurrence. The first documented report in Colorado was in the 1890s and in Wyoming in the early 1900s, with one of the first collections at 7500 feet elevation. Some land managers and scientists have historically minimized potential impacts of annual bromes in our region, but brome populations are exhibiting an increasing trend in Wyoming and Colorado and the rate of expansion is predicted to increase relative to climate change models. Current perceptions of downy brome impacts on forage availability and efficacy of control methods vary widely among natural resource professionals and land managers throughout the region. Although its prevalence is increasing, the current distribution may present opportunities to prevent crossing an ecological threshold in many areas because an increase in fire frequency has not yet occurred. Early research on downy brome control in the region investigated the use of herbicides such as atrazine, metribuzin and terbacil to reduce downy brome dominance while maintaining desirable species. Atrazine proved effective in multiple trials providing excellent control and an increase in forage grass production. Single applications of glyphosate and paraquat in late spring provided good to excellent control within a growing season, but poor control for longer periods. Sequential application of these herbicides for three years resulted in >90% control of downy brome with negligible negative impacts of perennial grasses, revealing an apparent strategy for depleting the short-lived downy brome seedbank. In heavily-infested areas, chemical control alone may be insufficient to convert annual-dominated rangelands to perennial-dominated grasslands with higher forage value. Seeding competitive cool-season perennial grasses in areas dominated by downy brome may pose a longer-term option for control. In one study, introduced cool-season forage grasses reduced downy brome biomass up to 100% three years after seeding. Challenges to developing a successful management program for such a widespread invasive as downy brome may be exacerbated where multiple ecological regions converge and ecological responses to control tactics differ across the management landscape. An additional challenge in both the western Great Plains and sagebrush steppe is the widespread surface disturbance related to the resource extraction industry. Such challenges may only be successfully addressed by implementing an integrated strategy including proactive prioritization of investment into protecting areas with high-quality habitat from future impacts, aggressively managing bromes in areas with high recovery potential and approaching thresholds, and managing grazing to favor desirable perennial species. Regional cooperative groups involving ranchers, agency personnel, researchers and others may lead to productive landscape-scale programs.

Integrated Management Prevents Cheating in Winter Wheat Cropping Systems. Drew Lyon*[1], Phillip W. Stahlman[2]; [1]University of Nebraska-Lincoln, Scottsbluff, NE, [2]Kansas State University, Hays, KS (184)

Several *Bromus* species including cheat, Japanese brome, and downy brome are troublesome in winter wheat-fallow rotations, continuous winter wheat, alfalfa, rangeland, and non-crop areas in the Central and Southern Great Plains. Downy brome is ubiquitous in the drier western portions of this region where winter wheat is extensively grown. Prior to the commercialization of sulfosulfuron in the mid 1990's, there were no herbicides that selectively controlled downy brome in winter wheat. Many wheat growers relied on moldboard plowing to bury the seed to a depth that prevented successful emergence, but moldboard plowing resulted in unacceptable soil erosion issues. Weed scientists working in winter wheat in the Central and Southern Great Plains have developed integrated approaches for downy brome control that include sanitation, cultural, mechanical, and chemical control methods. Crop rotation, i.e., adding a summer crop such as grain sorghum to the winter wheat-fallow rotation, has long been known as an effective control strategy for downy brome. Unfortunately, alternative crops have not always been as profitable as winter wheat in dryer portions of the region. When crop rotation is not possible, multiple strategies for downy brome control must be used to obtain acceptable control. Burying downy brome seed at least 4 inches deep can provide 95 to 100% control of downy brome, but subsequent deep tillage should be avoided for at least 4 years to prevent viable seed from returning to the soil surface. Light tillage, e.g., sweep or harrow, can be used after wheat harvest to improve seed-soil contact and increase germination rates during the fallow periods when tillage or nonselective herbicides can be used to kill the weeds before they set seed. In winter wheat-fallow rotations, atrazine may be applied in September following shallow tillage to control subsequent flushes. If rain is received close to the time of winter wheat seeding, a 7- to 10-day delay in seeding may allow for germination and emergence of downy brome that can be controlled with tillage or herbicides before seeding wheat. Surface broadcast N applications should be avoided during the growing season because downy brome often benefits more than the wheat. Nitrogen should be positioned below the wheat seed at planting to give wheat the greatest benefit from the fertilizer. Several sulfonylurea herbicides – sulfosulfuron, propoxycarbazone, propoxycarbozone plus mesosulfuron, and pyroxsulam – can provide excellent selective control of downy brome in winter wheat, particularly when applied POST in the fall. Imazamox can be used to control downy brome and other winter annual grass weeds in Clearfield® wheat, although this option is typically more expensive than the previously described herbicide options. In addition to these cultural, mechanical, and chemical control methods, an integrated control strategy also includes the elimination of seed sources, i.e., sanitation, which can be achieved by controlling downy brome along field edges and planting wheat seed free of weeds. Although biological control of downy brome has been researched, the viability of this approach in the field has never been confirmed. In the Southern Great Plains, winter wheat is often grown for both cattle grazing and grain. Grazing cheat-infested wheat has been shown to defoliate wheat more than cheat, which resulted in increased dockage levels in the harvested grain. Downy brome is a troublesome weed in winter wheat and an integrated management approach to control is necessary to give winter wheat the greatest advantage in the competition.

Developing Biocontrols for Cheatgrass: Progress and Future Prospects. Susan Meyer*; USDA Forestry Service, Provo, UT (185)

Cheatgrass or downy brome (*Bromus tectorum* L.) is probably the most common plant in the western United States. This winter annual grass weed can pose serious problems for intensive agriculture, particularly winter cereal grains. It is also a major invader and ecosystem engineer in semi-arid rangelands, where it perpetuates and spreads itself at the expense of native perennial vegetation through increasing the frequency of wildfire. Its spread has been called the most significant plant invasion in the modern history of North America. The best hope for controlling cheatgrass in rangelands is restoration and subsequent careful management of perennial vegetation, but establishing seedings into the cheatgrass monocultures that result from repeated burning is virtually impossible without some form of control. Traditional methods of control include burning early in the season before seed dispersal, post-emergence tillage, and both post-emergent and pre-emergent herbicide treatments. In the last twenty years, considerable effort has been expended to attempt to develop biocontrol tools to augment or complement these traditional control methods in an IPM (intergrated pest management) strategy. Because grasses are rarely amenable to biocontrol with herbivorous insects due to their generalist feeding habits, this effort has been focused on developing microbial biocontrol agents, namely deleterious rhizosphere bacteria and pathogenic fungi. Scientists at the Agricultural Research Service in Pullman, Washington, have led a 20-year effort to identify a strain of the bacterium *Pseudomonas fluorescens* that is effective against annual bromes but harmless to cereal crops and to test it in an agricultural setting. More recently they have expanded their scope to include investigation of possible use on rangelands. This biocontrol agent can reduce cheatgrass biomass production substantially when applied successfully. Another organism that received intensive study for several years is *Ustilago bullata*, a highly host-specific pathogen that occurs naturally on cheatgrass. The pathogen infects at the seedling stage, grows systemically within the infected plant, and completely prevents seed production of diseased plants (head smut disease). We were able to achieve high levels of disease in artificially seeded and inoculated plots, but were never able to accomplish this in natural cheatgrass stands, probably because of the narrow window of infection during coleoptile emergence, and the very specific range of conditions under which successful infection can take place. We then turned our attention to another naturally occurring cheatgrass pathogen, *Pyrenophora semeniperda*. This seed pathogen, whose stromata protruding from dead seeds earned it the moniker of 'black fingers of death', is extremely common in cheatgrass field seed banks, sometimes killing tens of thousands of seeds per square meter in a year. We learned through field and laboratory studies that its primary target was dormant or slowly-germinating seeds, meaning it was unlikely to be effective in killing the rapidly germinating seeds that establish a stand each year. However, this pathogen can kill ungerminated seeds, which is something that neither herbicides nor tillage can accomplish. We are working to develop this organism as a biocontrol to eliminate the carryover seed bank that can come back to haunt a seeding even after successful first-year control using other methods. Another lead that we are just now beginning to track down is the phenomenon of cheatgrass 'die-off' or stand failure due to causes other than drought. Die-offs probably have multiple causes that interact in complex ways, but there is considerable circumstantial evidence to support the idea of a soilborne pathogen as a die-off causal agent under at least some scenarios. Unlike black fingers of death, this putative pathogen can effectively eliminate fast-germinating seeds or the resulting seedlings. In effect, a 'die-off' is a case where some unknown natural agent has controlled the current-year cheatgrass stand. This leads to the questions of whether this natural form of control could be used as an opportunity for restoration seeding, and whether the die-off organism could itself be developed as a biocontrol agent for cheatgrass. It is unlikely that we will find a biocontrol 'magic bullet' that can control cheatgrass singlehandedly, but these organisms warrant further study, especially in an IPM setting where multiple biocontrol agents are used, either alone or in combination with herbicides. This line of research, namely the use of naturally occurring microbial organisms in an augmentative or inundative biocontrol strategy to temporarily control a weed in conjunction with restoration seeding, is still in its infancy, and should not be discounted until its possibilities have been thoroughly explored.

DISCUSSION SESSIONS AND SYMPOSIUM SUMMARIES

Project 1 Discussion Session: Weeds of Range and Natural Areas

Moderator: John (Lars) Baker, Fremont County Weed and Pest, Lander, WY

Topic: *Cooperative Weed Mapping – Sharing Skills and Resources Across Jurisdictional Boundaries*.

9:30 am

30 Minute Presentation by Lars Baker about the development of Wyoming's cooperative weed mapping program, which began with paper maps, hired its first full time technician in 1993 to begin the process of digitizing inventory data, with 300 records digitized in 1996. In 2003, the county began working to coordinate the greater Yellowstone data, and in 2011, over 40,000 records were added to the database, with 130,000 records for just Fremont County.

Successes

Current system now allows for any data submitted by the group to be accessed online, however, the program is not a data clearing house – data must be accessed through the participating county or district.

The shared effort has eliminated the need (and associated costs) for all cooperators to have GIS capability, with data collected in a variety of formats (at the county level) and submitted at different timings (weekly, monthly, etc.).

Allows a comparison of areas mapped vs. areas treated by having separate dedicated crews for each task, instead of slowing mapping crews by having them treat weeds.

External grant funds have been the primary source to support statewide mapping efforts and train outlying districts.

As of 2012, every county in the state participates in the program to some degree, with Federal land management agencies and private contractors also sharing data.

Challenges

Convincing stakeholders that mapping efforts are worth the time and money expended ($140,000 spent over the last five years in staff and hardware.

Public land management agencies tend to be driven by acres treated, not protected (mapping vs. treatment), thus the cost per treated acre appears expensive when compared to what is accomplished. As a result, there is generally a lack of funds for inventory compared to treatment.

10:00 am – 11:00 am

Discussion

Q: Do you receive data from neighboring states?

A: **(Tim D Amato)** Colorado also has an online system that will be accessible by public very soon

Q: Are there plans to share with the EDMAPS national data base?

A: (**Lars)** Yes, the challenge is that EDMAPS requires a voucher specimen – how often do you collect a voucher specimen?

Q: How do we adequately explain the value of protected versus treated acres? Do keep you keep track of the number of acres surveyed vs. treated?

A: Yes, we can show separate costs for mapping and treating

Q: Is there value in a high quality map? What is the right frequency of survey?

A: Varies by species and by need

Q: How do these ideas dovetail with Early Detection Rapid Response (EDRR)?

A: Analysis of the mapping data helps to prioritize treatment to isolated insipient infestations

Q: I've seen a lot of county maps, where populations are mapped and then sprayed – are you tracking how populations disappear?

A: **(Lars)** Yes, basically on high impact sites and high priority locations. We have a high priority strike team that only deals with high priority weeds. We're adding a second high priority crew, with the stress on keeping areas weed free. Cleared sites are maintained in the database as No Living Plant Found.

Q: Have you done any citizen outreach for mapping – cell phone maps, etc.?

A: **(Lars)** We're aware of the cell phone applications that some people are testing, but we have not utilized that.

Q: A question about targeted grazing - do you use this and if so, who provides the data?

A: **(Lars)** We have individuals who do it, some individuals using livestock rather effectively, or goats, Opinion: if you want to use livestock, adapt your management to take advantage of the resource (graze animals, sheep etc., on the target plant). There is presence / absence data for targeted grazing

Q: **(Todd Neel)** Back to the value of resolution – have there been situations where higher resolution is worthwhile?

A: **(Lars)** Yes- for example, I know where every dyer's woad is in Fremont County, but detail varies by species

Q: Do you track protected acres?

A: **(Lars)** Yes, we look at acres that we map, so (interrupted)

Q: What's the metric – if I protect one acre, how many affected acres are there?

A: **(Nevada Manager)** For example we often try to quantify things at a watershed level – if we have X known acres infested, we have a pretty good idea of what's been protected by a given treatment.

Q: In Idaho we have quite a few endangered species, are you tracking that as well?

A: **(Lars)** We have data on a number of species of interest to the USFS. We house the largest herbarium collection not affiliated with a 4 year college in the US.

Q: **(?)** Getting back to acres protected – this is an important issue that keeps coming up for us at the county level. There are questions of scale between different agencies – not comparing apples to apples. How do we provide a standard metric for acres protected?

A: **(Larry Lass)** I can respond to that – there has been a lot of work on this from the University of Idaho and the University of Montana, on a tool that predicts the spread of invasive species on the landscape without control, so you can predict, using this model / tool what will happen over a given period of time. There have already been rush skeleton weed and yellow star thistle spread models based on areas where there is a high likelihood of occurrence. Spread models will also be constrained by habitat issues. There has been past work that focused on aerial photography, not for the weed, but using reflectivity to determine potential habitat / likely habitat (prediction models)

A: **(Shawna Bautista)** From the federal side, this is obviously an issue we deal with as well, not just with weeds, but forest pests. I was recently at a meeting with the Office of Management and Budget (OMB), who sets the policy and direction for federal agencies. Federal land management agencies have been having discussions with OMB to come up with a measure for efforts directed to prevention. i.e., the value of protecting a "wilderness" acre to protect 1,000's of other acres. OMB does not seem to recognize the value of prevention, so perhaps there is value in having a model that allows you to show how acres treated reflect acres protected.

A/R: **(Lars)** At least in our area, USFS, BIA, BLM have all signed on to EDRR, regardless of the high cost of treatment per acre. Following up – funding issues – how do you justify the high cost of EDRR – again maybe the modeling tool has value here, in demonstrating protected areas and then projecting the cost of treating acres that are not protected in years down the road.

A: **(Larry?)** A future model is being developed for the interior Northwest, we are incorporating a survey that will estimate the loss of social welfare (loss of wildlife, water quality, recreation, forestry, livestock) we are in the process of integrating those costs onto the weed treatment management tool so you can then do a cost benefit analysis of treatment versus non-treatment (University of Idaho) and the costs of treatment versus the cost of the damage that would have occurred.

Q: Do you collect info that describes the factors influencing the spread of weed in each county or is it only presence / absence data?

A: **(Lars)** We are mostly collecting presence / absence data – there is much discussion about what factors have value, but also where to draw the line between research (understanding biology / ecology) and the time necessary to implement a successful management plan / control weeds.

A: **(Larry)** As a researcher who works on occurrence data, I am always happy to see polygon versus point data. I would rather see a hand drawn polygon versus a buffered point that represents "X' number of acres – the extra effort of a polygon far outweighs the time lost.

A/R: **(Lars)** What we do is take a buffered point, up until we reach an acre, at which point we begin using polygons. Only on scattered infestations are we dealing with individual points (there is the need for flexibility).

R: **(?)** It seems like there are enough "do nothing" examples throughout the west that we don't need a tool for this. It seems like without research you can still find numbers.

Q: (Lars to Tim) Last year you had a discussion topic about the technology sharing network could you update us on that?

A: (Tim) We tried to encourage WSWS to go the way of the Society for Range Management, where there are state chapters that develop research committees, state reports, etc. I still think we could do something like this with the WSWS, where we could share research efforts / get more demo plots out there.

Q: (Brian Mealor) So why not just work with your local SRM section instead of creating something new?

A: (Tim) I don't know that our interests would overlap as much as I'd like.

A: (Chad Cummings) It could be a really good idea, if WSWS could loop in a tour day with SRM's field day, there are certainly a lot of folks within SRM that are interested in these issues.

Q: (Brian) Does each state SRM section have a field tour every year?

A: (Chad) No, but, they do have an annual meeting.

R/Q: (Brian) Most states have a rep through SRM that's on the invasive species committee. Is this a discussion SRM should have in their invasive species committee? How many are concurrent members with SRM (about ½) – getting involved in the rangeland invasive species committee is important, saves overlap, etc. Having one more meeting is not much of a time saver.

Q: (**Mustafa Haidar**) As a scientist, I am very interested in mapping ideas – since you are collecting data from so many individuals, is there a unified mechanism for collecting data, and if not how do you think that affects the quality of data? **(how do you eliminate subjectivity)**

A: (Lars) It depends on the purpose of the data.

A: (Larry) – There are standards (NAWMA), however, you still have to adapt them for different needs

Q: (Todd) Given the question of subjectivity, are the NAWMA standards still relevant today?

A: (Larry) NAWMA pushes toward point data for small populations, example, there are several points in Idaho's data that represent 200 acres, however, if you're not careful you have large polygons, with uninfested islands. Right now Idaho's occurrence model is on 10 m increments, but we're working on a model that has 1 m increments.

Q: (Lars) For a scattered infestation, cost is much more related to gross acres than treated – having gross is more valuable, as a decision tool. Does this become a circular argument on what is the purpose of mapping?

A: (**Julie Kraft**) We just implemented a project with BLM, where we can **(?)** …NAWMA should always be considered as the minimum. Cost is always a factor in collecting data – what we can afford vs. what we can collect.

A: (Kim Edvarchuk) We can collect the extra data, but then there's the time investment in trying to train a field crew to collect extra data (discussion about training, turnover, and how this affects data quality and cost)

A: (Lars) There is a challenge in determining the minimum skill set to do the work.

A: **(Julie)** When dealing with a contractor, it is important to make sure you get what you pay for. You have to look at the variables that you want to make sure the contractor is still capable of collecting the data you need …that you have a professional contractor vs. "lowest bid" contractor, who may not be capable of collecting the data you want, or recognizing things that might be important to you in the field – unexpected invasive species, threatened and endangered species, etc.

Q: **(Kim)** Is NAWMA still valuable? Yes, the data standards are the same, however, the subjectivity is still there – how do you address it?

A: **(Lars)** There should always be an addendum to any map that talks about "how" the data was collected. I still think there is value in allowing field units to have a degree of subjectivity in their data collection.

11:00 am - Elect Chair for 2013

D. Chad Cummings volunteers to be chair elect for 2013.

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Project 2 Discussion Section: Weeds of Horticultural Crops

Moderator: Hank Mager, Bayer CropScience, Fountain Hills, AZ

Topic: *What role Does Horticulture Have in the Future of the WSWS?*

Presentations were made by Jesse Richardson, Brad Hanson, Kai Umeda

<u>Brad Hanson:</u>

Horticulture section only makes up 10-15% of papers at the WSWS meeting. The WSWS annual meeting is heavy on range and cereals (over 60% of the papers presented each year are in rage or agronomic crops). Horticulture in general and in this section is diverse –potatoes to vines. Horticultural crops and weed problems vary greatly across the western region and even from region to region within a state due to environmental limitations and local production practices.

Many of the presentations at WSWS are dominated by herbicide chemistry and herbicidal effects – relatively few herbicides are available in many "specialty crops" that make up the diverse horticulture industries. There are at the present time very few university weed scientists working on horticultural crops.

There are opportunities to build on some of the larger horticultural crops that are common across regions (e.g. onion, potato, and tree/vine). An example is the Tree and Vine symposium held at this meeting. Also, turf and ornamentals (especially sports turf) could be an area of growth for the section. There are opportunities for papers on ornamentals/containers depending on where the meeting is held. Another growth area may be regionally specific county-based extension faculty and researchers – there is a need to reach out directly to these folks when we are in appropriate regions.

Finally, maybe there is a need for focus on tillage and non-chemical weed control research in horticultural crops due to lack of chemistries.

<u>Kai Umeda:</u>

WSWS is short on work for weeds in turf and ornamentals. It is important to catch this segment with the next annual meeting being in San Diego where there is large turf and ornamentals industry - we need to start early to encourage the researchers (and students) in this discipline to submit papers/posters and feel that the WSWS conference will be worth their time (and money) to attend.

There are a lot of new herbicides in turf and support is needed for research work in this area. Funding mechanisms for future research will require creative and innovative methods. Need to find grants and foundations and even a "sugar daddy" interested in supporting research and extension.

<u>Jesse Richardson:</u>

Why are there not more herbicides in horticulture crops? Herbicides are not screened on horticultural crops and are instead screened for major crops such as rice, wheat, corn and soybean. In addition, horticultural crops often have the potential for high liability associated with low economic returns.

Herbicide tolerant crops are getting most of the attention. Starting in 2007, chemical companies spent more on seeds and traits then on agrochemicals – there is less chance to 'stumble on to' chemistry that may work on horticultural crops.

Other topics of discussion:

Regarding the cost of the WSWS meeting – should we have to pay for symposia and conference both or can they be optional?

Industry participation in WSWS is not automatic and guaranteed anymore like in the past - less funds are available for conferences

For the entire conference - coordinate conference to have other broader topics to attract people who may not see enough at the conference to justify attendance

Provide travel grants to some attendees.

Tom Lanini noted that he has found some herbicide chemistries that work in horticultural crops but there is little industry interest.

Some large companies are selling off older chemistries to smaller companies that don't have resources for testing in horticultural crops

Tim Smith suggested maybe a basic biology or herbicide chemistry – as general session - not separate. Tim also commented that "he is part of the audience that the WSWS is missing" – he is a county extension person and had never been informed of the WSWS meeting until being invited to the T&V symposium (even last year in Spokane a few miles from where he works!). We need to reach out to this audience and offer value.

Less emphasis on chemistry - open to more organic and alternative control methods and cover-cropping as cultural techniques. Weed science should begin to get integrated with other disciplines to enable broader cropping systems type grants.

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Project 3 Discussion Section: Weeds of Agronomic Crops

Moderators: Chad Asmus, BASF Corporation, Newton, KS; Joe Armstrong (Chair-elect) Okalahoma State University,

Topic: *How Can Industry and Academia Work Together to Encourage Growers to Proactively Adopt Herbicide Resistance Management Strategies?*

To facilitate discussion in this session, the original question was broken up into several individual components. Therefore, the first portion of the discussion focused on *growers* and how they, or other audiences such as consultants, retailers, and commercial applicators, can best be integrated in the effort to proactively manage herbicide resistant weeds. Most discussion agreed that every region, cropping system, etc. has at least one example of herbicide resistance and the importance of sharing these experiences with others. This point was repeated several times regarding the large-scale issues of herbicide resistant weeds in the south and southeast regions of the US and their efforts to share the "horror stories" of glyphosate-resistant Palmer amaranth.

Some discussion was also conducted regarding a central location for resistant weed educational materials, management strategies, and documentation of new cases. Jill Schroeder, New Mexico State University, briefly discussed the Weed Science Society of America's lesson modules on herbicide resistant weeds (available online at http://www.wssa.net/LessonModules/herbicide-resistant-weeds/index.htm). These materials are designed for educators and researchers to use and pass on to growers. Additionally, the International Survey of Herbicide Resistant Weeds website (http://www.weedscience.org) was also mentioned as the main source of information regarding current and new cases of herbicide resistant weeds in the US and around the globe.

A discussion regarding the best way to convey the threat of herbicide resistant weeds to producers was also held. Most were in agreement that many, if not all, producers are aware of the problem with herbicide resistant weeds, even if they are not currently experiencing it in their region or on their own farms. One way to deliver the message that was discussed was the greater economic cost of dealing with resistant weeds once they have established a large population in comparison to the costs of proactively managing these weeds. However, it was also acknowledged by several that the long-term economics of resistance prevention and management may not be persuasive in encouraging growers to adopt new management strategies, particularly given the low price of glyphosate and lack of an immediate return on investment. Rather, emphasis must be placed on crop and herbicide rotation and the benefits that a diverse crop production system can provide, such as reduced risk and better spread of time and resources.

In addition to growers, it was also discussed that one of the more important groups to reach with the message of herbicide resistant weeds would be agri-chemical retailers. Several in the audience mentioned that retailers have been identified by some producers as their primary source of pest management information. By engaging retailers in the effort of managing herbicide resistant weeds, this would provide an opportunity to "influence the influencers."

The second component of the original discussion question focused on the effort to *proactively adopt* resistance management strategies. During this part of the discussion, strategies, such as increased crop and herbicide rotation were discussed. As mentioned earlier that while the importance of proactive strategies may be understood by many growers, the convenience and economic benefit of a simplified (reactive) herbicide program remains the most widely adopted weed management approach. It was discussed that the issue with resistant weeds is a "herbicide problem, but the solution will not be herbicide-based." To reduce the near-exclusive dependence on herbicides for weed management, this discussion focused on several areas for improved research and outreach, such as developing management strategies specific to certain crops and geographies and that are convenient or easily adoptable by producers. Additionally, the need for continued research on population and seedbank dynamics and the role of economic thresholds in the era of herbicide resistance was also discussed.

Finally, the question of how *industry and academia* can best work together was posed to the group. Nearly all discussion mentioned the need for open communication and a consistent message to growers, retailers, and applicators regarding the threat of herbicide resistant weeds. Continued support for mode of action group number labeling on pesticide containers and labels was also expressed. Concerns regarding the frequent changes in herbicide trade names were also mentioned.

At the conclusion of the discussion session, Mayank Malik, Monsanto, was elected to serve as chair-elect for 2013.

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Project 4 Discussion Section: Teaching and Technology Transfer

Moderator: Gustavo Sbatella, Oregon State University, Madras, OR

Topic: *Adding Mobile Apps to the Weed Management Tool Box.*

Gustavo Sbatella presented a paper on "Mobile Apps and Weeds. A Potential Useful Tool or Just a New Gadget?" just prior to the start of the discussion section. The section started with an open discussion of the need to verify weed reports done by the general public using any of the invasive weed apps capable to report the location of a weed species. The attendees agreed that the task would require a lot of time and a person devoted to the duty of verifying the reports. In case the volume of reports is large, as an alternative it was suggested that priority be given to verifying reports of species that would fit in a quick detection and quick response program. The next topic was the cost of developing an app. The cost of developing a new app can be expensive. When the app includes a function that requires GPS, it increases the cost. Among platforms, Apple is costlier than the Android platform. Based on the experience of some of the attendees, it was suggested a cost of $5000 for the development of professional app.

The consensus from the audience was that weed identification and location are currently the most frequently used applications. Questions were raised about maybe the apps have not been powerful enough, or that smart phones are not fast enough to be useful for serious field work. Also new versions of phone operating systems should be considered. Apps may not work with newer versions. ARCinfo and QGIS are among the more powerful mapping apps, PC Mapper, Maverick are other simple mapping apps. The ARC server platform, like the one used in British Columbia is easy to use and provides several tools that help provide valuable information. The Southwest Environmental Network compiles data from various herbaria in the Southwest and it would be important in tapping into their resources when developing a mobile app for that region.

The discussion then shifted to who would use the app if we devote resources to developing one? Would the general public use it? In public lands, maybe hikers or amateur botanists? Most weed records currently in public lands made by the public are directly adjacent to trails. It would be useful to advertise the apps at trailheads so people are not only aware of the importance of invasive weeds but also increase the awareness of their presence in their area. In addition the public can help locate weeds by making records. The potential use of social media to advertise and market these apps was discussed, as well as Youtube videos for dissemination.

The attendee from South Dakota state university shared his experience with apps. Their noxious weed brochure was digitized and converted into a mobile app by SDSU. A total of 500 hits on the Android version were made to date. The use of smart phone technology varies with audiences; it has been more frequent among younger people, but this trend is likely to change over time as these kinds of phones become more popular. Regarding the development of apps at SDSU, budget cuts forced the loss of staff that had the skills to develop the apps. The question then becomes, how can we develop apps? What level of programming skills are necessary? The attendees with more experience recommended that at least a C+ class is needed to have the basic skill to write an app.

All attendees agreed on the necessity to find a way to distinguish weed management apps and sites from cannabis apps and sites.

Apps are currently used to facilitate plant identification and homeowners are the largest consumers of weed ID skills from Extension. This suggests the need for developing a weed seedling ID app specifically target for homeowners. For one person, 20% of weed ID requests came as picture messages. The advantage of digitizing the WSSA database and including the Weeds of the West pictures for use in an app were discussed. These files are 20Mb which is pretty big, nevertheless it is approximately the same size as the SDSU app. Based on SDSU experience it's clear that the size of picture files can be a limitation.

Advantages and disadvantages of other types of apps were discussed for use in Weed Science such as:

- Symptoms of herbicide damage and crop damage
- Weed ID
- Mapping
- Control recommendations
- MSDS
- Herbicide resistance management
- Clearinghouse of online databases

The last topic discussed was the possibility of developing a WSWS app, maybe Weeds of the West. It would be necessary to investigate the costs compared to printing paper copies. Where would it be marketed? Sold as a supplement or replacement to hardcopy?

Finally, Ryan Rapp was nominated and elected to serve as chair-elect for Project 4 in 2014. Kelly Young will be the 2013 Chair.

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Project 5 Discussion Session: Basic Biology and Ecology

Moderator: Bill McCloskey, University of Arizona

Topic: *Can the National Phenology Network Be Used in Invasive Weed Research?*

1. Jake Weltzin (USGS) presented an overview of the USA National Phenology Network (NPN) and discussed the role of citizen scientists in collecting data on life cycle events of plants and animals. He also described how the project is working to disseminate this data and act as a repository for similar data sets. Lars Anderson asked whether NPN plans to integrate data loggers into the network to collect more robust data in addition to observations by individuals. Jake Weltzin responded that this was being explored: for example, NPN is working with NOAA to integrate meteorological data into the system. Lars Anderson also suggested that NPN could connect with chapters of the Aquatic Plant Management Society to recruit observers, as members of this society are frequently in the field.

Jake Weltzin noted that NPN is now managing phenological data from a number of California state and national parks, and plans to incorporate data from NEON. However, adding data from NSF-funded LTER sites is a problem due to the different monitoring and recording protocols across various sites. Likewise, the National Invasive Species Council and BONAP (Biota of North America Project) collect phenological data, and there are a number of international databases, some of which contain phenological observations going back hundreds of years, but the difficulty of standardizing these data means that NPN will probably function more effectively as a portal to access these databases rather than attempting to integrate them.

Project participants discussed ways NPN could expand data gathering beyond simple observations of phenological events, and the challenges of standardizing observations contributed by a large number of citizen volunteers. Participants also discussed using the NPN to monitor invasive species occurrence and spread. Lars Anderson pointed to the power of having thousands of "eyes on the ground" to do this, but Jake Weltzin described concerns with the implication of inaccurate reports, especially for federally listed species, and potential problems with observers intentionally maintaining invasive species to monitor.

Other business:

1. A possible name change for Project 5 was discussed. Bob Stougaard reported from the WSWS summer board meeting that renaming Project 5 had been suggested as a way to attract a wider range of participants. Plant breeders and molecular biologists were suggested as one target group for increasing WSWS meeting attendance. Greg Hughes suggested that a name change alone would be insufficient, and that invitations to personal contacts would be needed. Several alternative project names were discussed but no decision was taken on a replacement for the current name. Sarah Ward proposed that a short description of the scope and focus of each project could be posted along with the call for papers to help presenters select the most appropriate project. Lars Anderson suggested that such a "vision statement" for Project 5 could include wording to encourage submission of research presentations using molecular tools in weedy and invasive plant research.
2. Participants discussed the challenge of broadening the appeal of the WSWS meeting for invasive plant researchers who might currently consider WSWS too agronomic. Several participants commented on attendance conflicts created by running Weeds of Agronomic Crops and Weeds of Range and Natural Areas concurrently with Basic Biology and

Ecology section, leading to potential participants – including presenters – being split between sections. Bill McCloskey suggested that for 2013 the Program Chair could be more proactive in reallocating papers to different sections to balance the length of sections and the distribution of topics.

3. Brian Schutte (New Mexico State University) was nominated and elected to serve as Chair-Elect. Sarah Ward (Colorado State University) will be the 2013 Chair.

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Chair-elect 2012:
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Chair-elect 2013:
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Symposium Summary: Weeds of Horticultural Crops – Tree and Vine Weed Control: New Issues and Opportunities in the U.S.

The Tree and Vine Symposium was represented by 8 presenters. The presentations provided different insights and perspectives on Issues and Opportunities in different tree and vine crops depending on the geography represented (California, New Mexico, Arizona, Washington State, and Florida), the crops discussed in each state (vines, pome and stone, pecans and citrus) and from University versus Multi-National Company perspectives. There were from 25 to 50 people participating during the afternoon of the symposium.

The Key Issue identified and discussed by many presenters can be broadly identified as "resistant weeds". The current focus from a weed resistance standpoint was primarily *Conyza* spp, primarily in California, with some indication that this weed may be expanding in other states. Several presenters expressed their concern about future weed shifts due to weed selection with current products, and the next resistant weed on the horizon for future concern was identified as herbicide resistant *Amaranthus* spp. An additional issue identified was the high reliance on the use of glyphosate in all markets and ALS products in a few markets for weed control in tree and vine markets for many years.

Application technology was touched upon by several presenters as a future area for improvement. Surprisingly, it was identified by several presenters that the cost for each herbicide application in their respective tree and/or vine crops ranged from $18-$20/acre.

Symposium Summary: Ecology and management of downy brome (*Bromus tectorum*) in the West: What can the past tell us about the future?

The symposium aimed to address downy brome in crop and non-crop systems in different regions of the western US, including how the problem has changed over time and the current state-of-the-art management principles being applied across systems and regions. The cross-system, multi-region speaker slate included nine 20-minute presentations that provided insights from years of experience and research on management of downy brome and highlighted unique aspects of downy brome ecology and management. Crop and non-crop scientists from different regions of the West helped to identify important commonalities, contrasts, and novel ideas regarding downy brome ecology and management. The symposium ended with a 15-minute synthesis and 30-minute panel discussion with the opportunity for attendees to ask questions and provide insights. Commonalities across systems and regions included the widespread prevalence of downy brome; necessity of integrated management and understanding of biology and ecology to improve management; herbicide resistance and its potential to impact management; emphasis on whole system instead of singularly-focused weed management; need to maintain and promote vigor of desired competitive vegetation; role of microorganisms; and that many regions are now managing a complex of annual invasive grasses (including downy brome) instead of only downy brome. Contrasts identified included the difference between regions where downy brome is widespread and nearly monotypic versus co-existing with perennial grasses and forbs; importance of disturbance versus competition in driving plant community dynamics; limitation in management options due to climate (i.e. moisture and temperature regimes); and variation in incidence of herbicide resistance. Finally, novel management ideas included using old tools in new ways (e.g., tillage practices, growth regulator herbicides as seed sterilants, and various cultural options) and strategic deployment of such tools; predicting plant population dynamics based on climate conditions, especially precipitation; managing downy brome as part of a multi-pest systems; continued breeding of competitive plant materials; and biological control.

Respectfully submitted by symposium co-chairs Cini Brown, Ian Burke, and Jane Mangold.

WESTERN SOCIETY OFWEED SCIENCE NET WORTH REPORT

April 1, 2011 through March 31, 2012

ASSETS	
Cash and Bank Accounts	
Checking	49,337.22
Money Market	96,237.03
TOTAL Cash and Bank Accounts	145,574.25
Other Assets	
Asset (Weeds of the West unsold inventory)	38,378.50
TOTAL Other Assets	38,378.50
Investments	
RBC Dain Rauscher Acnt	210,005.19
TOTAL Investments	210,005.19
TOTAL ASSETS	393,957.94
TOTAL LIABILITIES	0
OVERALL TOTAL	393,957.94

WSWS CASH FLOW REPORT

April 1, 2011 through March 31, 2012

INFLOWS	
Annual Meeting Income	67,035.88
Bio Control Of Invasives Book	255.96
California Weeds Books	1645
DVD Weed ID	49.95
EBIPM Course	6,325.00
Interest Inc	252
Invasive Plants Book	165.31
Noxious Weed Shortcourse	15,050.00
Student Travel Account	1,087.00
Sustaining Member Dues	12,350.00
Weeds Of The West	46,145.05
TOTAL INFLOWS	150,361.15
OUTFLOWS	
Annual Meeting Expense	17,223.06
Book Handling Fee	655
California Weed Books	1,570.00
Noxious Weed Short Course	24,275.73
CAST Annual Dues and Support	2,050.00
Deposit For 2013 Meeting	8,000.00
Director Of Science Policy	8,832.00
Insurance	1,088.13
Merchant Account	3,488.82
Newsletter	22
Service Contract	20,000.00
Stipend (Proceedings and Res. Prog. Rep. Editors	1,500.00
Supplies	222.87
Tax Preparation	812.1
Taxes and Fees	30
Travel To WSWS Meeting	5,027.23
Student Travel Account	3,525
Web Site Host	610
Web Site Transactions	2,484.00
Weed Olympics	2,308.13
WSSA Rep Travel	919.24
Weeds of the West	59,836.50
TOTAL OUTFLOWS	164,479.81
OVERALL TOTAL	-14,118.66

WSWS 2012 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.

Jodi Holt

Dr. Jodi Holt is a professor of plant physiology and the chair of the Department of Botany and Plant Sciences at University of California, Riverside. She has been a professor of plant physiology with research and teaching responsibility since 1982 at UC Riverside, and department chair since 2003. Her many contributions to Weed Science range from herbicide resistance research, to modeling temperature and moisture-based weed emergence and development, to studying the biology and management of invasive weed species. Jodi has been an active and important member of the Western Society of Weed Science and Weed Science Society of America.

In the WSWS:
Through her career to date, Dr. Holt authored or co-authored over 36 technical refereed journal publications and eight book chapters including a co-authoring a well-respected book, Ecology of Weeds and Invasive Plants: Relationship to Agriculture and Natural Resource Management. She has also authored or co-authored over 55 semi-technical publication, special reports, and proceedings pertaining to invasive plant science issues. She made more than 69 presentations or posters as an invited speaker or contributor at the WSWS meeting and other weed science related professional meetings, and served on numerous committees in WSWS and WSSA. Dr. Holt also served as a consultant and expert on Pandora's vegetation in James Cameron's Avatar movie.

Dr. Holt has been a mentor to many graduate students over the years and has served as major professor for 16 graduate students. Several of these have been in collaboration with weed scientists at other universities in addition with faculty at UC Riverside.

Her numerous awards and recognitions include: Outstanding paper published in Weed Science (1992 and 2000); Fellow WSSA (2000), Fellow AAAS (2006), UC Riverside Distinguished Teaching award (2009), and WSSA Outstanding Research award (2010).

Lars Anderson

Dr. Lars Anderson retired in January 2012 from his position as lead scientist and director of the USDA Agricultural Research Service (ARS) Exotic and Invasive Weed Research Unit in Davis, California. Dr. Anderson received his Ph.D. from the University of California, Santa Barbara in 1974 and worked for 37 years on basic and applied research on the biology and management of invasive aquatic weeds. His work experience included two years with the US Environmental Protection Service and 35 years with the USDA-ARS. During his career he developed basic physiological and ecological information directly related to improving control and eradication of invasive aquatic plants with chemical and non-chemical methods. In addition to his research program he also developed a strong outreach and education program.

In the WSWS, Dr. Anderson has been an active member of the Western Society of Weed Science and California Invasive Plant Council, and served as president of the Western Aquatic Plant Management Society, Aquatic Plant Management Society, and the California Weed Science Society. During his career he published over 70 peer-reviewed publications and 35 peer-reviewed technical reports and popular articles. Dr. Anderson led an expansion of the WSWS Aquatic Section which eventually evolved to the Western Aquatic Plant Management Society in 1985, of which he was a co-founder. He has been actively involved in policy and political issues with regard to invasive aquatic species.

Dr. Anderson served as a graduate advisor for 12 students (both MS and Ph.D.). He is currently President of Board of Trustees for the Explicit Science Center.

Dr. Anderson has received numerous awards and recognitions including the USDA Unit Distinguished Service Award and the California Weed Science Society Award of Excellence.

WSWS 2012 OUTSTANDING WEED SCIENTIST, PRIVATE SECTOR –
Brett Oemichen

Mr. Oemichen spent over 30 years in the crop protection profession working for Elanco Products, Dow Elanco, and Dow AgroSciences, retiring in 2010. He has worked in a number of sectors including sales and marketing, product development management, field research and development, and technical service. His territory expanded into the western U.S. and Brett became a member of the WSWS in 2005. He has been an active participant at our meetings presenting both papers and posters. All of his letters describe his professionalism, his knowledge, and how he is generous with his time, knowledge, and talents. In addition, they describe him as a good listener and colleague. I feel that I can summarize his contributions best by quoting from two of his letters of support for this award. First – "I strongly recommend Brett Oemichen's nomination as WSWS Outstanding Weed Scientist. His career of innovation in sales and technical development of herbicides and other crop protection products exemplifies something all weed scientists should strive for regardless of whether they work in the public or private sectors.' –and second: "Brett's strength as a weed scientist comes from a deep knowledge of the diverse market geography he covered and the understanding of grower's unmet needs, especially in cereals. He took this knowledge and came up with affordable technical solutions that were tailored to those needs, and followed through with well thought out R&D programs to ensure delivery of the technical promise. Brett is truly a leader among his peers in this regard."

WSWS 2012 OUTSTANDING WEED SCIENTIST, EARLY CAREER – Andrew Kniss

Dr. Kniss is an Assistant Professor in the Department of Plant Sciences at the University of Wyoming. He has responsibilities for research and teaching in weed science and has been in his position since august of 2007. Dr. Kniss has published 19 journal articles (13 in the last four years!), mentored 6 graduate students, and secured $850,000 in grant funding. He is an active member of WSWS serving on committees and as chair of the teaching and technology section. He has also been active in the discipline attending and presenting at WSSA as well as serving as a reviewer for several journals. All of his letters of nomination and support speak very highly of his talent as a researcher and speaker. The one thing that stood out from all of his letters is that everyone who works or interacts with Andrew is impressed with his talent and enthusiasm for Weed Science and his work. They all speak to his potential as a scientist and professional and state that he has made and will continue to make significant contributions to our discipline. I will summarize their comments by quoting from one of his letters of support. “When I work with Andrew, I am reminded of why I became a scientist. His enthusiasm for the process and dedication to the task is contagious. I am truly fortunate to have a young colleague like Andrew to work with. He is an Outstanding Weed Scientist that I expect to see accomplish a great many important things during his career.”

WSWS 2012 WEED MANAGER AWARD – Jerry Asher

Jill Schroeder (left, Award Committee Chair), Cathy Asher (holding award) and Julie Lipelt, daughter of Jerry Asher accepting award with President Vanelle Peterson (right).

Mr. Jerry Asher was a graduate of the University of California. He was employed by the BLM for his entire 40 year career, serving as a wildlife biologist in California and New Mexico, Area Manager and District Management in Oregon, and as a member of the National Weed Team. Mr. Asher was nominated by the Bureau of Land Management and the BLM National Weed Team and the letters of nomination and support were signed by many of his colleagues, including all members representing the agencies of the FICMNEW committee, who expressed their highest regard for his many contributions to weed management on BLM lands. His nominator, Robert Abbey, stated “I can honestly say that I have never met a more committed, passionate, and effective weed manager than Jerry Asher. His influence on weed management in federal land management agencies cannot be overstated.” The FICMNEW committee’s support letter stated “Clearly, his life achievements have led to the establishment and implementation of sound public policy and management guidance which will last for decades to come.” Please join me in recognizing the many contributions made by Mr. Jerry Asher to weed science and management with this Weed Manager Award.

Mr. Asher passed away last September; Mrs. Cathy Asher and family attended the awards banquet and accepted the award in his memory.

WSWS 2012 PROFESSIONAL STAFF AWARD – James Sebastian

Mr Sebastain is a Research Associate in Weed Science at Colorado State University. He has been an active contributor as author or coauthor to the WSWS Research Progress report since 1988 and the WSWS annual meeting Proceedings since 1996. His nominator, Dr. Scott Nissen, commented that "He is absolutely and totally dedicated to supporting invasive plant management research at Colorado State University. He works extremely long hours, travels from one end the state to the other, sleeps in his truck to save research funds and is always willing to share his expertise with land managers." James has worked at CSU for 24 years and has contributed to a range of research projects that have been published by Dr. Beck and graduate students under his direction. When it was active Jim was involved with the Leafy Spurge Task Force and more recently has presented research results at the Tamarisk Research Conference. Jim also co-authored a Weed Technology manuscript with Dr. Beck that was published in 2000.

WSWS 2012 PRESIDENTIAL AWARD OF MERIT – Tim Miller

President Vanelle Peterson presented Tim Miller with the Presidential Award of Merit for his cheerful, ever present willingness to assist the WSWS. During 2011-2012 he reviewed changes to the Weeds of the West and assisted at both the 2011 and 2012 meetings on short notice.

WSWS 2012 STUDENT SCHOLARSHIP RECIPIENTS

Ann Bernert (left), Oregon State University

Marcelo Moretti (middle), University of California, Davis

Rachel Brownsey (right), University of California, Davis

WSWS 2012 GRADUATE STUDENT PAPER AND POSTER AWARDS

Oral Paper Contest Awards – Basic Biology and Ecology

First Place – Andrew Wiersma, Colorado State University

Second Place (not shown) – Mohsen Mohseni-Moghadam, New Mexico State University

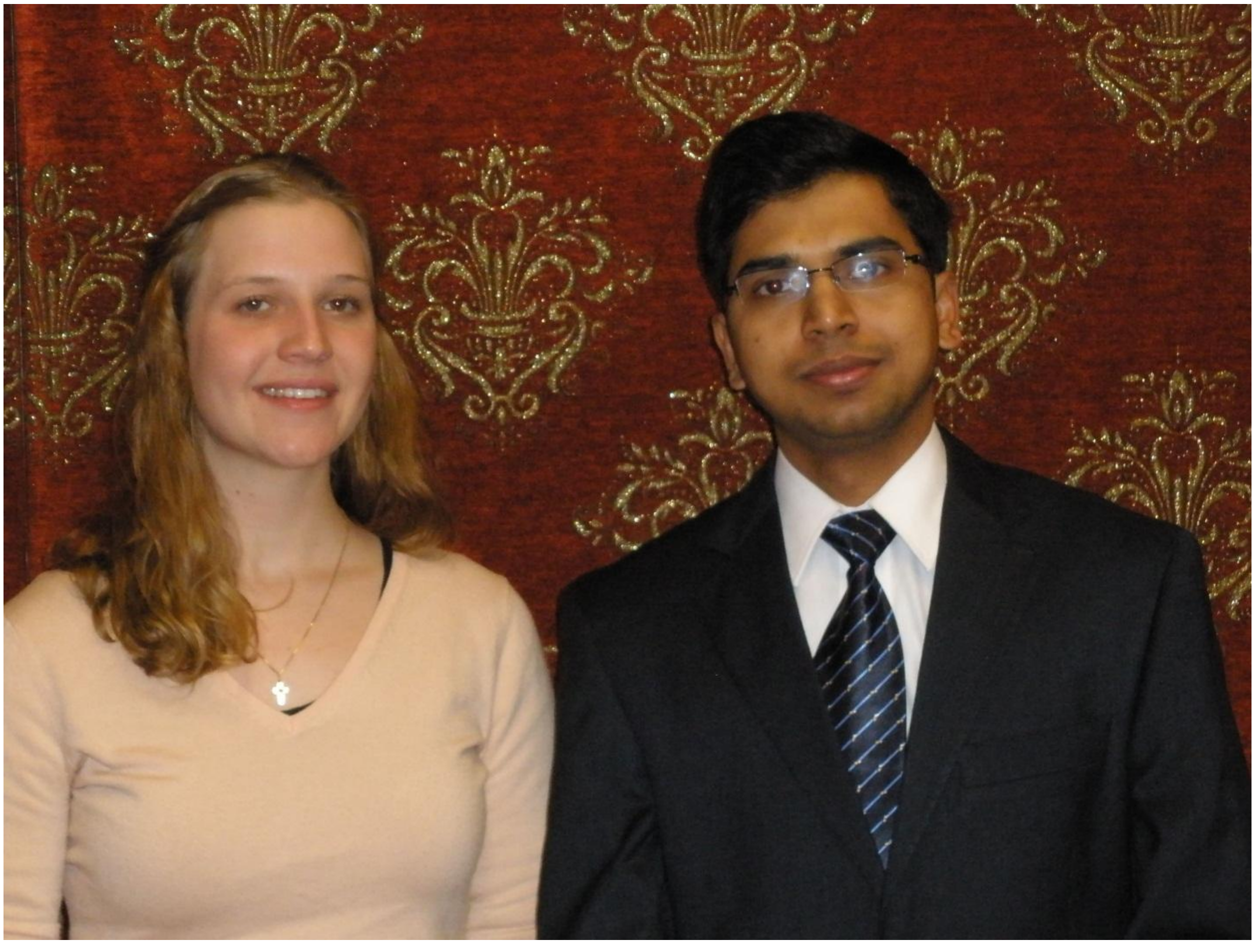
Oral Paper Contest Awards – Range and Natural Areas or Agronomy

First Place (left) – Krista Ehlert, Montana State University

Second Place (middle) – Brandon Greet, University of Wyoming

Third Place (right) – Holden Hergert, University of Wyoming

Poster Presentation Awards – Basic Biology and Ecology



First Place (left) – Louise Lorent, University of Wyoming

Second Place (right) – Aman Anand, North Dakota State University

Poster Presentation Awards – Range and Natural Areas or Agronomy

First Place (left) – Holden Hergert, University of Wyoming

Second Place (right) – Heather Elwood, Utah State University

Poster Presentation Awards – Undergraduate Poster

First Place – Ann Bernert, Oregon State University

WSWS 2012 ANNUAL MEETING NECROLOGY REPORT

Jim Helmer

Jim Helmer was born September 28, 1936 in Watonga, OK. He graduated from Oklahoma State University in 1958 with a BS degree in Agronomy. In 1963, he earned his PhD in Agronomy/Seed Technology. He later accepted a position as assistant professor of Agronomy. Jim started with Eli Lilly in 1967 He held various research and management positions with Eli Lilly and subsequently with DowElanco Company until his retirement in 1995 He contributed to the development of Balan, Treflan and Paarlan, and the introduction of Surflan and Treflan. Jim developed an in-the-field herbicide training program for sales representative and field research scientists. In 1992, Jim proposed that DowElanco sponsor a breakfast at the Western Society of Weed Science conference. The business meeting breakfast significantly increased membership attendance and participation in society activities. Jim will be remembered as the ultimate professional. Fun to work with and a team player that led by example.

Jim passed away at his home in Fresno, Ca on September 9, 2011. Jim was preceded in death by Iris, his wife of 47 years. He is survived by three daughters: Tina Spooner, Debbie Linville and Tara Beach and 8 grandchildren of Fresno.

Jerry Asher

Jerry Edward Asher was born March 3, 1938, in Pendleton, OR. He graduated from UC Davis with a degree in Range Management. Jerry then began a long career with the Bureau of Land Management (BLM) and his dedication to public service. Later in Jerry's career he won accolades and awards for his work as the "Weed Warrior." He was relentless in his efforts to bring this problem to the attention of the public and to various government agencies, including testifying before Congress. He worked hard at finding funding and solutions to this problem on our public lands. Jerry was awarded the 2012 WSWS Outstanding Land manager award

Jerry died peacefully at home on September 12, 2011, with his wife, Cathy, and beloved dog, Sydni, by his side. He was 73. He carried his children, Jeff and Julie, and his granddaughters, Erin and Makenna, in his heart.

Bill B. Fischer

Bill Fischer was born on August 28, 1921 in (then) Czechoslovakia, as Bela Fischer. Bill attended Ohio State and then UC Davis where he received a Master's degree in Horticulture. Bill worked for UC Cooperative Extension in Fresno County for 35 years, specializing in weed control. He studied the effectiveness of herbicides on weeds. Many of us remember Bill for his work on the California Grower's Weed Identification Handbook. The Handbook remains an important reference for growers. After retiring in 1991 he continued working in the industry for eight years.

Bill celebrated his 90th birthday in August and died peacefully at home on January 30th.He is survived by his beloved wife of 56-years, Jane; his son Andrew and his wife Linda, his grandchildren Lucy and Jacob and his two brothers, Joseph and Louis. He was preceded in death by his daughter Susan.

Tim Playford

Tim Playford passed away from complications from Alzheimer's disease March 4, 2012. Tim had a 30 plus year career with Dow AgroSciences. He started with Dow Chemical as a sales Representative in Illinois in the mid-1970's and then moved to Midland, MI as a communications manager then on to Billings, MT where he led the Billings District as District Sales Manager of then, DowElanco and ultimately Dow AgroSciences. He was a nationally recognized leader and instrumental in the formulation of the National Invasive Weed Awareness Council, Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) and the National Weed Awareness Week in Washington, DC. Tim was also responsible for the initial formulation of North American Weed Management Association many years ago. Tim managed the DAS relationship with the National Cattlemen's Beef Association and presented the National Environmental Stewardship Award on numerous occasions. He is survived by his wife, Dawn Rafferty, Nevada Department of Agriculture Invasive Weed Coordinator

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