2016- Weed Research Report
Lassen, Modoc, Sierra and Plumas Counties

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Trade names of pesticides are used throughout this report for informational purposes only, and are not an endorsement of chemicals not mentioned, or an endorsement over chemicals from other companies.

I would like to sincerely thank all the cooperators, who allowed my colleagues and I to conduct these field trials on their land. I really appreciate the alterations of your management practices, donations of time, equipment, and labor to accommodate this work. Without your generosity, and help none of this work would have been completed.

In no specific order, cooperators included in this report are: Buck Parks, Jay Dow, Herb Jasper, John Flournoy, Billy Flournoy, Tim Garrod, Luke Garrod, Don Blickenstaff, Pam Cherney, Craig Hemphill, Marty Svendsen, and Ed Svendsen.

Additionally, I would like to thank Eric Rubio with Stanislaus Farm supply at The Pardner for help finding sites, and donation of product which allowed these trials to be completed.

For more information about any of the trials described, please do not hesitate to contact me.

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Weed Control with Sharpen and Shark in Alfalfa-Orchardgrass Mix:

Alfalfa and orchardgrass mixture is a common crop grown in the Intermountain Region. Seeding orchardgrass into older alfalfa stands can improve the yield of a thinning alfalfa stand, make the crop more competitive with weeds, and extend stand life. Mixtures of grass and alfalfa in small bales can also bring a premium price for the horse market. However, weed control can be a challenge, as options in these systems is limited. Ground disturbing techniques such as tillage are not used because the crops are perennial. In addition, most herbicides are injurious to one of the crops—herbicides are safe to the alfalfa or the grass but not both. Common weeds such as shepherd's-purse, tansy mustard and hare barely (foxtail- *Hordeum murinum*) can be problematic.

The herbicides Sharpen (saflufenacil) and Shark (carfentrazone) were recently registered for alfalfa in California. Both Shark and Sharpen are burn-down herbicides (similar to Gramoxone) that are effective at controlling small weeds, but do not move downward to plant roots. Sharpen does have some soil residual activity and can control certain weeds as they are germinating, but this activity is minimal at the rates used in alfalfa. This trial was conducted to test the crop safety and weed control achieved with these products in an alfalfa/orchardgrass system. Two sites were located near Doyle, CA. One site (Site one) was an old established alfalfa/orchardgrass stand with low weed pressure, and the other site (Site two) was an old alfalfa stand that was just interseeded with orchardgrass the previous fall with high weed pressure.

Study Investigators: Tom Getts and Steve Orloff

Cooperators: Tim and Luke Garrod- Bird Flat Ranch

Herbicide applications: Were made using a CO_2 powered backpack sprayer at 20 gallons per acre with 110 02 flat fan nozzles. All treatments included 0.25% NIS v/v, except the Sharpen treatments which included 1% MSO v/v.

Site 1 (Older Field): Applications were made March 3, 2016. Orchardgrass was 1.5-3.5 inches, alfalfa was 1-3 inches, cheatgrass was 1 inch, mustard species were 1-4 inch rosettes. Applications were made at 5:00 pm, at 53 deg. F, with 63 percent RH and 5 mph winds.

Site 2 (Seedling Field): Applications were made March 17, 2016. Alfalfa was 1-3 inches, orchardgrass was 2-4 inches, cheatgrass/foxtails were 1-3 inches, and mustard species were 2-5 inch rosettes. Applications were made at 6 pm, at 55 deg. F, with 61% RH and no wind.

Plot size: Four replications of 10 x 20 ft. plots were laid out in a randomized complete block design at each site.

Data collected: Weed control and crop injury evaluations were taken visually for Site one on March 29th, April 13th and May 10th. Weed control and crop injury evaluations for Site two were taken on March 23rd and then again on April 13th.

Results/Discussion:

Site 1 (Older Field)- Both Shark and Sharpen caused considerable initial burndown of the alfalfa plants, but by mid-April injury symptoms had diminished greatly in all treatments (Figure 1). Orchardgrass showed some spotting on the leaves from both Shark and Sharpen applications in the March assessment. These injury symptoms were reduced by the April evaluation and were not noticeable in May (Figure 2). By May, before cutting, injury symptoms for both crops were negligible in most plots. However, orchardgrass treated with ½ pound Dimetric (metibuzin) + 1.3 pts Gramoxone showed severe injury in March and was still injured in May. Weed populations were not uniform enough throughout the site to report reliable control data.

Site 2 (Seedling field): In the March rating, both Sharpen and Shark caused 85% to 95% burndown of alfalfa. The alfalfa grew out of most of the injury, but some symptoms were still apparent at the April evaluation, particularly for the Sharpen applications (Figure 3). Orchardgrass showed moderate symptoms during the March evaluation, with almost no symptoms apparent by the April evaluation. Both alfalfa and orchardgrass plants had broken dormancy at the time of the herbicide application. An earlier application before crop dormancy was broken may have resulted in less injury occurring.

There were dense cheatgrass and foxtail populations within the study area. Some injury symptoms on hare barley were initially observed from Sharpen treatments, causing chlorosis (yellowing) for the March evaluation (Figure 4) (Picture 4). By April, these symptoms had subsided. Cheatgrass was relatively unaffected.

The main two broadleaf weeds present at the site were tansy mustard and shepherd's purse. Tansy mustard was not effectively controlled by the 2,4-D + buctril treatment, but was controlled by most other treatments including both Shark and Sharpen (Figure 5). Shepherd's purse showed injury from Shark and Sharpen treatments in March, however, many plants grew out of the injury. Shepherd's purse control ranged from 45 to 80 percent control by the April evaluation.

The application made on March 17th was probably too late. It was made to a crop which had broken dormancy, resulting in injury the alfalfa did not fully recover from. The shepherd's purse was not effectively controlled, and the hare barley showed some symptoms from the herbicide treatments, but quickly grew out of them. None of the treatments tested resulted in effective weed control at this application timing. Future studies may look at the effectiveness of earlier application timings of Shark and Sharpen, to reduce crop injury and increase weed control.

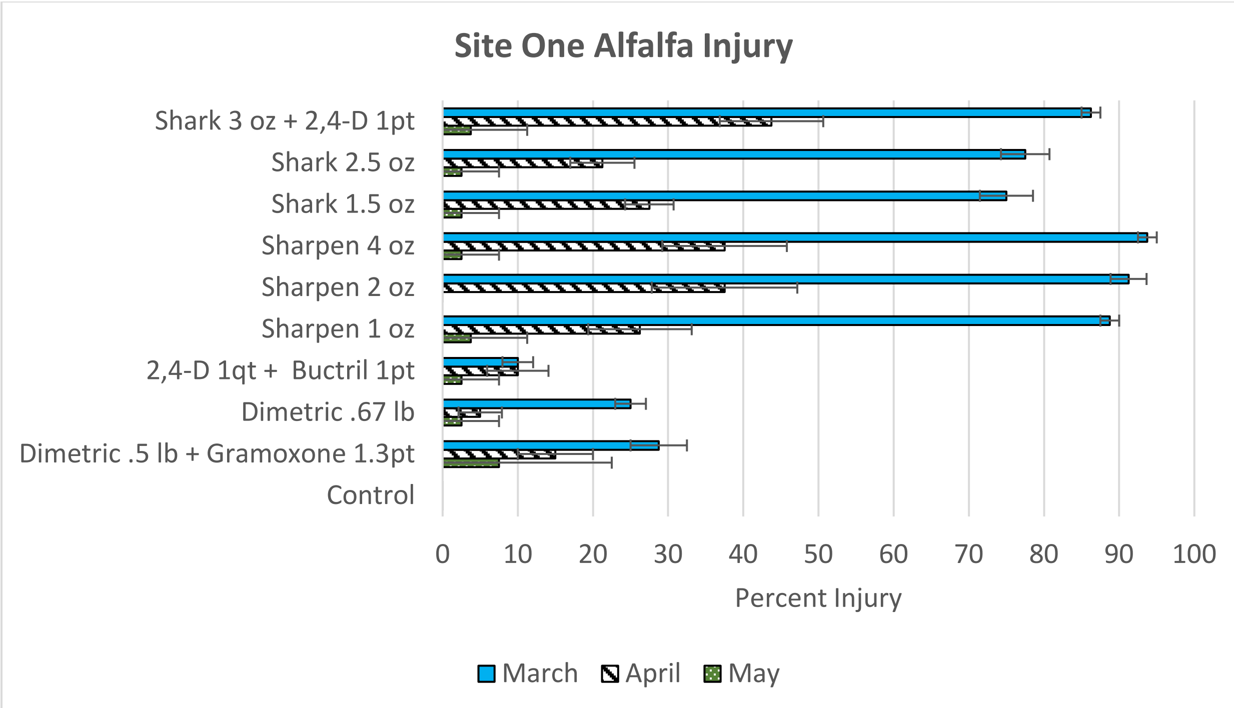

Figure 1: Displays the percent injury for alfalfa at Site 1 (the older stand). Error bars indicate 95% confidence intervals.

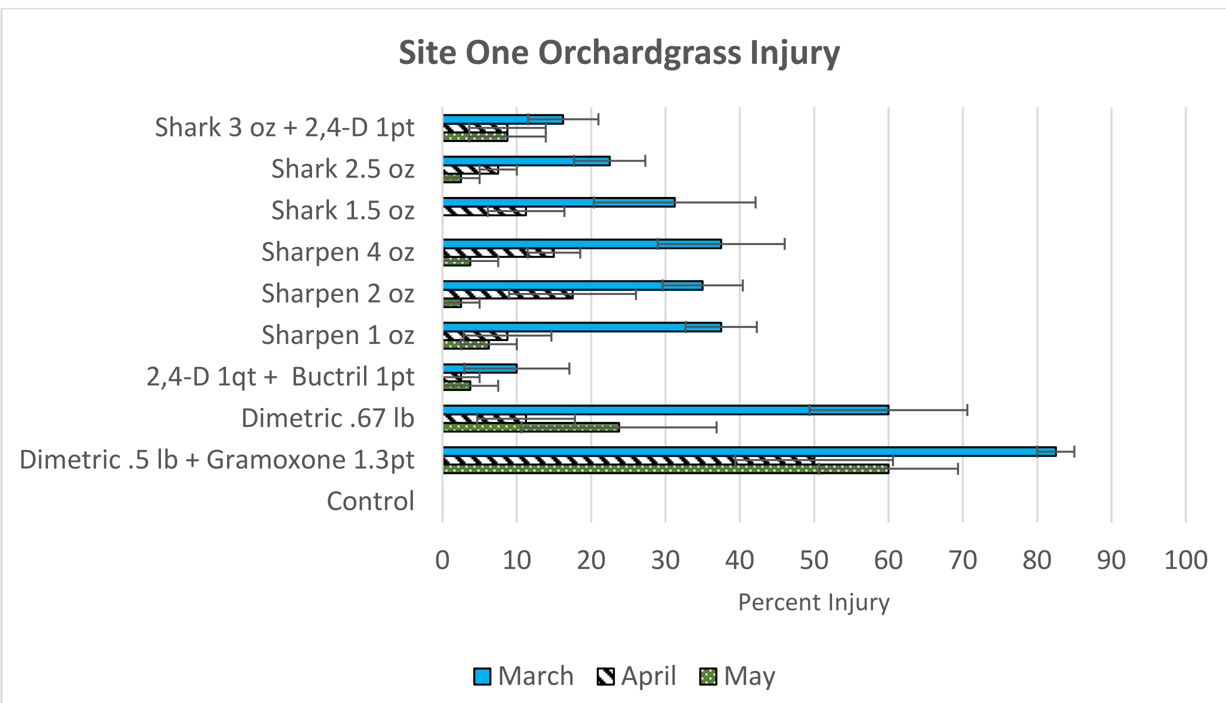

Figure 2: Displays the percent injury for orchardgrass at Site 1 (the older stand). Error bars indicate 95% confidence intervals.

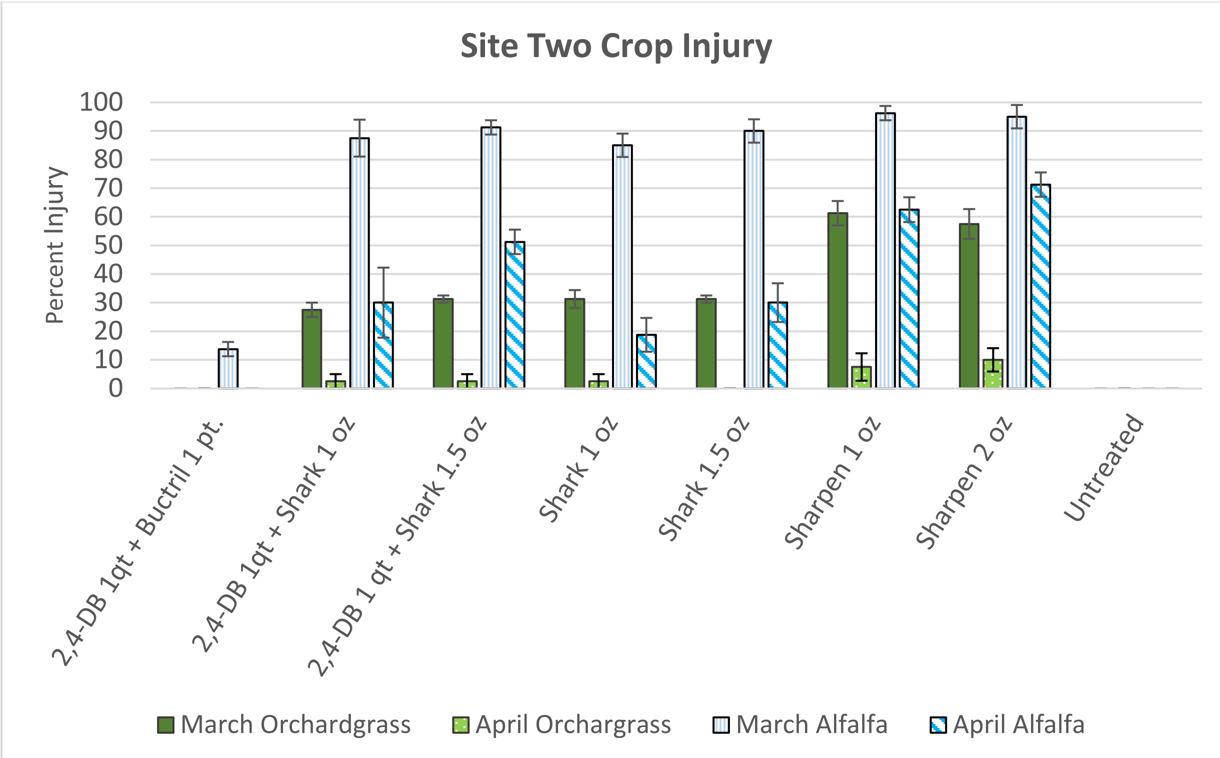

Figure 3: Displays the percent crop injury at Site 2 (the seedling stand) for both alfalfa and orchardgrass. Error bars indicate 95% confidence intervals for each species at each timing individually.

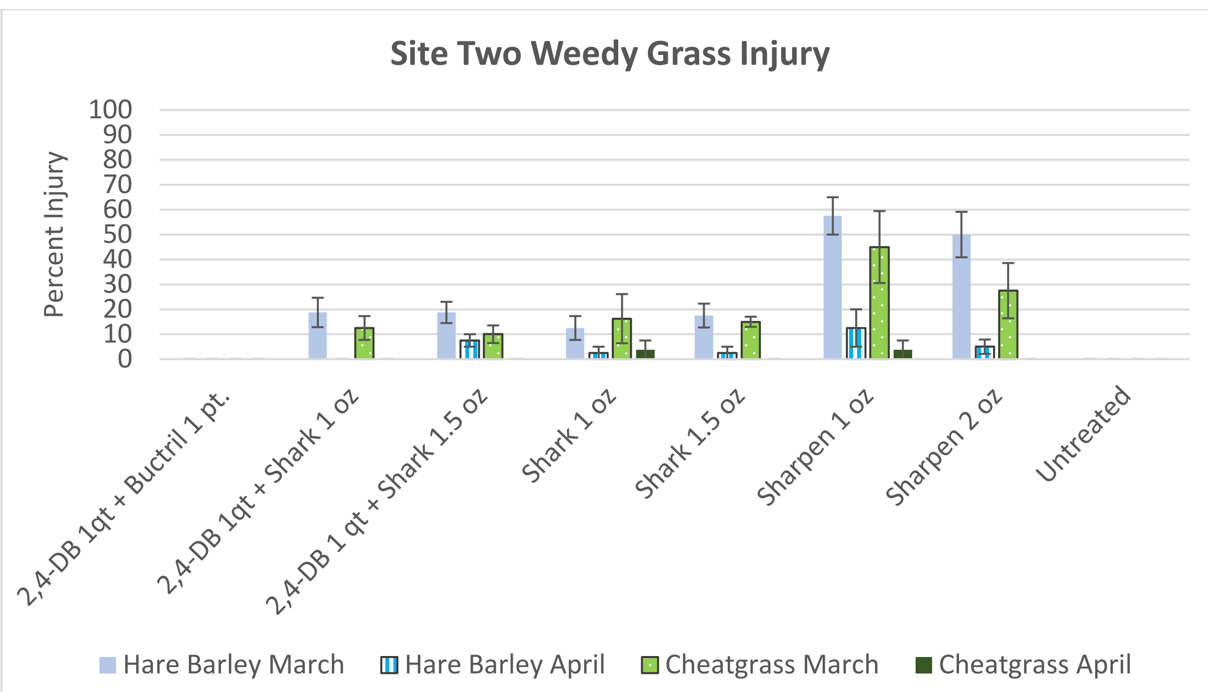

Figure 4: Displays injury to cheatgrass and hare barley at both rating dates. Error bars indicate 95% confidence intervals for each species at each timing individually.

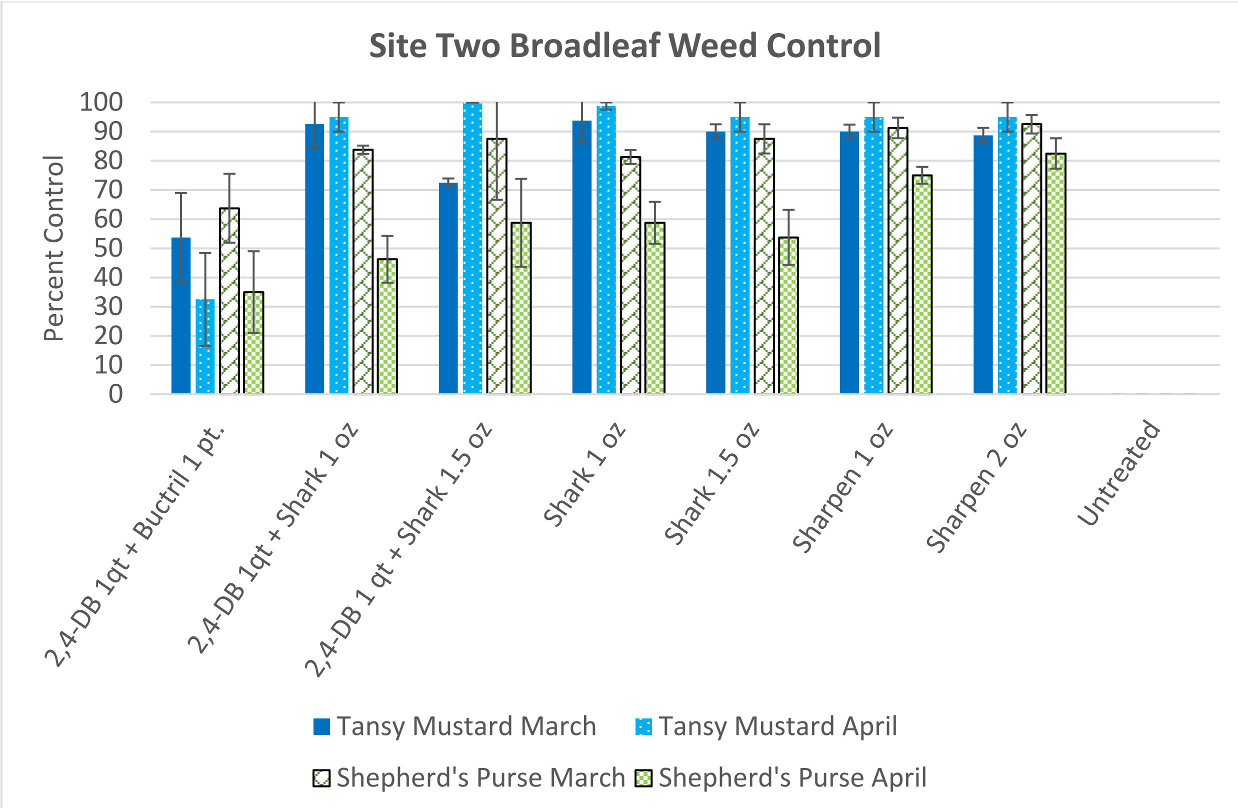

Figure 5: Displays the percent control for tansy mustard and shepherd's purse in the seedling orchardgrass alfalfa stand. Error bars indicate 95% confidence intervals for each species at each timing individually.

Pictures:

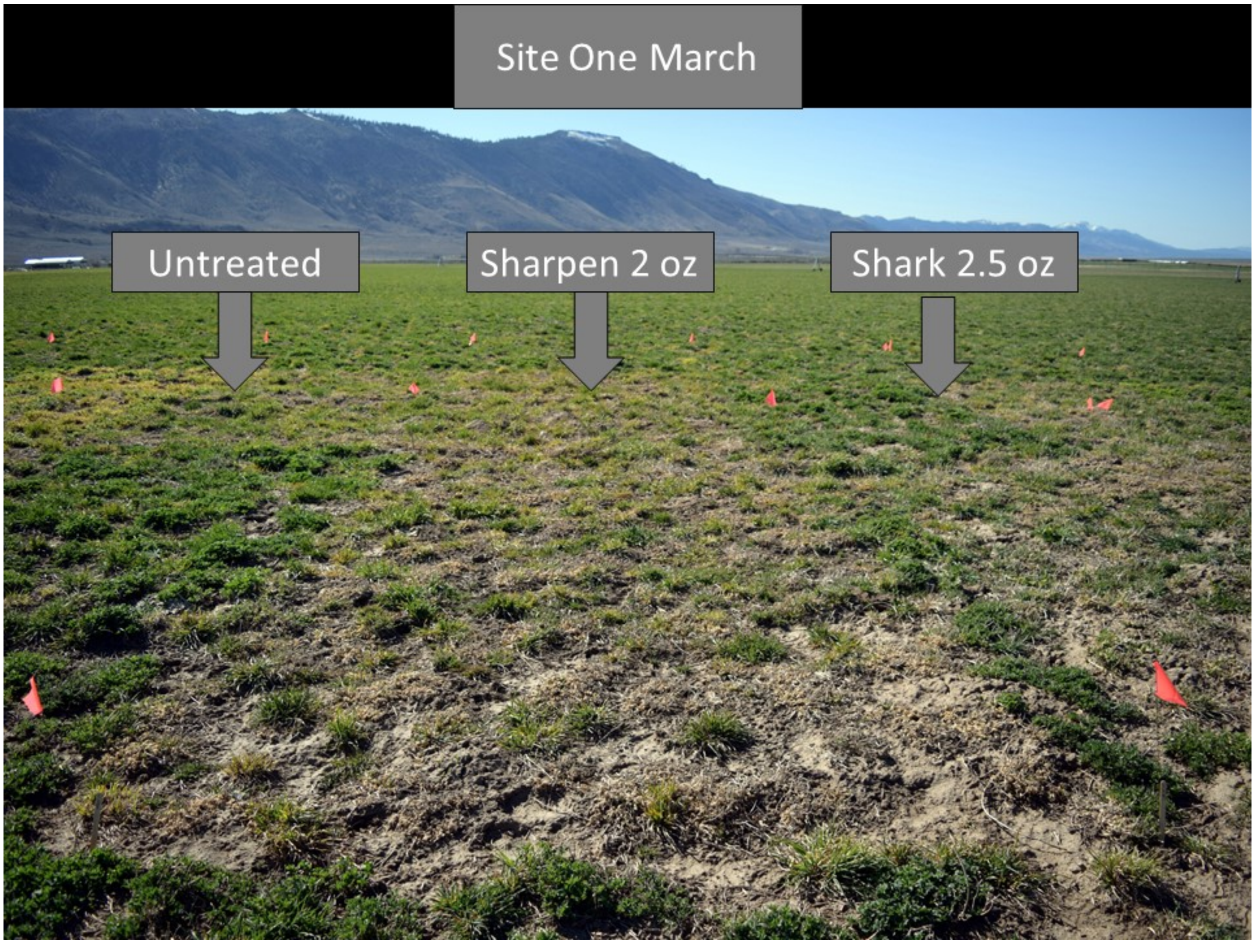

Photo 1: Site 1 (older stand), alfalfa burndown is apparent in the Shark and Sharpen plots compared to untreated check.

Photo 2: Same plots in April, difficult to detect much injury.

Photo 3: Orchardgrass yellowing (chlorosis) at Site 1 (older stand) in the Diametric + Gramoxone plot.

Photo 4: Hare barley and orchardgrass yellowing at Site 2 (seedling stand) from Sharpen application. Picture was taken in March. Both the weeds and the crop grew out of injury.

Weed Control in Alfalfa Grown for Seed

Background: Alfalfa seed production fields can often have more weeds than alfalfa produced for hay and a few factors can contribute to this. Alfalfa grown for seed production is often planted in rows, resulting in more room for weed pressure. Additionally, alfalfa grown for hay is mechanically cut multiple times throughout the growing season, which can help control annual weeds growing in the field. Typical conventional weed control regimes look at a combination of soil-residual herbicides applied with a burndown product while the alfalfa is still dormant. The parasitic plant dodder has historically been an issue in the field where this trial was located. This trial investigated different combinations of herbicides, along with split application timings, with dodder control in mind.

Study Investigators: Tom Getts, Rob Wilson

Cooperators: Don Blickenstaff

Date of herbicide applications: February 12th, February 29th, and April 26th

Application method: Plots were 10 x 20 ft. replicated four times in a randomized complete block design. A CO2 pressurized backpack sprayer was used to make applications at 20 gal/acre with 110 02 Flat Fan Nozzles. There were three application timings: one in February, one in March, and one in April depending on treatment.

Application conditions: February 12th applications were made at 11:30 am, at 48 deg. F with 61% RH and 3.5 mph winds. The majority of weeds had not emerged, and the alfalfa was still dormant. February 29th applications were made at 10:00 am, at 48 deg. F with 52% RH and 3-4 mph wind. More mustard weeds had germinated, and alfalfa had 1-2 inches of active growth. April 26th applications were made at 11:30 am, at 54 deg. F with 30% RH and 1-5 mph winds. Tansy Mustard was 3-8 inches, Kochia 1 inch, Russian thistle 1-3 inches, and Prickly lettuce 1-4 inches.

Treatment list

1-Febuary-2/3 lb Velpar + 2.67 pts Gramoxone + 2 pts Prowl H20. April- 2 pts Prowl H20
2-Febuary- .83 lb Dimetric + 2.67 pts Gramoxone + 2 pts Prowl H20. April- 2 pts Prowl H20
3-Febuary- .83 lb Dimetric + 2.67 pts Gramoxone. April- 4 pts Prowl H20
4-February- .83 lb Dimetric + 2.67 pts Gramoxone.
5-Febuary- 4 pts Prowl H20 + 2.67 pts Gramoxone.
6- Late February- .66 lb Velpar + 2.67 pts Gramoxone.
7- Late February- .66 lb Velpar + 2.67 pts Gramoxone+ 2 pts Prowl H20. April- 2 pts Prowl H20
8-Untreated
*all applications included NIS at 0.25% v/v

Data collected: Visual assessment of weed control and alfalfa injury was collected on March 21st, April 27th and June 13th.

Results summary: Alfalfa injury assessed on March 21st indicated more injury from the February 29th herbicide applications, compared to application made February 12th (Figure one). By April 27th, the alfalfa had grown out of all injury from all herbicide applications. Weed populations assessed in the field were cereal ryegrass (Figure two), tansy mustard (Figure three), tumble mustard (Figure four), kochia (Figure five), Russian thistle (Figure six), and prickly lettuce (Figure seven). No herbicide treatments gave greater than 90% overall weed control by the June assessment timepoint (Figure eight). Dodder was not observed in any plots, including the untreated control. Generally, control ratings were higher in March and declined through the growing season, which would be expected as Dimetric and Velpar applications degraded. Most applications gave good to moderate weed control.

*Velpar applications did not work as expected, potentially because the Velpar used was approximately 5 years old.

*Russian thistle was the most difficult species to control, none of the treatments offered better than 90% control for Russian thistle

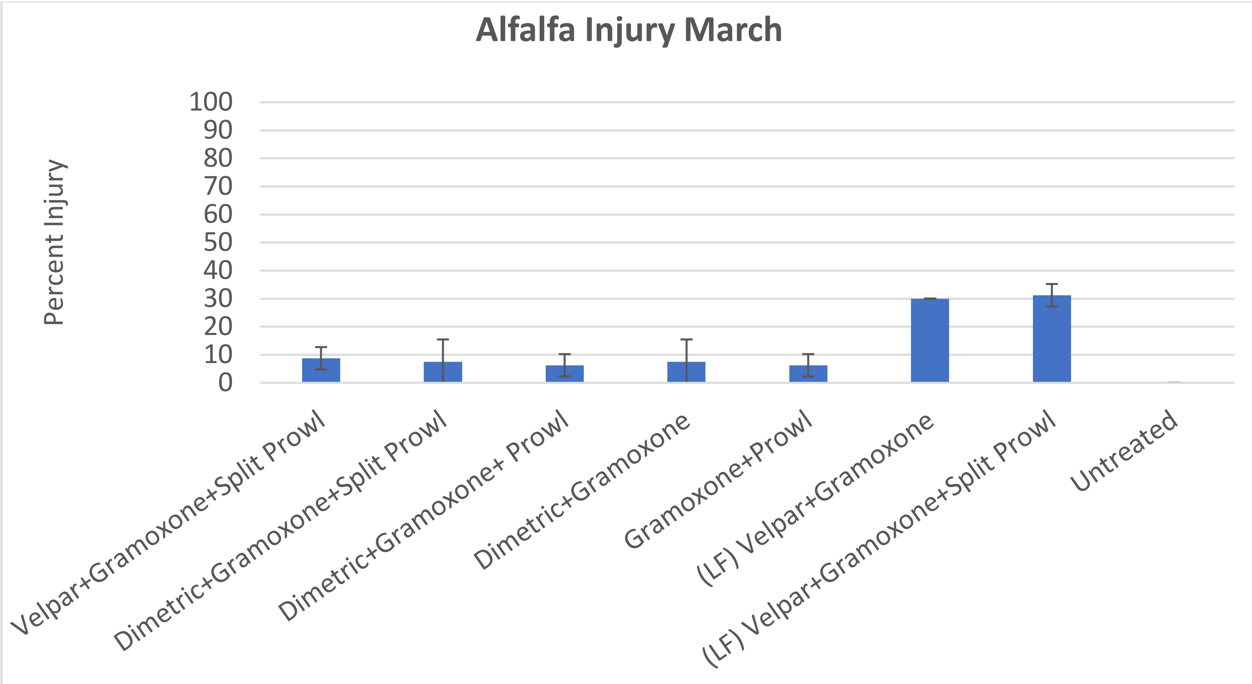

Figure one: Displays the percent injury observed for alfalfa at the March assessment. Error bars indicate 95% confidence intervals.

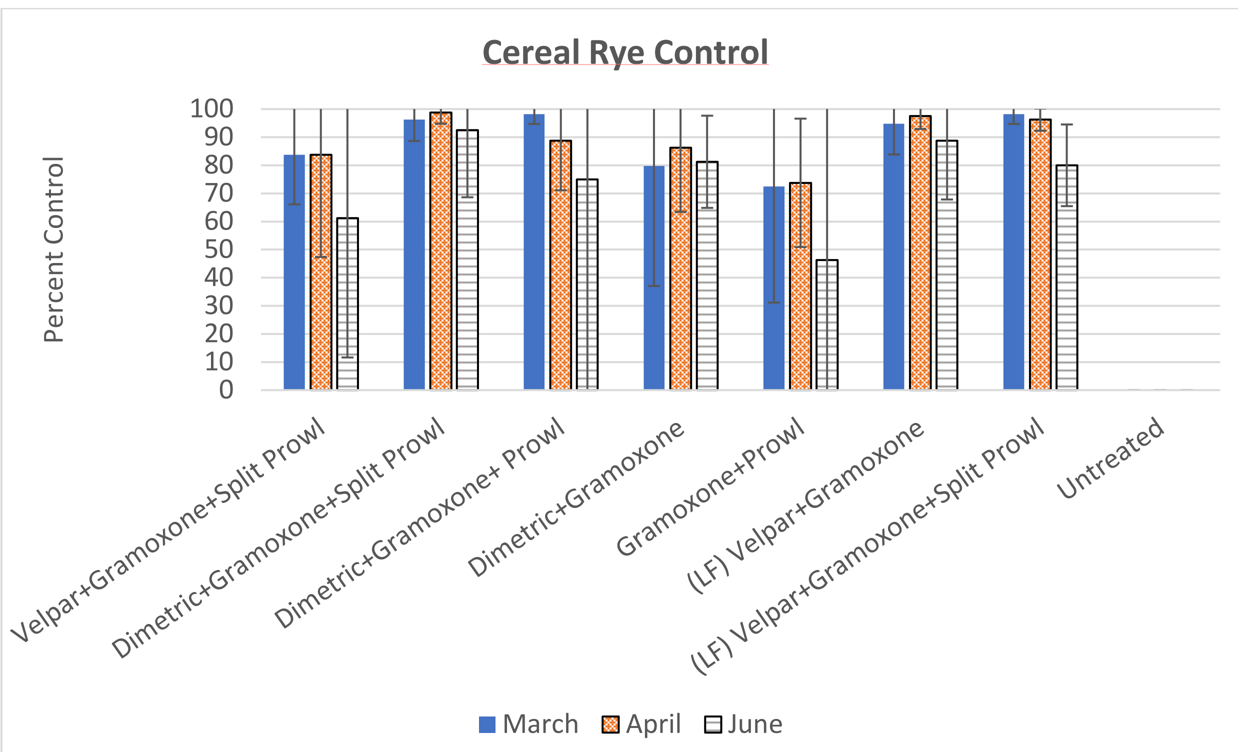

Figure two: Displays cereal rye control throughout the study. Error bars indicate 95% confidence intervals for each assessment timepoint.

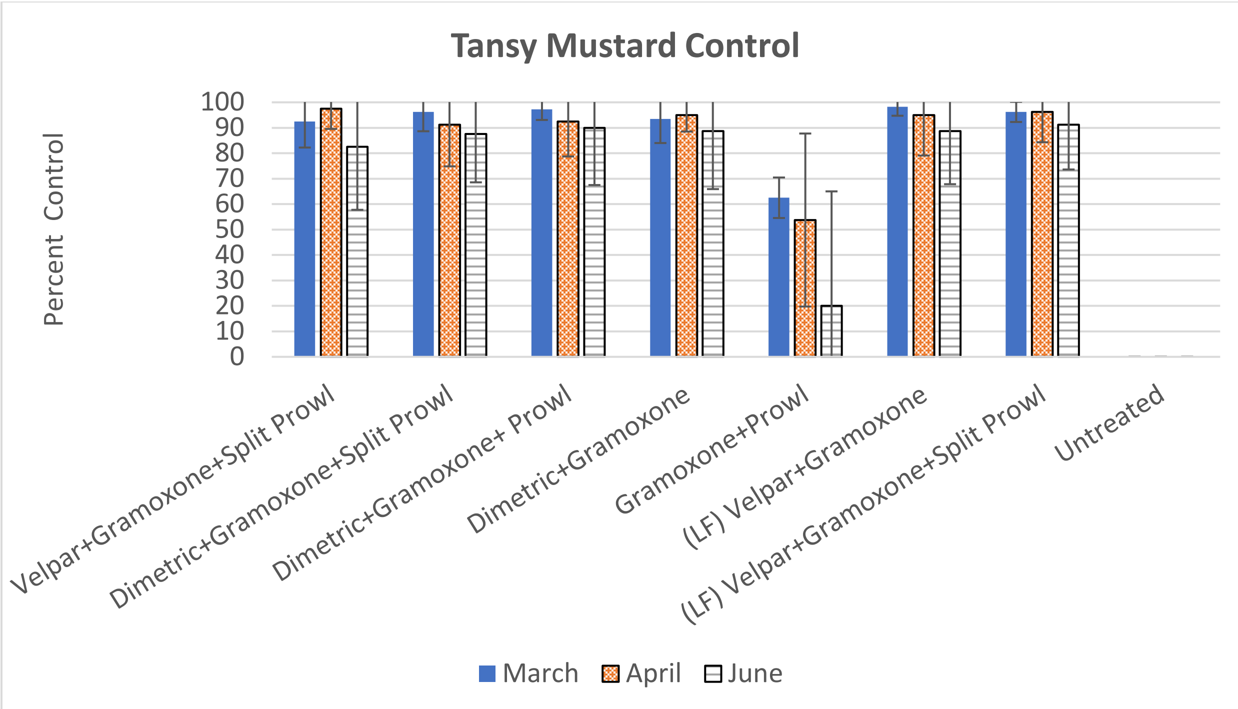

Figure three: Displays tansy mustard control throughout the study. Error bars indicate 95% confidence intervals for each assessment timepoint.

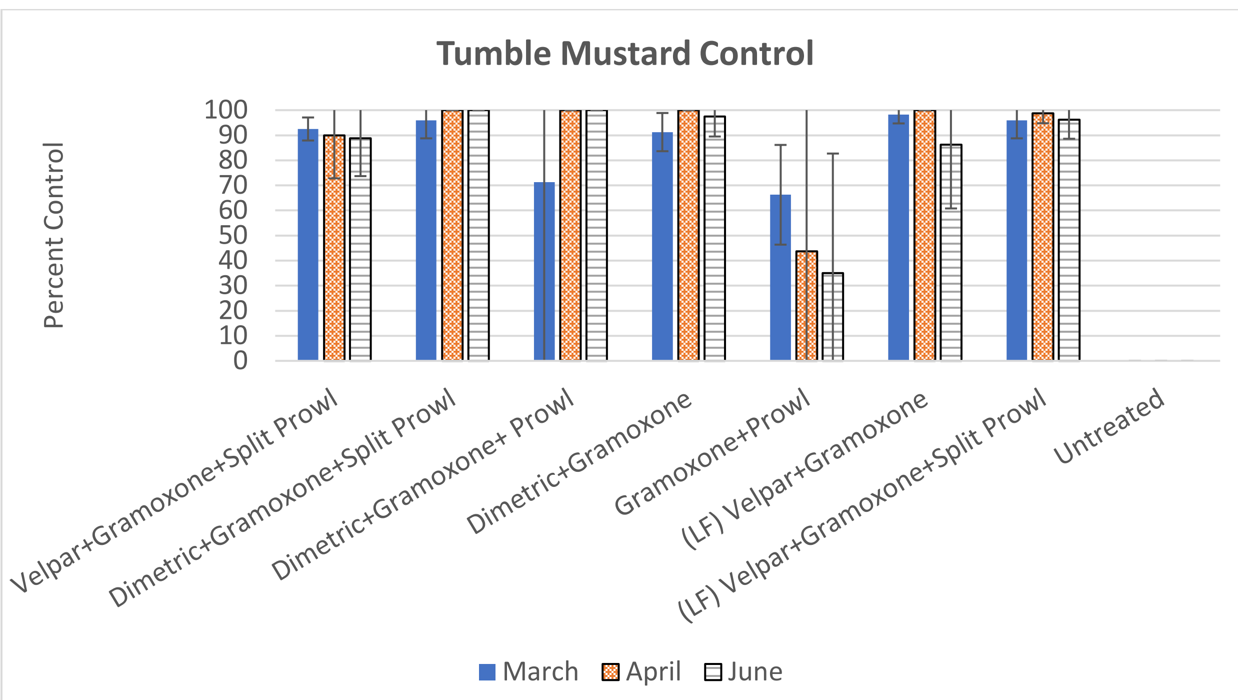

Figure four: Displays tumble mustard control throughout the study. Error bars indicate 95% confidence intervals for each assessment timepoint.

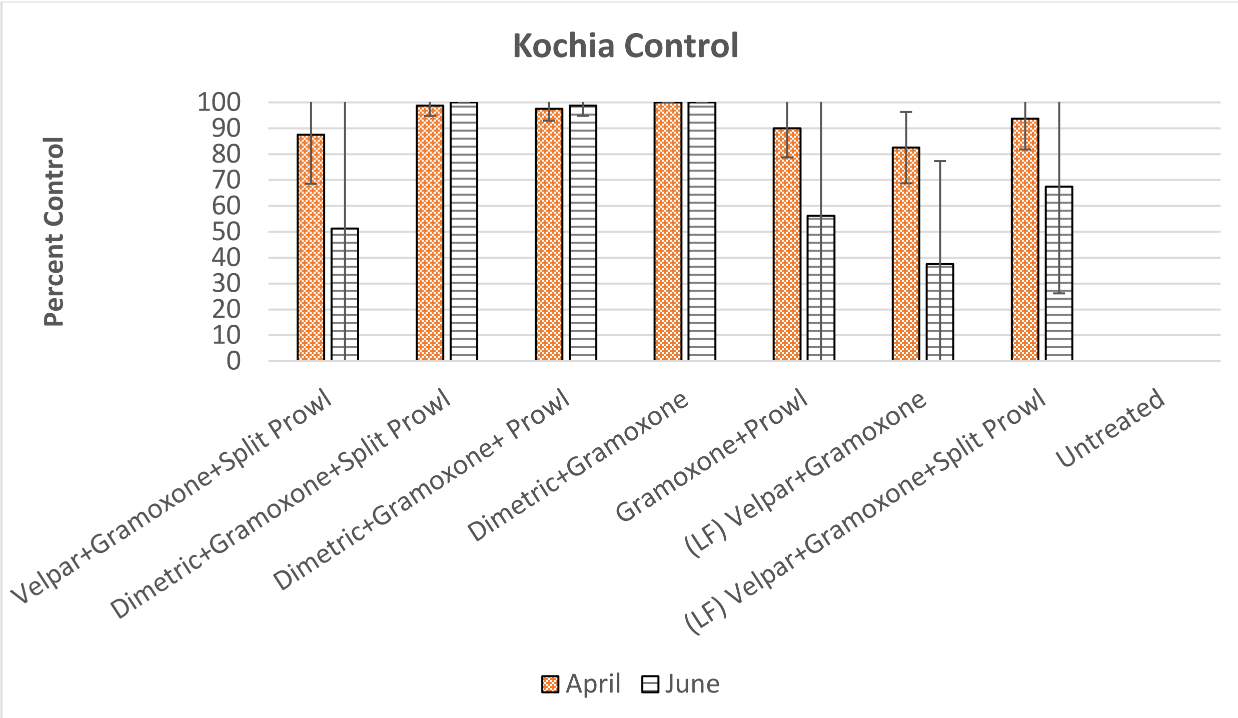

Figure five: Displays kochia control throughout the study. Orange columns represent April, and grey columns represent June. Error bars indicate 95% confidence intervals for each assessment timepoint.

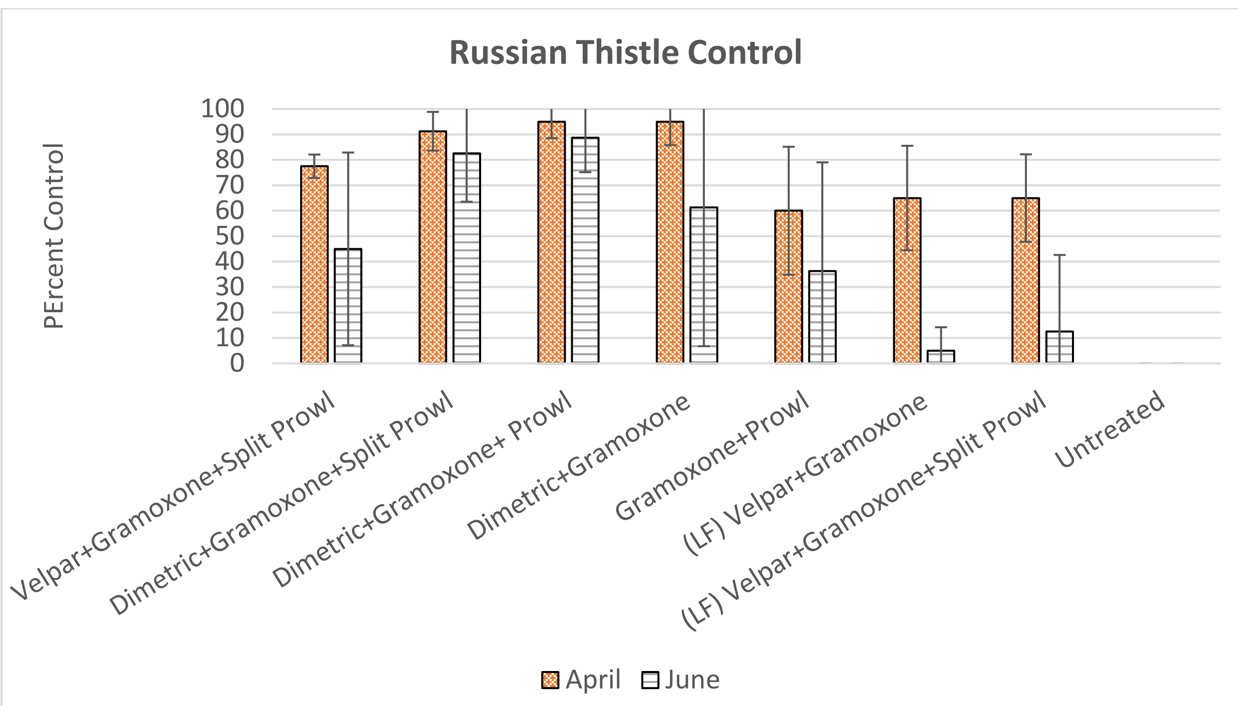

Figure six: Displays Russian thistle control throughout the study. Error bars indicate 95% confidence intervals for each assessment timepoint.

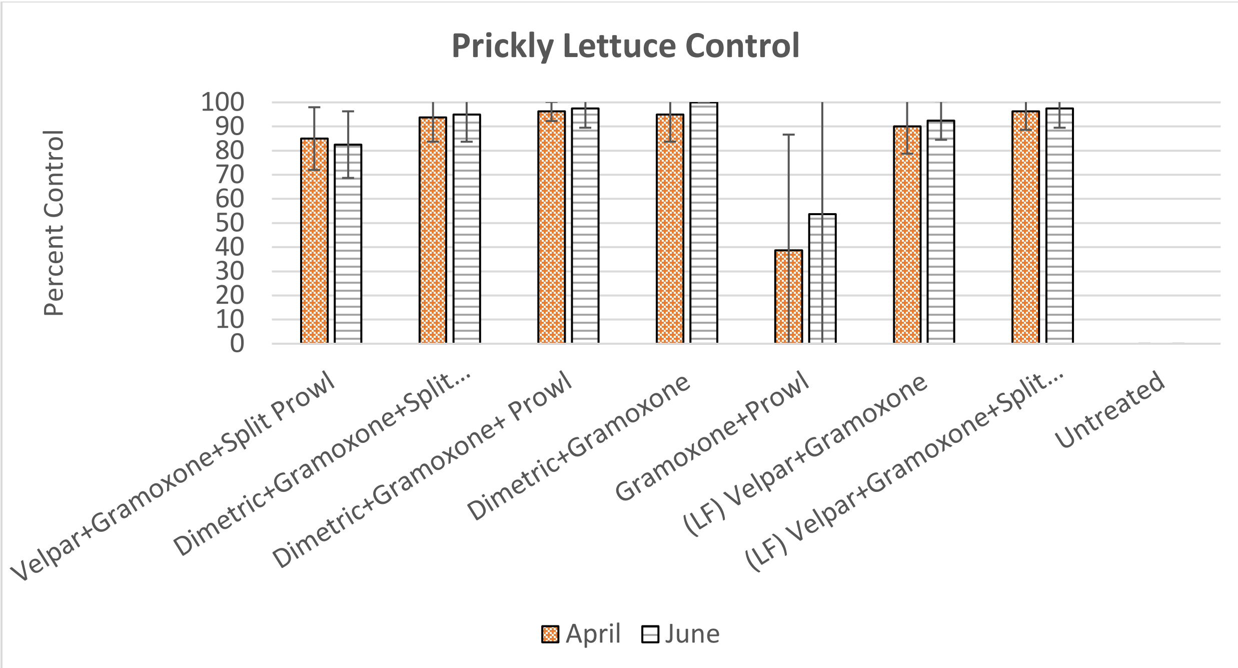

Figure seven: Displays prickly lettuce control throughout the study. Error bars indicate 95% confidence intervals for each assessment timepoint.

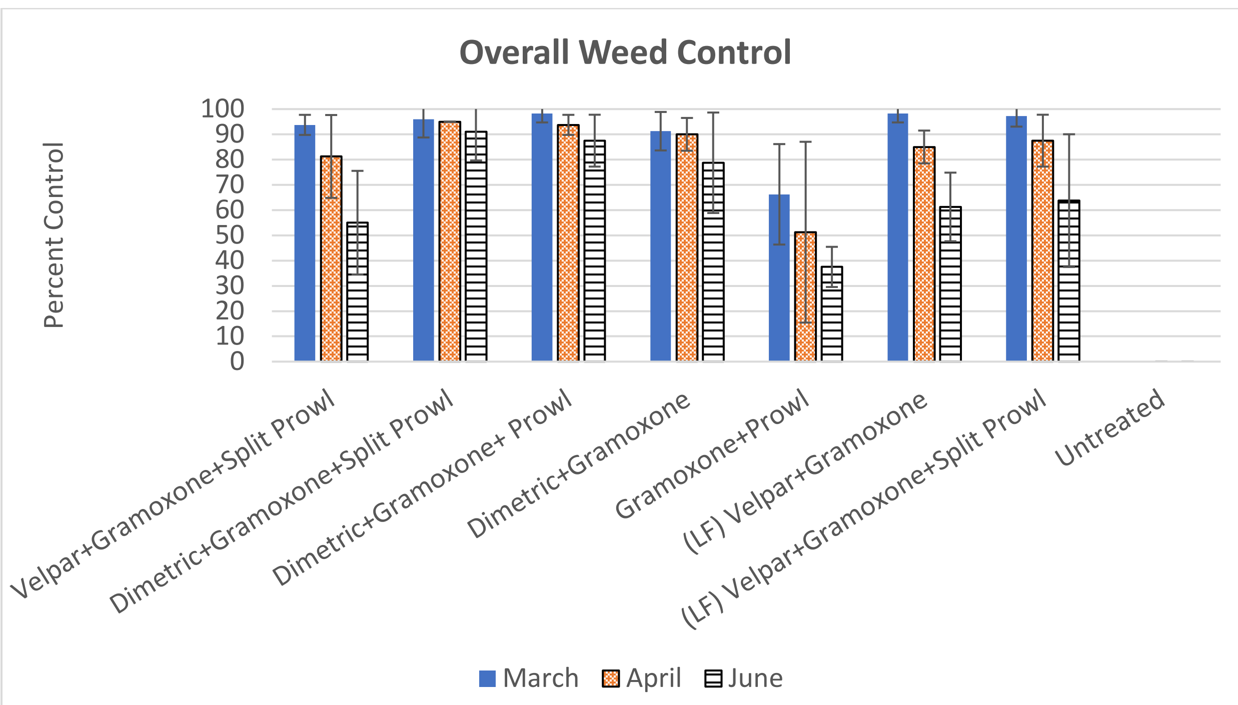

Figure eight: Displays overall weed control throughout the study

Error bars indicate 95% confidence intervals for each assessment timepoint.

***Published in the Western Alfalfa and Forage Symposium Proceedings.**

Local Cooperator: Jay Dow

ROUNDUP READY ALFALFA:

AVOIDING INJURY WHILE MAXIMIZING WEED CONTROL

Steve Orloff, Rob Wilson, Tom Getts and Brad Hanson[1]

ABSTRACT

Roundup Ready (RR) alfalfa is a popular weed management strategy for alfalfa producers in California and other western states, with the greatest advantages considered to be excellent weed control without crop injury. However, recent research and field observations have documented that injury is possible under certain conditions. In several instances in the Intermountain region of northern California, glyphosate treatment followed by cold temperatures have resulted in crop injury. It appears that the specific combination of herbicide timing, alfalfa physiological stage, and weather conditions associated with the observed injury may not be common, which may explain why this has been observed in some areas and not others. In addition, there is some evidence that this glyphosate-associated injury may also be masked by more severe frost damage that also can occur under similar conditions. Research results and field observations to date suggests that injury is affected by the temperatures after an application, height of the alfalfa (taller alfalfa being more prone to injury), and stand age (no injury to seedling alfalfa and less injury to recently established alfalfa compared with fields established for over a year). Treating when the alfalfa is 2-inches tall or less is advised to avoid injury in areas prone to cold temperatures after an application. While this relatively cautious recommendation shortens the herbicide application window, it also minimizes the possibility of injury. Application to 2-inch tall alfalfa also helps ensure effective weed control because the weeds are typically small and easier to control and spray coverage is often better at this crop growth stage. For most annual weeds, the highest labeled rate of glyphosate (44 oz. of PowerMax or equivalent for other glyphosate formulations) is not needed, and a lower labeled rate will provide acceptable control while minimizing the possibility of injury. This application timing is also compatible for tank mixes with soil residual herbicides, which also are recommended sometime during the life of the alfalfa stand to help avoid the evolution of glyphosate-resistant weeds. Glyphosate-induced injury symptoms have been observed only in the first cutting; no visible injury or yield reductions have been observed in second- and later cuttings.

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Key Words: Herbicides, glyphosate, weed control, phytotoxicity, transgenic alfalfa, application timing

The advent of Roundup Ready (RR) alfalfa has had a significant impact on current-day alfalfa production. Glyphosate is a highly effective, broad spectrum herbicide that is very cost effective for growers. The development of RR varieties allows this effective herbicide to be applied directly over the top of alfalfa without injuring the crop and presents a huge advantage, especially for difficult-to-control weeds. The technology has been readily adopted in the West and has become a popular weed management strategy in many alfalfa production regions. Aside from issues related to exporting GMO alfalfa to some countries, most growers are pleased with the technology.

The technology and its fit in alfalfa production systems has been thoroughly researched throughout the U.S. In addition, RR alfalfa has now been used extensively in commercial fields since it was first released in 2005 and subsequently rereleased in 2011. The main advantages are improved weed control, ease-of-use, and avoidance of crop injury. Most of the research to assess crop injury was conducted with seedling alfalfa, believing that—if injury was possible—it would be far more likely with seedling than established alfalfa. No published results have indicated risks of crop injury under normal or extreme use rates.

Observations of Injury

Two years ago, in the spring of 2014, we observed significant crop injury in a grower's established field of RR alfalfa in Scott Valley, a high-elevation valley located in the Intermountain area of northern California. A portion of a field where irrigation wheel-lines were anchored for the winter was left untreated, and the alfalfa growth was much taller in that area compared with the treated portions of the field. This was a mystery, as previous research and grower experience after years of RR alfalfa use had not indicated an injury problem. Logical potential causes for poor growth in the glyphosate-treated area, such as spray-tank contamination, a bad batch of glyphosate or non-herbicide-related management practices (fertilization, irrigation, pest management, etc.), were systematically ruled out. A test plot was conducted in the untreated strip using Roundup PowerMax from different sources at two rates with and without surfactant to see if the injury could be duplicated. No injury symptoms or effect on alfalfa growth was observed in any of the plots during that later-spring trial.

This was a perplexing problem but at that point, was attributed to being an unexplainable single-year aberration. However, the same type of injury was observed again in the region during spring of 2015. Yield was monitored in three affected commercial RR alfalfa fields in the Scott Valley by harvesting treated and untreated areas with a plot harvester. In the most severely affected field, a first-cutting yield reduction of 0.8 tons per acre was observed; however, the alfalfa recovered by second cutting.

After considerable deliberation, the theory was developed that cold temperatures after an application of glyphosate was a key contributing factor. This could explain why some fields were affected and others were not, and why we did not observe any symptoms in the test plot that was conducted in 2014 in the untreated area of the field where injury was first detected. (No frosts occurred after the late date when the application was made in the test plot.)

Researching the Cause

These were field observations on farmer's fields, but could we repeat these results with a more controlled study with a scientific approach? A replicated field experiment was conducted in the spring of 2015 at the University of California Intermountain Research and Extension Center in Tulelake, California. Compared to Scott Valley, alfalfa growth in Tulelake typically is slower in the spring, and very late-spring frosts are more commonplace. Alfalfa was treated with 22 and 44 fluid ounces of Roundup PowerMax per acre, and fortunately followed by a cold weather system a few days later. A reduction in alfalfa height was observed as well as a yield reduction of 0.3 and 0.4 tons per acre for the 22- and 44-ounce rates of Roundup, respectively. Injury did not carry over into the second cutting.

An additional field trial was conducted during the summer of 2015 in the same commercial field that had significant injury in the spring. The same rates used in the spring trial in Tulelake were applied after first cutting to 6- to 8-inch-tall alfalfa in the commercial field. The plots were carefully inspected after the application. No injury symptoms were ever observed on the alfalfa and there was no difference in alfalfa yield with any of the treatments. These results again suggested that cold weather after application was required for injury to occur.

Fall 2015 Studies. Additional trials were conducted in the fall of 2015. While fall is not a time of year when growers ordinarily treat fields with Roundup, a frost sometime after application is virtually guaranteed, enabling us to further evaluate the theory that cold temperatures after application can result in injury. Alfalfa was treated on weekly intervals at the same rates as the studies mentioned above from mid-September through October. Cold temperatures followed within a week of these treatments and resulted in the same injury symptoms observed in the spring in some of the trials. These fall studies suggested that injury was related to the height of the alfalfa (taller alfalfa, around 10 inches, seemed to be more susceptible than shorter alfalfa), the age of the stand (older fields more susceptible than a field planted within a few months), and higher Roundup rates resulted in more injury.

Figure 1. *This Roundup Ready alfalfa test plot in the fall of 2015 shows a high rate of glyphosate injury in front of the research assistant, as compared with untreated plots to the sides and back.*

<u>Spring 2016 Studies.</u> To get a better handle on the conditions that lead to injury and to quantify the amount of injury, we conducted 16 field trials in the spring of 2016 in locations throughout the Intermountain area of Northern California (Scott Valley, Butte Valley, Tulelake and the Susanville area) and a trial in Christmas Valley in Central Oregon, managed by Mylen Bohle with Oregon State University. There were four different protocols for these trials with different levels of intensity but the objectives were similar: to better understand the conditions that lead to injury, and more specifically, to evaluate the effect of glyphosate rate and alfalfa growth stage at the time of application to develop recommendations on how to avoid potential injury.

The core set of treatments in the field trials included an untreated control, a standard herbicide treatment, and glyphosate (Roundup PowerMax) applied at 22 and 44 ounces of product per acre at specified alfalfa growth stages or on a weekly basis from March through April. The standard treatment was Sencor (metribuzin) plus Gramoxone (paraquat) at 0.67 pounds and 1 quart of product per acre, respectively. Raptor (imazamox) was used as the standard treatment in Christmas Valley, Oregon, because it was too late to use Sencor and Gramoxone when this trial was established. Temperature data loggers were installed at each site to record nighttime low temperatures at alfalfa canopy height.

Unfortunately, as is often the case with field research, a few of the trials were unsuccessful: severe hail storms at one site, significant alfalfa weevil infestation at others, and general field variability in some trials. However, reliable data was obtained from most of the trials. Injury symptoms were observed at all but one of the 16 trials. The trial where no injury was observed was the only new seeding field in the study. Because it was a new planting, its development lagged behind the other fields in the spring and therefore each growth stage treatment was applied somewhat later when temperatures were generally warmer. In addition, this location was the warmest of all the sites and the combination of being a warmer site and a new planting may explain the lack of symptoms.

The degree of injury varied somewhat by field, and in general related to the extent of cold temperatures after application. For the sites in the Scott Valley (Siskiyou County), the colder sites generally had more injury as did older stands compared to sites that were less cold or younger. Overall, the injury was not as severe as was seen the previous two years. This was likely due to a significantly wetter spring with mild nighttime temperatures for the first half of April (minimum temperatures for early April 2016 were nearly 13 degrees higher than in 2015).

Even with the more mild temperatures in 2016, alfalfa height at most sites was reduced slightly with the application of Roundup, with the 44 fl oz rate causing more stunting than the 22 fl oz rate. At the sites where yield data was collected, yield decline was typically 0.3 to 0.4 tons per acre for the 44 fl oz rate and 0.1 to 0.3 tons per acre for the 22 fl oz rate. Alfalfa that was taller at the time of treatment (8-10 inches) tended to have a greater yield reduction than when the alfalfa was shorter (4-5 inches) at application. However, some injury was still evident when alfalfa had 4 inches of growth at the time of treatment. In another trial with more treatment timings, an application was made to 2-inch tall alfalfa and this treatment did not have reduced 1st cutting yield.

One site had no statistical, or even a numerical difference, in yield between the untreated control and any of the glyphosate treatments regardless of application rate or timing. This was the coldest site of all and had low temperatures in the teens after some of the applications. This site also had four inches of snow within a month of harvest. While this site showed injury symptoms earlier in the season, it appears that frost injury caused by extremely low temperatures may mask the effects observed in other fields. At this very cold site, all the alfalfa, whether glyphosate treated or not, was equally injured.

Second cutting yield was also measured for most of the field sites where we harvested the first cutting. The alfalfa recovered at all sites and there was no yield difference on second cutting, which is in agreement with what was observed in 2015.

What the Injury Looks Like

After observing this phenomenon for a few years now in commercial fields and research plots, we have a good sense for the symptoms and when they appear after an application. Unlike typical herbicide injury symptoms, the injury observed after a glyphosate application and cold temperatures takes several weeks to appear. The earliest we have observed even the very initial symptoms is about a week after application. This was with a fall application. The earliest we have observed injury in the spring has been 10 days to 2 weeks after an application. An untrained eye would have difficulty picking up these very initial symptoms—individual stems that are slightly tipped over and wilted (Figure 2). Only scattered plants show symptoms and they are commonly an individual stem to a few stems per plant. Affected stems wilt at the tip and curl downward forming a shepherd's crook (Figure 3). Eventually, the leaves turn chlorotic and then gradually become necrotic and dry up and die (Figure 4). As alfalfa growth continues in the spring, these damaged stems can disappear in the canopy.

Alfalfa leaves on affected plants may look somewhat pinched or narrow and dull green rather than a lush vigorous bright green color. The plants appear less thrifty and are typically stunted (Figure 5). Most of these symptoms are not readily apparent until 3 weeks to a month after application unless you are familiar with the symptoms and know what to look for. The symptoms look essentially like frost damage, and if there is not an untreated area for comparison, they may be hard to discern.

The temperature that occurs after the application is believed to affect the severity of the symptoms—less injury after a mild frost, increasing injury with a frost in the mid-20's and, as noted above, very low temperatures may injure all the plants so severely that any additional injury related to a glyphosate application is not discernable. However, the specific thresholds (temperature, duration, and timing relative to treatment) are still not well understood.

Is Glyphosate Injury to RR Alfalfa Unique to the Intermountain Area of Northern California? Initial observations of injury were in Scott Valley, but our research has since shown that injury can occur in other locations in the Intermountain area of Northern California and Central Oregon. It has now been observed in commercial fields in these areas as well. It is not known how widespread the potential is for injury and additional research and field inspections are needed. It is feasible that injury also could occur in other alfalfa production regions with similar environmental conditions. Frost(s) after an application of glyphosate can occur in many alfalfa production regions; however, injury may be more likely in the

Intermountain area due to the erratic and often unpredictable springtime weather. Late spring frosts after alfalfa has "broken dormancy" in this region are commonplace as cold fronts move in off the Pacific Ocean and cold temperatures are common the first clear morning after a weather system passes. Other areas of the US may be colder over the winter, but once spring comes, temperatures rise on a more even upward trajectory.

Avoiding Injury and Achieving Effective Weed Control

Early application timing is the key to avoid the possibility of injury. Glyphosate is a highly effective postemergence herbicide without appreciable pre-emergence activity. Therefore, when used alone, glyphosate is usually one of the last applications made for winter annual weed control when producers/applicators likely have multiple fields to treat. Growers who use soil-residual herbicides (alone or in combination with paraquat) typically make these applications earlier in the winter or spring and then RR fields are treated with glyphosate later. The advantages of this timing strategy are twofold: it ensures weed emergence prior to the herbicide application and it extends the herbicide application window, which may be desirable when multiple fields need to be treated. In some areas, applications have been made to alfalfa 6 inches or taller. This extended window for herbicide application helps applicators dodge inclement weather and allows fields to be retreated later in the season if there are any weed escapes.

In light of these research results, however, growers are encouraged to make applications when alfalfa regrowth in spring is 2 inches or less in areas with spring environmental conditions conducive to injury. This timing is similar to other postemergence herbicides in alfalfa that also have a spring growth restriction, such as Gramoxone. Applying glyphosate to 2-inch tall alfalfa also helps ensure effective weed control because the weeds at this time are typically smaller and easier to control. This application timing is also compatible for tank mixes with soil residual herbicides which often must be applied before the alfalfa has 2 inches of spring growth. Tank mixing with a soil-active herbicide is an effective practice to help avoid the evolution of glyphosate-resistant weeds. However, if glyphosate is used alone and the application is made too early, especially to a "weak" stand, subsequent weed emergence may be a concern.

A logical question relates to the interval between an application and a frost event. Specifically: *How long should the interval be between a glyphosate application and a frost event to avoid the possibility of injury?* If we knew how long that interval was, perhaps a later application would be feasible if one was confident there wouldn't be a frost for a given time period. However, the specific parameters such as time-to-frost, degree of cold temperature, and duration of cold exposure are not well understood at this time. This has been challenging to answer with field research because the timing or severity of a frost cannot be controlled. There is more control in a greenhouse or laboratory study, but it has proven extremely difficult to duplicate field conditions, especially using older alfalfa plants. Because we do not know the required time interval between an application and cold temperatures to avoid injury, it is best to apply early (before alfalfa has 2 inches of spring growth) to be safe. Cold weather fronts and spring frost events are too difficult to predict to have confidence in many areas that a frost will not occur after an application, so the safest strategy in frost-prone areas is to adhere to the recommendation of a 2-inch spring growth cutoff.

The glyphosate application rate also affects injury. We have consistently seen more injury with the 44 fl oz rate of Roundup PowerMax than with the 22 fl oz rate. The maximum label rate per application of 44 fl oz of Roundup PowerMax (or equivalent rate for other glyphosate formulations) is not needed for most annual weeds, especially if they are treated when the alfalfa only has 2 inches of spring growth and the weeds are small. Therefore, for locations prone to late spring frosts, the maximum single application rate is generally not recommended.

Current Research Effort

We are currently conducting extensive research to better understand the actual mechanism for injury. This is important because knowing the underlying cause of these symptoms can help toward further development of recommended management practices to avoid or minimize injury. We have theories as to the cause of injury, but additional investigation is definitely needed to prove or disprove existing theories.

Top left: Figure 2. Individual wilted stems that are tipped over are the first indication of injury.

Top Right: Figure 3. Stems wilt at the tip and curl downward forming a shepherd's crook.

Bottom Right: Figure 4. Affected Stems eventually dry up and leaves turn necrotic.

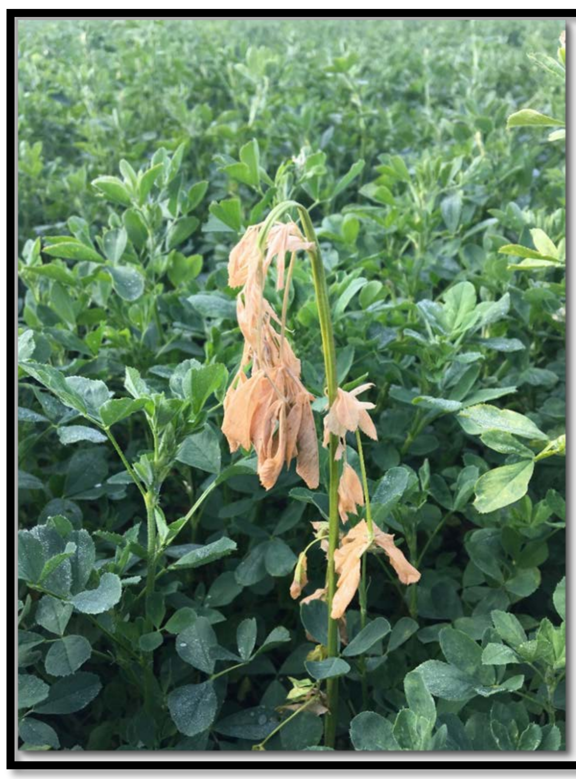

Figure 5: Untreated plot on the left and glyphosate treated on the right. Note the chlorotic plant in the middle of the treated alfalfa photo and wilted stems to the right of this plant and in the top left corner.

Stage One Juniper Control with Various Physical and Chemical Techniques

Introduction: Juniper is a native tree species which has been expanding outside of its historical range encroaching on other ecotypes. Fire suppression practices throughout the 20th and 21st century have created favorable conditions for juniper establishment. Once juniper has become established wildfires may burn hotter consuming desirable woody species such as sagebrush, additionally creating an environment which can favor invasive annual grasses. Reduction of sagebrush, and increased invasive annual grass populations can both degrade sage grouse habitat. When juniper trees are small, control efforts can be more economical as there is less woody biomass to deal with. This trial set out to assess what control methods are most effective, and the most economical for landowners to peruse. The experiment evaluated multiple chemical and physical control techniques including burning, lopping, hack and squirt, and Ezject herbicide applications.

Study Investigators: David Lile, Laura Snell, Janyne Little and Tom Getts

Cooperators: Buck Parks, Billy Flournoy, John Flournoy

Study Design: Application of control treatments were made March 4th 2106. Trees ranged in size from 2-7 feet in height and 1-4 inches in diameter at ground level. Individual trees were considered replications. At least 25 trees were selected for each treatment at each site; except the Milestone and Method hack and squirt treatments, which were only tested on 10 trees at both sites.

Treatment methods: Lopping was conducted with hand shears near the soil surface. A propane burner was used to torch the base of the tree, all the way around the trunk. One Imazapyr Ezject cartridges was injected for trees smaller than 2.5 inches in diameter, where multiple shells were used on larger trees. Hack and squirt treatments included one cut to the base of the trunk with a hatchet. Glyphosate treatments received 3 ml of undiluted herbicide, milestone and method treatments each received one ml of undiluted herbicide per tree.

Data Collected: Mortality of the trees and percent of dead foliage was assessed November 23rd 2016. Treatment application time was recorded to determine labor involved.

Results: Numerically lopping was the most effective treatment (Figure one). No trees showed growth at the Adin site, where only 20% assessed had some shoots growing at the Likely site. However, because some of the trees regrew at the Likely site, this indicates lopping could still require additional follow up monitoring and treatment. Propane burning resulted in 60% mortality of the juniper at both sites. On average burning resulted in 75% of the foliage becoming necrotic (Figure 2). Some of the propane treated trees may have suffered higher mortality with more time under the flame. Typically, lower foliage of the burned tree would be dead where the terminal leader would be alive. Herbicide treatments were largely ineffective, with only a small percentage of trees experiencing mortality. Throughout herbicide treatments, terminal leaders were often dead, but portions of the foliage was alive. Hack and Squirt herbicide treatments may have been more effective, if multiple cuts were made to the stems.

Lopping, the most effective treatment took the most time per tree at nearly 40 seconds, where hack and squirt treatments were the fastest at 26 seconds (Figure 3).

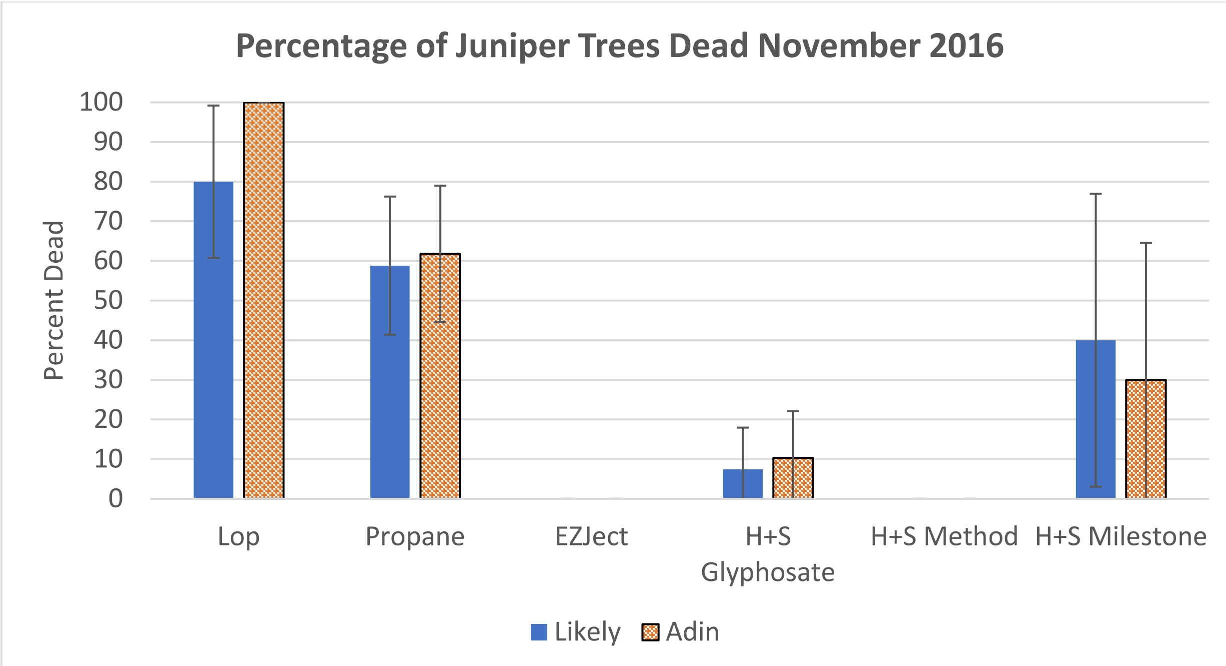

Figure one: Shows the percent of trees dead nine months after treatment in November of 2016. Blue columns represent the Likely site, and checkered columns represent the Adin site. Error bars indicate 95% confidence intervals.

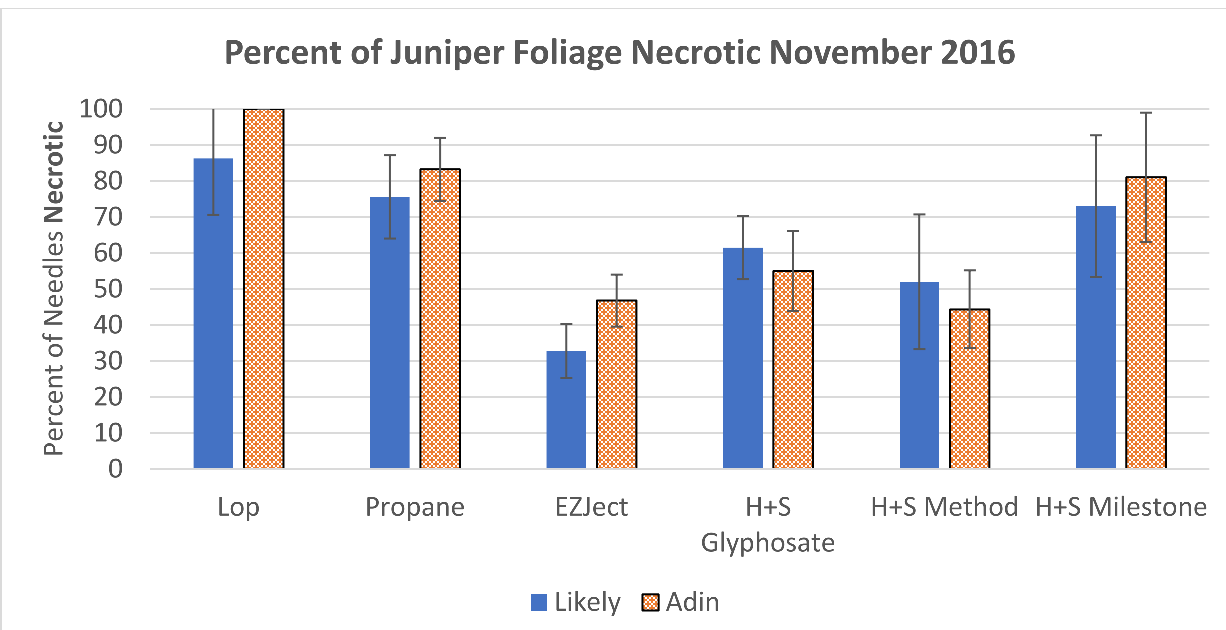

Figure two: Displays the average percentage of necrotic tissue for each juniper. Blue columns represent the Likely site, and checkered columns represent the Adin site. Error bars indicate 95% confidence intervals.

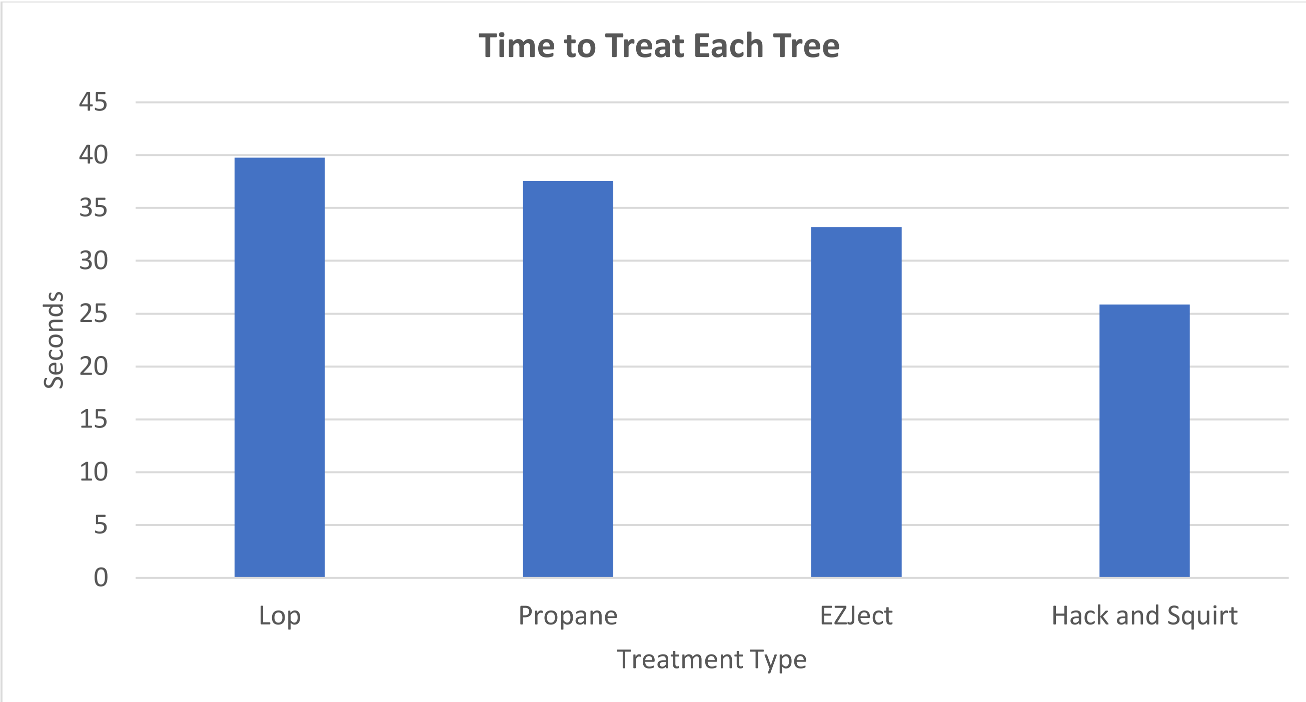

Figure 3. Displays the average time to treat each tree by application method in seconds.

Picture One: Lopped Tree with some regrowth.

(Left) Picture two: Tree treated with propane burner, terminal leader alive.

(Below) Picture Three: Glyphosate Hack and Squirt treatment, two branches alive

Medusahead Control and Perennial Grass Seeding

Introduction: Medusahead is an invasive winter annual grass which can form monocultures on rangelands throughout California, Oregon, Washington and Idaho. In Northeastern California, medusahead is highly competitive on heavy clay, shrink swell soils. Medusahead forms a thick thatch layer and achieving control can be difficult. After controlling monocultures of invasive species, seeding desirable species is often needed to shift the plant community. This study set out to test spring applications of Esplanade and various other herbicides for medusahead control. All herbicides were tank mixed with Accord (glyphosate) to control the medusahead which was already emerged. Eight perennial grass species will be planted within the plots in the spring of 2017, to assess their tolerance to the herbicide residues, and potential to become established.

Study Investigators: Tom Getts, Laura Snell and Rob Wilson

Cooperators: Buck Parks and Herb Jasper

Study Design: Herbicides applied to 10 x 20 ft. plots replicated four times in a randomized complete block design, at two study sites. Applications were made with 110 02 flat fan nozzles at 20 gal/acre and all treatments included a 0.25% NIS v/v. Eight perennial grass species will be planted within herbicide treatments.

Applications: Initial applications made on March 17th outside of Adin and March 19th outside of Goose Lake. Medusahead plants were 1-3 inches tall with 2-3 leaves. Accord XRT 2 (glyphosate) was included in all tank mixes to control actively growing medusahead. (*In the Accord XRT 2 only plot, an additional application was made on April 18th for a total of 32 fl oz/acre applied.) Control was not effective from initial Accord XRT 2 applications throughout the study, and all plots (besides the untreated) were retreated with Accord XRT 2 on May 13th.

Site conditions: Both sites had clay soils with dense medusahead infestations.

Data Collected and Results: Visual control evaluations were assessed on May 12th. These evaluations indicated good control for some of the herbicide treatments (Figure one). (Panoramic 12 oz., and Esplanade+Method combinations). Other herbicide treatments had relatively poor control. Previous research indicated 12-16 oz/acre of formulated glyphosate would effectively control emerged medusahead. None of the treatments provided 100% control possibly because of a thick litter layer. In May, an additional application of glyphosate was made in all plots to control escaped medusahead and eliminate seed production in 2016 (except within the untreated check).

Visual control evaluations were made again in October to assess broadleaf/forb plant populations before medusahead germinated (Figure two). Adin only had one species of broadleaf plant growing, prickly lettuce, in very low numbers throughout the study. Goose Lake had a considerably higher population of broadleaf plants growing throughout the study. Figure three shows the breakdown of major broadleaf plants at Goose Lake by species, with the highest number of broadleaf plants growing in Esplanade plots.

In November, after the medusahead had germinated, visual assessment of medusahead control was collected. Greater than 90% control was achieved in all plots containing Esplanade (Figure four). Only 12 oz. of Panoramic at the Adin site resulted in at least 90% control. The 14 oz/acre rate of Milestone resulted in less than 80% control at both study sites. Both application rates of Method (alone) resulted in less than 72% control at both sites. Multiple applications of Accord XRT 2 numerically provided the least amount of control compared to other treatments. At both sites there was a significant amount of bare ground (Figure five). Herbicide treatments with greater medusahead control, generally resulted in more bare ground.

Future actions: Sherman big bluegrass, blue bunch wheatgrass, hycrest wheatgrass, western wheatgrass, intermediate wheatgrass, Russian wildrye, Great Basin wildrye and squirreltail will be drill seeded in spring of 2017. Future assessment of medusahead control and perennial grass establishment will be made throughout the next two growing seasons.

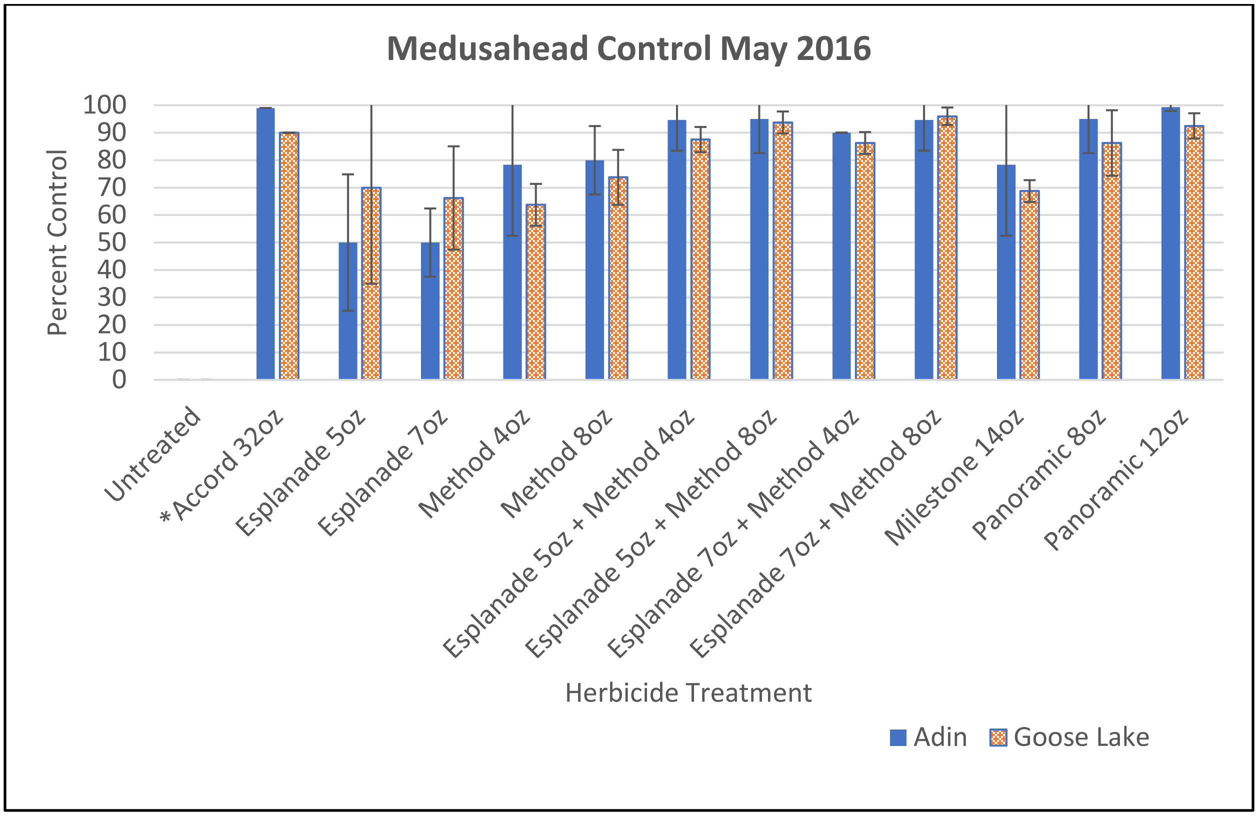

Figure one: Medusahead visual control assessment May 12, 2016. Treatments are in oz product/acre. Error bars indicate 95% confidence intervals. (*Split application- two applications of 16 fl oz/acre for a total of 32 fl oz/acre)

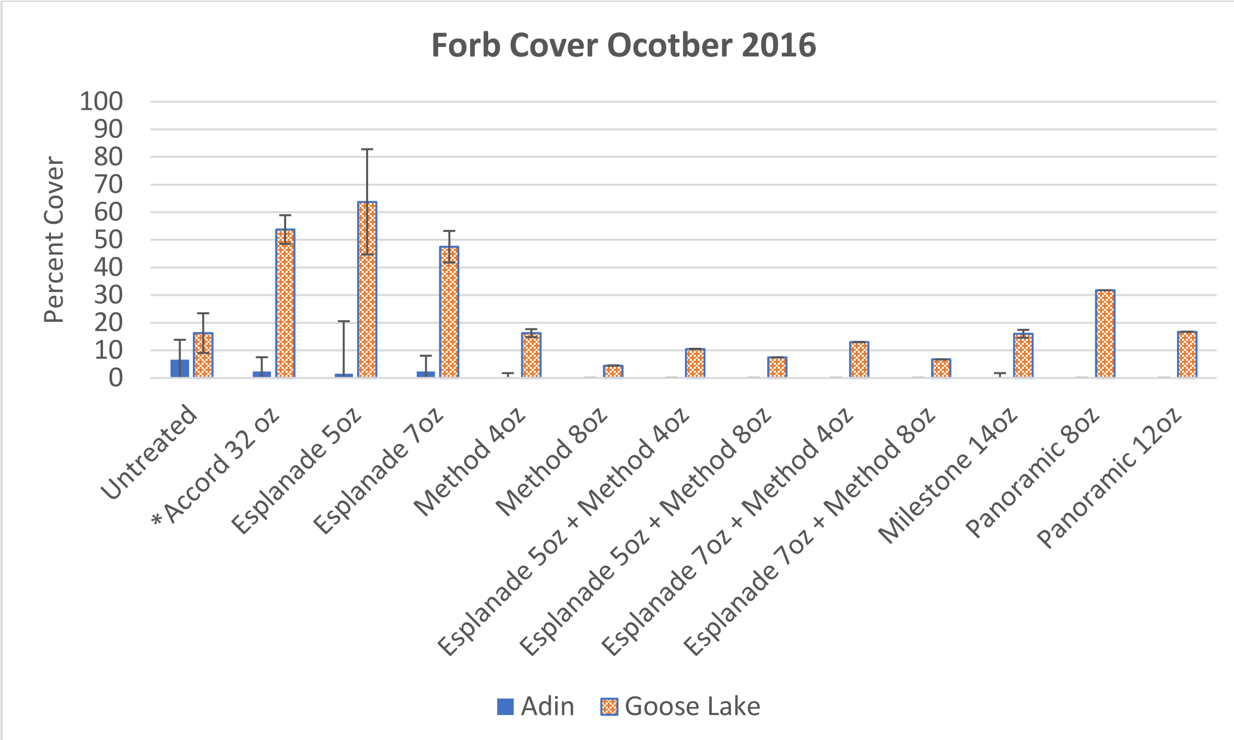

Figure two: Visual assessment of forb cover at both sites in October of 2016. Treatments are in oz product/acre. Error bars indicate 95% confidence intervals. (*Split application- two applications of 16 fl oz/acre for a total of 32 fl oz/acre)

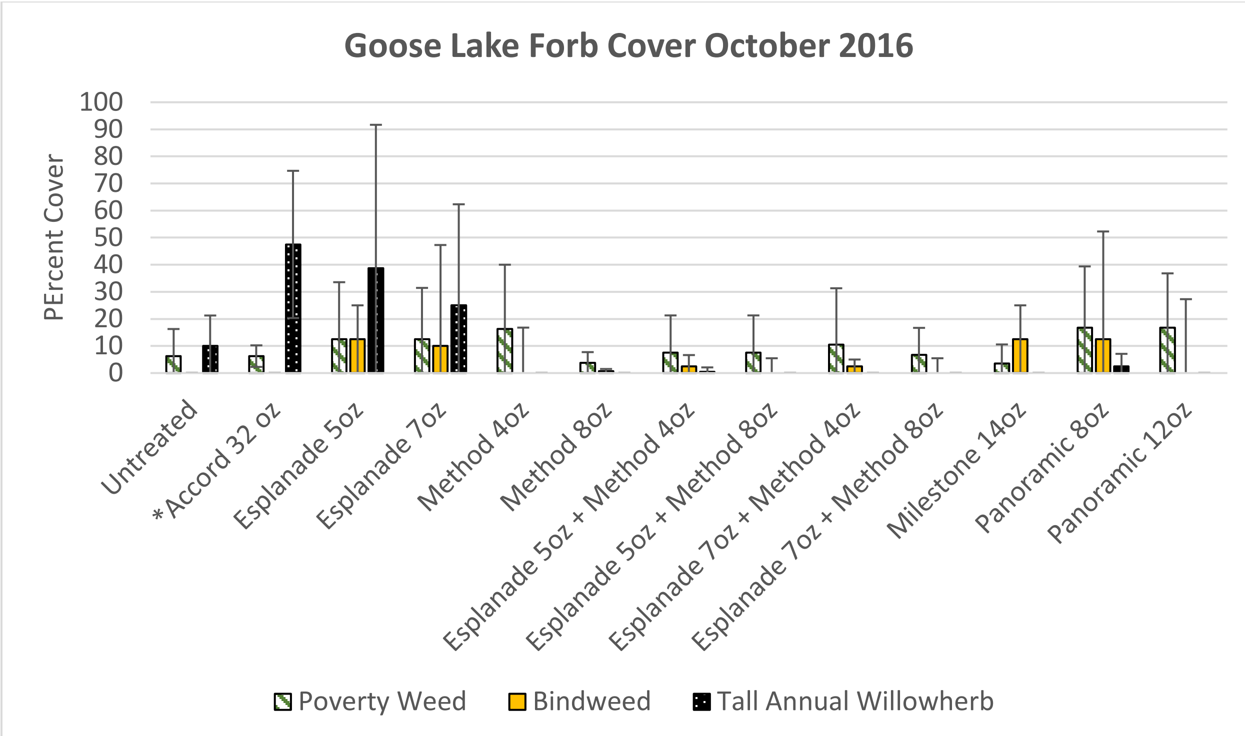

Figure three: Visual assessment of forb cover in October of 2016. Treatments are in oz product/acre. Error bars indicate 95% confidence intervals. (*Split application- two applications of 16 fl oz/acre for a total of 32 fl oz/acre)

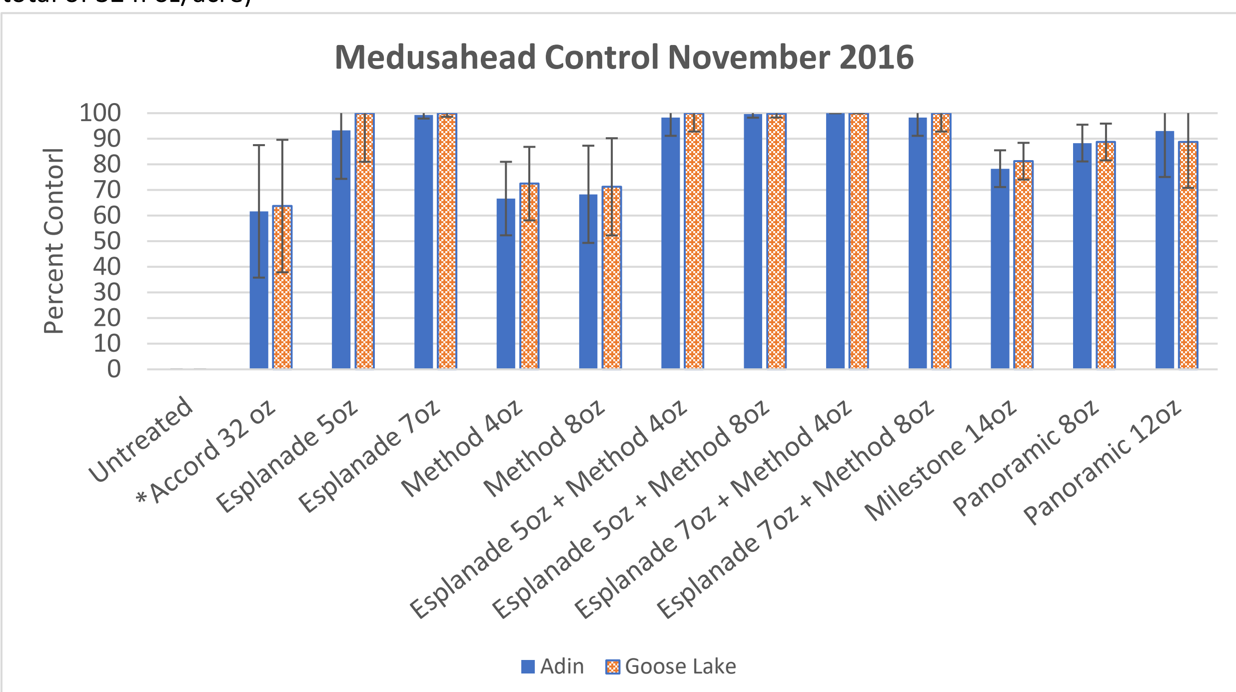

Figure four: Medusahead visual control assessment November of 2016. Plants were in the 2-3 leaf stage. Treatments are in oz product/acre. Error bars indicate 95% confidence intervals. (*Split application- two applications of 16 fl oz/acre for a total of 32 fl oz/acre)

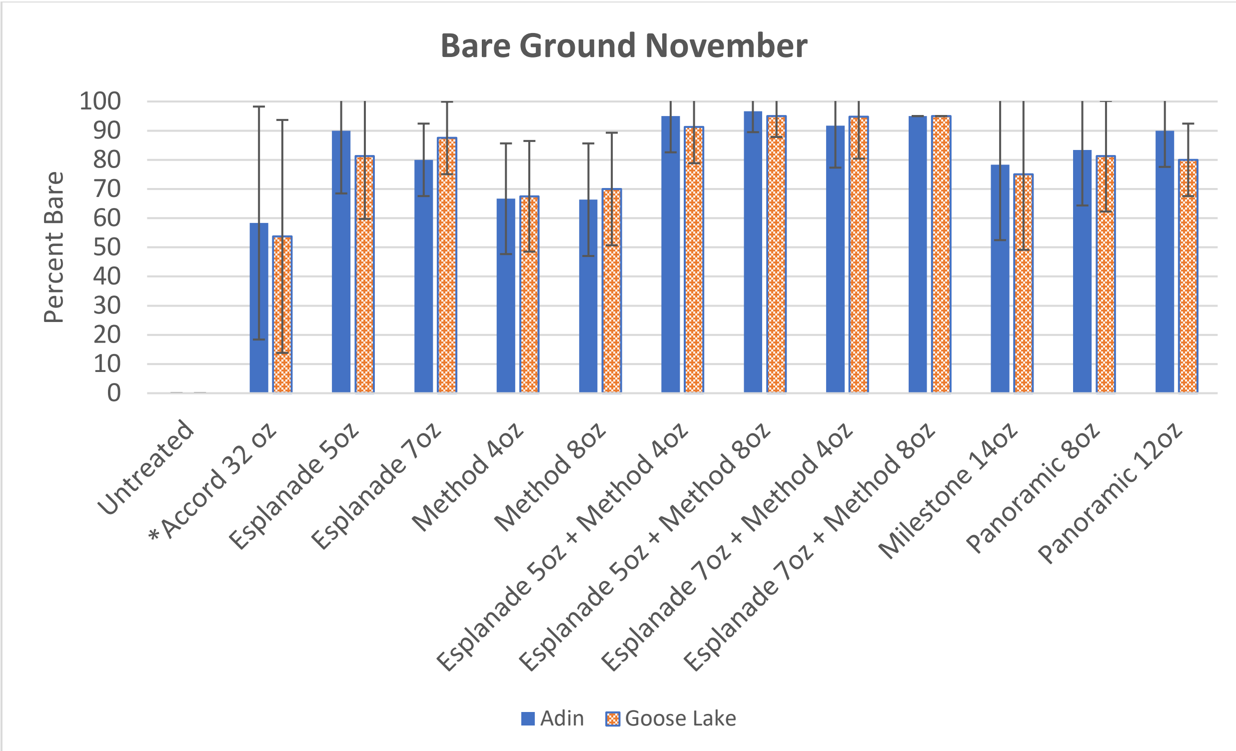

Figure five: Bare ground assessment November of 2016. Treatments are in oz product/acre. Error bars indicate 95% confidence intervals. (*Split application- two applications of 16 fl oz/acre for a total of 32 fl oz/acre)

Pictures

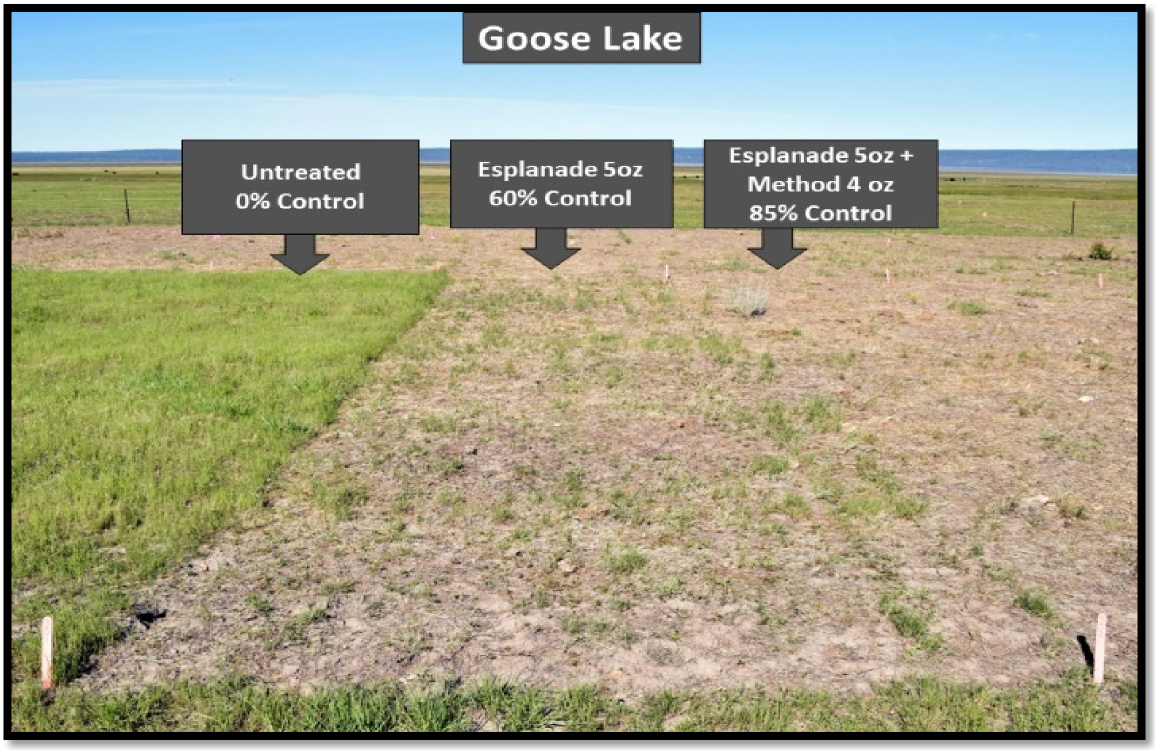

Photo one: Goose Lake site in May.

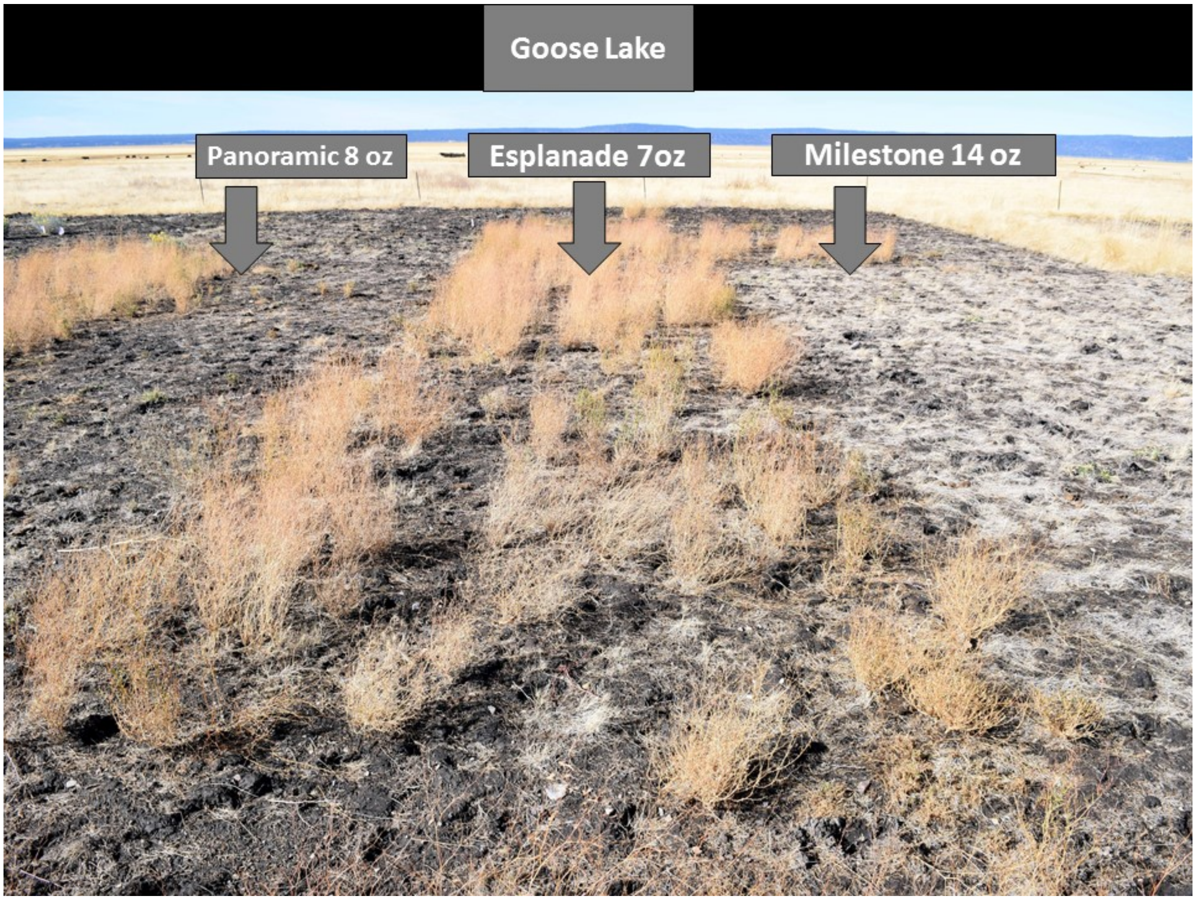

Photo two: Goose Lake site in October.

Photo three: Adin site in November.

Medusahead Control with Preemergent Herbicide Applications

Introduction: Medusahead is an invasive winter annual grass which accumulates silica and does not provide quality forage for livestock. There are limited control options which are effective in the Intermountain Region of California. Fire and application of Milestone (aminopyralid) have been shown to work well in lower elevations. Fire, in combination with Panoramic (imazapic) and seeding, has been shown to work well in other states. However, Panoramic is not registered in California, and cannot be used or purchased in the state. Esplanade (indaziflam) has been shown to control cheatgrass for three years with a single application in Colorado. Some of these experiments in Colorado did nothing to remove the litter layer left behind, and still achieved good control with cheatgrass. This study was set up to assess pre-emergent control of medusahead using Esplanade, Milestone, Method and Panoramic.

Study Investigators: Tom Getts, Laura Snell and Rob Wilson

Cooperators: John Flournoy and Herb Jasper

Date of herbicide applications: Willow Creek Ranch applications were made September 8th at 9:30 am at 64 deg. F with 35% RH and 3 mph west wind. Likely site applications were made September 13th at 9:00 am at 51 deg. F with 40% RH and 1.25 mph north wind. Applications were made on top of litter layer from previous growing season. No medusahead had germinated at time of application. All treatments included a 0.25% NIS v/v, and were applied with a CO2 pressurized backpack sprayer at 20 gal/acre with 110 02 flat fan nozzles.

Study design: Four replications of 10 x 20 ft. plots laid out in a randomized complete block design at both study sites. Method and Esplanade currently do not have a grazing label, so sites were fenced.

Plant community: Both sites were heavily dominated with medusahead, with small populations of cheatgrass and North African wiregrass. At the Likely site there were populations of various perennial bunchgrasses present. At the Willow Creek site, bulbous bluegrass and tall wheatgrass could be found in the plots.

Data collected: Visual evaluation of medusahead control was conducted in November of 2016 after germination occurred. Plants were in the 1-3 leaf growth stage.

Results: Control was variable at both sites and across replications, and in areas of thicker litter there appeared to be more medusahead growing. Initial results indicated some medusahead control with all treatments that included Esplanade (Figure one). However, control was poor, with no more than a maximum of 80% control. Other treatments, Panoramic, Method and Milestone (even the 14 oz/acre rate) on average offered less than 30% control. Plots will continue to be monitored throughout 2017 and 2018.

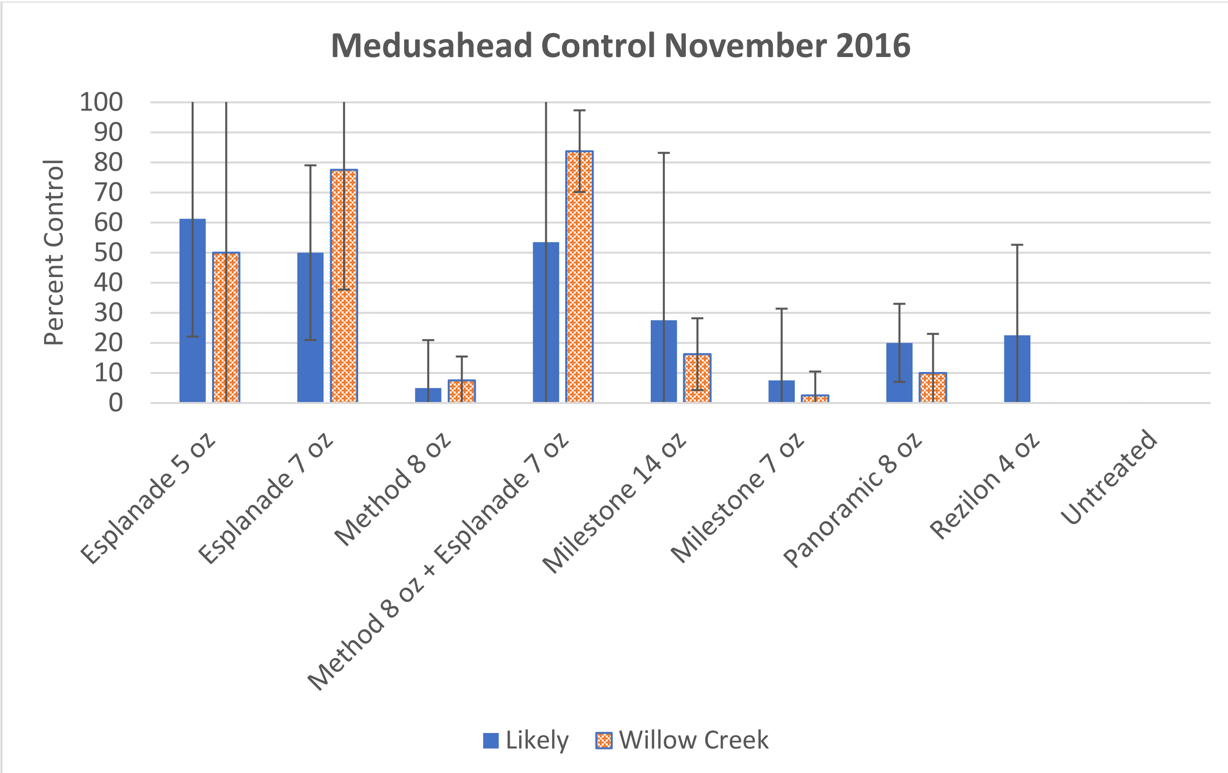

Figure one: Assessment of medusahead control November 2016. Treatments are expressed in in oz product/acre. Blue columns indicate the Likely site and checkered columns indicate the Willow Creek site. Error bars indicate 95% confidence intervals.

Fall Applications to Tall Whitetop

Research has shown tall whitetop is most effectively controlled with herbicide applications at the bud stage. Other perennial species are effectively controlled by herbicide applications in the late fall. These late fall applications are effective with herbicides which have soil residual activity, and in areas where organic matter is relatively low. Developing root buds of some perennial weeds are able to absorb herbicide at this time. A trial was implemented to test some late fall Telar applications to tall whitetop out at the Honey Lake State Wildlife area. Two sites were selected, one with a dense stand of tall whitetop stalks, and one with a thin stand of tall whitetop stalks from the previous growing season.

The study was inconclusive. When the plots were visited in the spring, plant growth was inconsistent within the plots at both sites. Many of the untreated plots did not have plants growing within them, and likewise many of the plots which received herbicide application had plants growing within them. Because of these inconsistencies, the study was monitored but abandoned. However, as areas that received herbicide application did have actively growing plants, this indicates that a fall application was not effective at these sites.

Interestingly, much of the tall whitetop surrounding the study site was stunted and showing injury symptoms. An overall stand reduction seemed apparent outside of the plots. Many of the plants had insect damage on the leaves and to the stem. Stems had been bored into, by what is suspected to be a stem boring weevil. However, at other places around the valley pepperweed was found with similar holes in the stems from a stem boring insect, and no stand decline. Another possibility which caused the pepperweed stand to decline is a drop in water table. Before the study was implemented there had been numerous years of drought, which potentially could have taken a toll on the perennial plant. Another possibility is that the stand may have been treated with herbicides previously. When locating the site, there was no record of recent herbicide application, but Telar in dry conditions can have soil residual activity for years.

Applications Made: November 20th 3:45 pm. 57 deg F, 41% RH, wind 3mph.

Cooperator: Pam Cherney Honey Lake State Wildlife Area

Picture of thick tall whitetop site. The thick litter layer from the previous year’s growth are the grey stems. Patchy stunted tall whitetop within the plots.

Other ongoing studies implemented- results coming soon

Tall Whitetop Control with Drizzle Applications

Tall Whitetop is a tough-to-control perennial weed with deep roots. Previous research has shown a combination of physical methods with application of herbicides at the bud stage can be effective. This study set out to test the drizzle method of herbicide application for tall whitetop.

The drizzle method was developed in Hawaii to treat weeds quickly and economically, and has been shown to be effective on other perennial weeds. It involves applying herbicide at a very low application volume of 2-5 gallons per acre. Typical tractor or ATV applications apply herbicides anywhere from 10 to 20 gallons per acre. Backpack herbicide application volumes typically range from 20 gallons to over 100 gallons per acre. This means that small backpacks and spray tanks need to be refilled frequently. If effective, the drizzle method would require fewer fill ups. Additionally, low application volumes of systemic herbicides like glyphosate have been shown to be more effective than higher application volumes applied to perennial weeds such as bindweed. This study set out to test if the drizzle method offers good control of tall whitetop. Specifically, to investigate certain herbicide combinations which are labeled for use around waterways.

Cooperator: Craig Hemphill

Scotch Thistle Control with Aminocyclopyrachlor

Scotch thistle is a very difficult-to-control biannual (sometimes annual or perennial) weed species which is problematic in pastures, rangeland and field edges. Long soil seed life makes this thistle species very difficult to control. Research has shown that applications made at the rosette stage of the plants life cycle are much more effective than application made to bolting plants. Applications are sometimes made to fall rosettes, however, most research has focused on the spring rosette application. This study set out to test various herbicides which have long soil residual activity for fall, spring, and summer, application time points. Results will be collected and reported over the coming years.

Cooperators: Marty Svendsen and Ed Svendsen.