USING POST-EMERGENT HERBICIDES TO CONTROL THE COOL SEASON INVASIVE PERENNIAL *AMELICHLOA CLANDESTINE*

A Thesis

Presented to the

Faculty of College of Graduates Studies and Research

Angelo State University

In Partial Fulfillment of the

Requirements for the Degree

MASTER OF SCIENCE

by

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December 2018

Major: Animal Science

USING POST-EMERGENT HERBICIDES TO CONTROL THE COOL SEASON

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ABSTRACT

Mexican needlegrass is an invasive cool season perennial grass that has formed a dense monoculture in Concho County, Texas. Once established, Mexican needlegrass is difficult to manage because it's drought hardy and can survive in multiple soil types. Management strategies for Mexican needlegrass in Texas are not well known. Three herbicide treatments, Pastora, Esplanade, Roundup, and a control, were applied in February with three replications per treatment in order to test the efficacy of herbicides and to monitor species composition changes after the control of Mexican needlegrass. Applications of Roundup and Esplanade resulted initial topkill of Mexican needlegrass, but resprouting occurred on several plants 7 months after spraying. There was a trend that Roundup had higher mortality rates compared to Esplanade and Pastora. All herbicide treatments reduced above ground forage production of Mexican needlegrass. Above ground forage production of Texas wintergrass and warm season grasses increased after herbicide applications.

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INTRODUCTION

Controlling the spread of invasive plant species is a continuous problem on many rangelands (Whisenant 1999). The introduction of invasive species can occur through wind dispersal, water dispersal, birds, grazing or browsing, and natural plant encroachment. Non-natural means of introduction can be from soil disturbances such as roadwork, pipeline digging, and top soil removal. Some seed mixtures for planting may accidently contain unwanted species.

Invasive plants can have a negative impact on the natural ecosystems because of their ability to out-compete native plants, avoid herbivory, or their adaptability to various habitats (Kettenring and Adams 2011). Once invasive grasses are established, it can become an ongoing expensive endeavor to manage or eradicate the plant. Perhaps the best option for controlling invasive plants is to identify the problem early before the plant has the chance to become well established. The difficulties with managing an invasive plant early is correctly identifying the plant and knowing how the plant responds to different control treatments. In this study the focus is on an invasive grass species in Concho County, Texas.

Mexican needlegrass (*Amelichloa clandestine* [Hack.]) or (*Achnatherum clandestinum* [Hack.] Barkworth) is native to northern Mexico to Colombia. Another common name known for Mexican needlegrass is Mexican ricegrass. Mexican needlegrass had a former botanical name, *Stipa clandestine* (Hack.), that still may be used in nurseries and online sales.

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In California, Mexican needlegrass is almost undistinguishable from *Amelichloa brachychaeta* (Godr.) Arriaga & Barkworth. In addition, many landowners may confuse Mexican with the desirable cool season perennial grass Texas wintergrass (*Nassella leucotricha* [Trin. & Rupr.] Pohl).

The use of Mexican needlegrass as an ornamental grass is popular. It is an attractive drought hardy species that can survive and thrive in multiple soil types. Mexican needlegrass is a cool season perennial grass that sprouts a silver inflorescence in late spring, goes dormant and turns a dark green in the summer (or hotter months), and has a bright green flush of growth in winter and early spring (Texas Invasives). The grass readily re-seeds and produces several small seeds that can easily be picked up and carried by animals or long distances by wind. In addition to the seeds on the panicles, there are hidden seeds in the basal leaf sheaths (Russell and Rector 2017). Even though Mexican needlegrass is a hardy low maintenance grass, it has been noted that Mexican needlegrass does not fare well in soils that receive annual rainfall exceeding 125 cm. In addition, it also does not grow well in cooler climates with soils that are not well drained.

Management strategies for Mexican needlegrass in Texas are unknown. With the recent discovery of the plant in Concho County it is important to assess several management strategies to slow or stop further encroachment. In Texas, cattle and goats will consume Mexican needlegrass but deer rarely consume it. For this experiment, three herbicides were compared for efficacy of control of the plant. The treatments are Pastora, Esplanade, Roundup, and a control. The active ingredient for Pastora is Nicosulfuron. Roundup’s active ingredient is Glyphosate. Esplanade consists of Glyphosate, Indaziflam, and Diquat dibromide. All three herbicides are nonselective post-emergent weed killers designed for broadleaf weeds and grassy weeds. Esplanade apparently has some pre-emergent properties as well, while Roundup and Pastora, are strictly post-emergent herbicides. Pastora is different than Roundup because it is a granule herbicide. The treatments were applied in February when a majority of non-target species were dormant. The efficacy of each treatment was measured and recorded.

OBJECTIVE

The objectives of the study were to determine the efficacy of herbicides, Pastora, Esplanade, or Roundup, in controlling Mexican needlegrass and to monitor species composition changes after treatment.

LITERATURE REVIEW

There is little available information on how to manage Mexican needlegrass, and no information was available on how to control the species. Indeed, the species is often confused with other ornamental cool season perennials including Mexican feathergrass (*Nassella tenuissima* [Trin.] Barkworth). This species is very similar to Mexican needlegrass in that it is a popular ornamental grass that is drought hardy and readily reseeds forming dense monocultures (Blood 2006; Russell and Landers Jr. 2017). The countries of Australia and New Zealand have been working on eradicating and controlling Mexican feathergrass since the 1990s. The noxious weed was imported through international trade, more specifically from specialty nurseries in California, for the use in landscaping. Mexican feathergrass was imported to Australia from New Zealand and California before its potential as a problem species was realized. It has been estimated that Australia spends an excess of $3,300 million per year to control weeds (McLaren et al. (1999). Jacobs et al. (1998), noted that while it is important to identify how a problem species is introduced, it is more important to identify if a weed has already been naturalized and to remove plants from propagation, sale, and cultivation.

Australia has taken several measures to prevent the further naturalization of Mexican feathergrass. The country has banned the import and sales of Mexican feathergrass. Initially, Mexican feathergrass was promoted for rock gardens, natural prairie gardens, and low water maintenance gardens. This is no longer the case. In fact, it is now illegal to sell the plant for ornamental purposes in many regions. Some state and territory government agencies offer rewards for any notifications leading to the removal of Mexican feathergrass. Agencies continuously share information about the plant trade with the public through media coverage.

They share information on weeds that have been declared invasive under legislation and also include weeds that have not yet been declared as a preventative measure. Media coverage over weeds has resulted in reports to weed agencies from the public. Partnerships with the horticultural media and the public have made a difference in the prevention and removal of Mexican feathergrass in Australia.

Besides media awareness, active management strategies are also taken. Depending on the situation, plants were removed by herbicides, individual plant removal, and rock removal. Afforestation is another approach sometimes taken by Australia in the management of invasive grasses in grasslands. It has been recommended by Jacobs et al. (1998) that experienced Weeds Officers should be trained to identify the differences between Mexican feathergrass and other cool season species.

The invasion of Mexican needlegrass in west central Texas remains in its infancy. Based on observations by landowners and others, it is clear that the species is spreading quickly. Once effective methods of control have been identified, other steps similar to those in Australia may be necessary to effectively control the spread of the species.

METHODS

This study was conducted on the Denis Ranch, located 40.4 km from San Angelo, in Concho County. The site consisted of 51.9% Frio silty clay loam and 48.1% Nuvalde silty clay loam. Percent slopes ranged from 0 to 3 percent. Before invasion of Mexican needlegrass, the site was dominated be a mixture of warm season grasses.

Three herbicide treatments were applied to stands of Mexican needlegrass. The treatments were Pastora, Esplanade, Roundup, and a control (no herbicide use). All of the treatments were replicated three times (n = 3 x 4 = 12 plots). The plot sizes for each treatment were 15 m by 15 m. Herbicide spraying was applied in February of 2018. Spraying methods that were used are broadcast spraying and individual plant treatment (IPT).

Changes in species composition and percent canopy cover were determined using the line intercept method (Bonham 1989). A tape measure was placed from the northwest corner of each plot to the southeast corner. For plants intercepting the line, basal cover (cm) was recorded by species. Samples were collected initially and at 7 months post treatment. Promising results should have shown an increase in species composition and plant diversity within the treatment plots.

Changes in herbaceous above ground production were determined by clipping three 0.3 m^2 quadrats per plot initially, and at 7 months post treatment (Bonham 1989). Mortality rates of Mexican needlegrass were assessed by counting the number of live and dead plants per plot both initially and at 7 months. Comparisons were made between herbicide treatments to determine efficacy of control.

Data was analyzed using analysis of variance with herbicide treatment as the main effect and plots nested within treatments as replications. Day of collection (pre- vs post-treatment) served as a repeated measure. Means were separated using Tukey's protected LSD when $P \leq 0.05$. Data was analyzed using the statistical package JMP (SAS 2007).

RESULTS

Mortality rates of Mexican needlegrass were similar ($P > 0.05$) among treatments (Fig. 1). Mortality rates ranged from 28.2% for Roundup to 2.8% for Esplanade. Above ground primary-production of Mexican needlegrass was also similar for pre- to post-spray and for all treatments (treatment, time, and treatment by time interaction were similar, $P > 0.05$, Fig. 2). Variability was high for all treatments, resulting in a relatively high standard error and lack of statistical difference.

Based on Figure 2, there appeared to be a trend in reduction of above ground primary production following applications of Esplanade, Roundup, and Pastora. Thus, orthogonal contrasts were used to compare pre- and post-spraying above ground primary production separately for each treatment to identify any potential statistical difference. When pre- and post-spraying were compared for each treatment using orthogonal contrast, Esplanade, Roundup, and Pastora applications all decreased above ground primary-production of Mexican needlegrass (Table 1). Percent basal cover of Mexican needlegrass did not differ among treatments or across of time (Fig. 3).

Above ground primary-production of Texas wintergrass was similar for pre- to post spray for all treatments (treatment, time, and treatment by time interaction were similar, $P > 0.05$, Fig. 4). Variability was again relatively high resulting in a lack of statistical difference. When pre- and post-spraying data were compared for each treatment using orthogonal contrast, Esplanade, Roundup, and Pastora applications all increased above ground primary-production of Texas wintergrass (Table 2). Percent basal cover of Texas wintergrass was similar among treatments or across of time (Fig. 5).

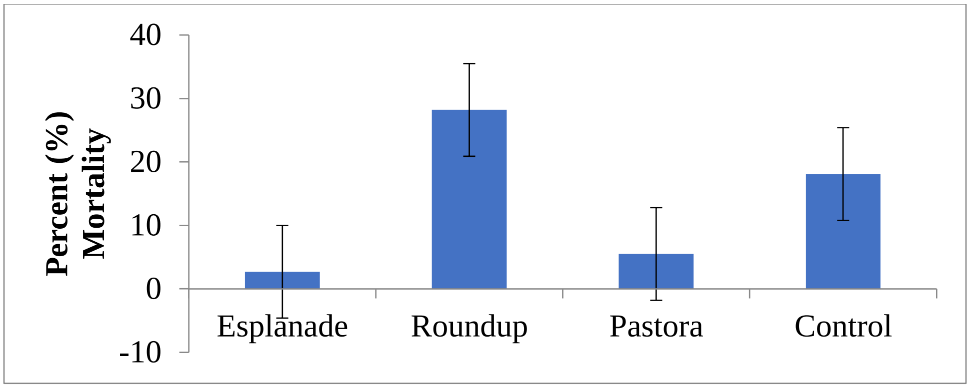

Figure 1. Percent (%) mortality of Mexican needlegrass following treatment with either Esplanade, Roundup, Pastora, or no herbicide application (control). Data was collected 7 months after spraying.

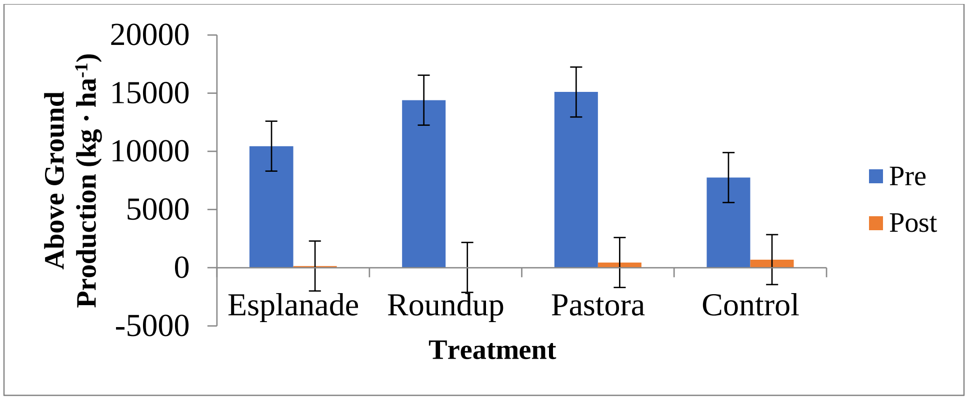

Figure 2. Above ground production (kg · ha^{-1}) of Mexican needlegrass for both pre- and post-treatment with Esplanade, Roundup, Pastora, or no herbicide application (control). Data was collected 7 months after spraying.

Table 1. Comparison of above ground production ($kg \cdot ha^{-1}$) of Mexican needlegrass following treatment with Esplanade, Roundup, Pastora, or no herbicide application (control). Pre- and post-treatment are compared for each herbicide application using orthogonal contrast.

Treatment	Pre	Post	SEM	P-value
Esplanade	10,450^a	150^b	2124	0.03
Roundup	14,440^a	30^b	2019	0.01
Pastora	15,100^a	450^b	2181	0.01
Control	7750	700	2253	0.09

$^{a-b}$Means within rows with different superscripts differ ($P < 0.05$).

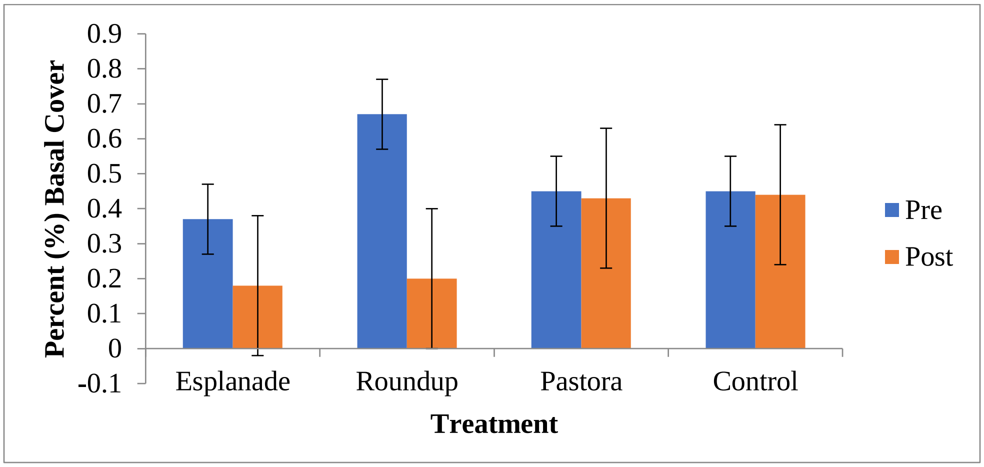

Figure 3. Percent (%) basal cover of Mexican needlegrass for both pre- and post-treatment with Esplanade, Roundup, Pastora, or no herbicide application (control). Data was collected 7 months after spraying.

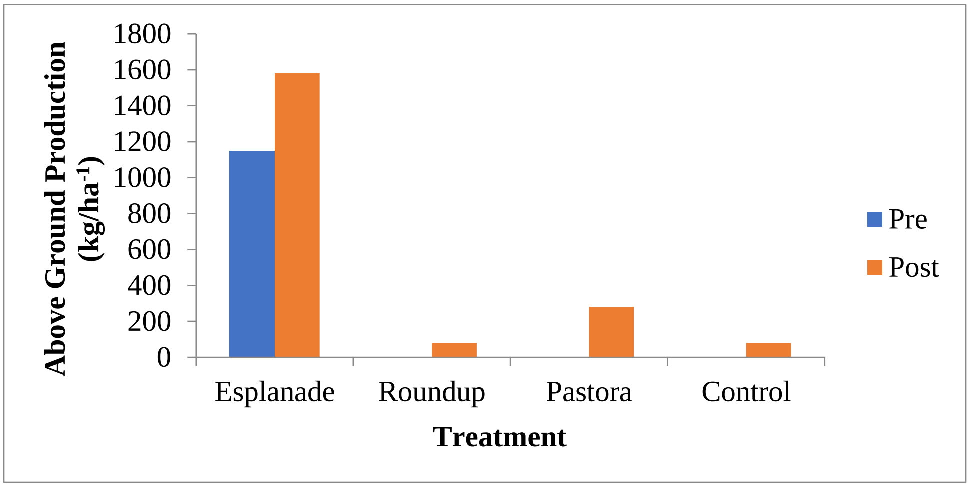

Figure 4. Above ground production (kg · ha^{-1}) of Texas wintergrass for both pre- and post-treatment with Esplanade, Roundup, Pastora, or no herbicide application (control). Data was collected 7 months after spraying.

Table 2. Comparison of above ground production (kg · ha^{-1}) of Texas wintergrass following treatment with Esplanade, Roundup, Pastora, or no herbicide application (control). Pre- and post-treatment are compared for each herbicide application using orthogonal contrast.

Treatment	**Pre**	**Post**	**SEM**	**P-value**
Esplanade	1,150	1,580	970	0.8
Roundup	0a	80b	14	0.02
Pastora	0	280	86	0.08
Control	0a	80b	14	0.02

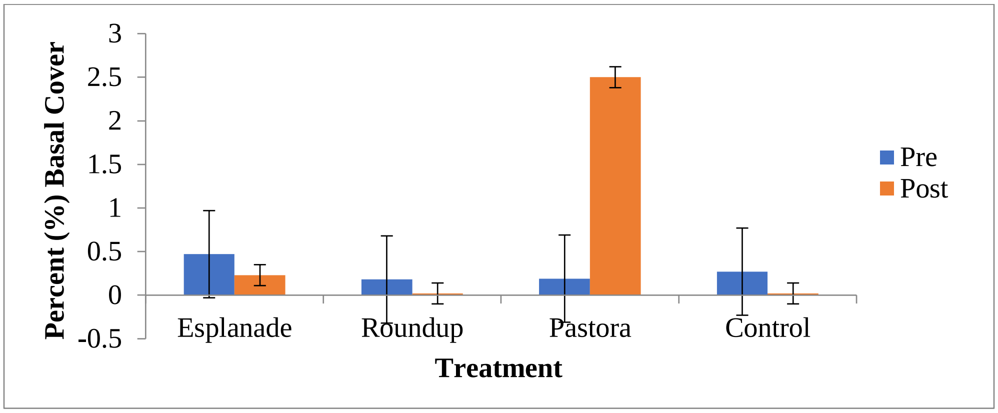

Figure 5. Percent (%) basal cover of Texas wintergrass for both pre- and post-treatment with Esplanade, Roundup, Pastora, or no herbicide application (control). Data was collected 7 months after spraying.

Above ground primary-production for warm season grasses was similar for pre- to post-spray for all treatments (treatment, time, and treatment by time interaction were similar $P > 0.05$, Fig. 6). Once again, variability was relatively high resulting in a lack of statistical difference. When we compared each pre- and post-spraying for each treatment using orthogonal contrast, Esplanade, Roundup, and Pastora applications all increased above ground primary-production for warm season grasses (Table 3). Percent basal cover of warm season grasses was similar among treatments or across time (Fig. 7).

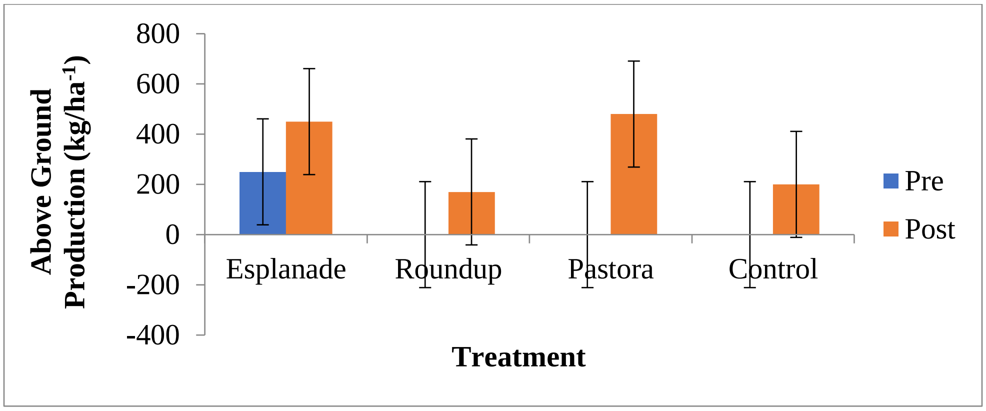

Figure 6. Above ground production (kg · ha^{-1}) of warm season grasses for both pre- and post-treatment with Esplanade, Roundup, Pastora, or no herbicide application (control). Data was collected 7 months after spraying.

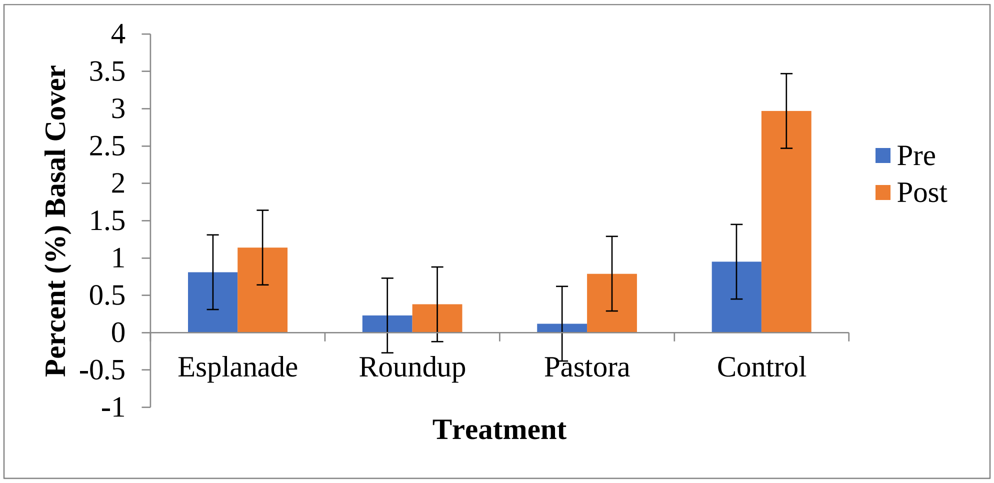

Figure 7. Percent (%) basal cover of warm season grasses for both pre- and post-treatment with Esplanade, Roundup, Pastora, or no herbicide application (control). Data was collected 7 months after spraying.

Table 3. Comparison of above ground production (kg · ha^{-1}) of warm season grasses following treatment with Esplanade, Roundup, Pastora, or no herbicide application (control). Pre- and post-treatment are compared for each herbicide application using orthogonal contrast.

Treatment	Pre	Post	SEM	P-value
Esplanade	250	420	270	0.7
Roundup	0	170	89	0.2
Pastora	0	480	298	0.3
Control	0	200	90	0.2

DISCUSSION

Mortality rates were lower than expected 7 months post-spray. A month after spraying, Roundup and Esplanade resulted in initial topkill of Mexican needlegrass. However, re-sprouting occurred at the axillary buds on several plants. There was a trend, although not statistically different, of a higher mortality rates after the application of Roundup compared to Esplanade and Pastora. Mortality rates in the control plots were higher than expected. This could have been the result of drift when Roundup was applied.

All herbicide treatments, Roundup, Esplanade, and Pastora reduced above ground primary-forage production when comparing pre- and post-spray forage production. Given that plants were re-sprouting 7 months after spraying indicates that reduction in above ground production may be a short-term response. Changes in percent basal cover are typically used to monitor long-term changes in species composition and cover. Seven months post-treatment, there were no differences in basal cover of Mexican needlegrass following herbicide application. If Mexican needlegrass is effectively controlled using herbicides, changes in basal cover should only appear after other species have had the opportunity to establish. Thus, changes in percent basal cover may be more noticeable in subsequent years.

Above ground primary-forage production of Texas wintergrass increased following herbicide applications. Both Mexican needlegrass and Texas wintergrass are cool season perennial grasses that begin growth in the fall and continue actively growing throughout the winter. Apparently, Texas wintergrass was still dormant because of dry conditions or had not established or initiated growth until after spraying herbicides. Otherwise, Texas wintergrass cover should have decreased following herbicide treatments.

Although not statistically different, all herbicide applications tended to increase warm season grass production. If warm season grasses are able to establish following control efforts, Mexican needlegrass cover may be further suppressed. Most of the precipitation received at the site occurs during May, June, and September, when warm season grasses are actively growing. Winter applications of broad spectrum herbicides like Esplanade, Roundup, and Pastora should have little impact on warm season grasses because plants are dormant. Broad spectrum herbicides only impact plants that are actively growing during the time that herbicides are applied.

Results from the study are consistent with a previous research that used Tebuthiuron, Glyphosate, and Imazapyr + Glyphosate to target and reduce cool season grass production without decreasing warm season grass production (Hillhouse et al. 2015). In this study, Roundup appeared to be most effective in managing Mexican needlegrass because of a trend toward higher mortality rate, and higher reduced forage production rate.

The research site for the current study was located in a flood basin where Mexican needlegrass had established in a dense stand. Apparently, the seeds were transported by water from another location. Most other locations in the region where Mexican needlegrass has established are located adjacent to a stream or in a flood plain. Thus, controlling Mexican needlegrass once it is detected is essential to prevent its further spread along waterways.

Herbicides may not the only means of management. Seasonal prescribed fire in addition to herbicide use may further increase mortality rates, decrease the above ground primary production, and decrease percent basal cover of Mexican needlegrass. Kral et al. (2018) compared late-growing season, dormant season, and early-growing season prescribed fires for controlling the cool season grass Kentucky bluegrass, while maintaining warm season grasses. Depending on the region, late-growing season or dormant season burns decreased the cool season target grass and benefited the warm season grasses. Hillhouse et al. (2015) had some plots that were treated with Tebuthiuron in Oct. or Nov., and then annually burned in late March. Both trials regardless of rate of spray of Tebuthiuron between plots, showed substantial increases in warm season grass yields and reduced cool season grass yields. Thus, the continual herbicide applications or herbicides plus the use of fire benefited warm season grasses.

Likewise, targeted livestock grazing may reduce cover of Mexican needlegrass. Cattle will consume the plant, but the effect of long-term intensive grazing on the plant is unknown. On-going research has shown that Mexican needlegrass will continue to initiate new growth even after repeated defoliation of plants growing in the greenhouse, indicating that livestock grazing may have little long-term impact on Mexican needlegrass.

There are other herbicides available as well. Imazapyr is a broad-spectrum herbicide that will control annual and perennial grasses. Imazapyr or combining Imazapyr and Roundup may further enhance Mexican needlegrass control.

IMPLICATIONS

Encroachment of invasive plants can be detrimental to grasslands by decreasing the biodiversity of natural prairies. Identifying an invasive plant early and managing that plant early can help prevent the development of monocultures and further encroachment. Management strategies for Mexican needlegrass are lacking and certainly subject to change as more information becomes available through research. A management plan for Mexican needlegrass should consider the goals of the property owner, effects on non-target species, and how to implement tools and resources already available. Given the plant's response to broad spectrum herbicides, a combination of management strategies may be required to effectively control the plant.

LITERATURE CITED

Blood, K., 2006. Serious potential, new and emerging weeds promoted in the horticultural media. In Proceedings of the 15th Australian Weeds Conference, eds C. Preston, JH Watts and ND Crossman (Weed management Society of South Australia, Adelaide, pp. 683-686.

Bonham, C. D. 1989. Measurements for Terrestrial Vegetation. John Wiley and Sons, New York. 338 pages.

Burrell, C. C., 2000. Ornamental grasses. *Landscape Architecture* 90:26-31.

Hillhouse, H. L., W. H. Schacht, R. A. Masters, B. B. Sleugh, and C. W. Kopp. 2015. Tebuthiuron use in restoring degraded tallgrass prairies and warm-season grass pastures. *The American Midland Naturalist* 173:99-109.

Jacobs, S. W. L., J. Everett, and M. A. Torres. 1998. *Nassella tenuissima* (Gramineae) recorded from Australia, a potential new weed related to Serrated Tussock. *Telopea* 8:41-46.

Kettenring, K. M., and C. R. Adams. 2011. Lessons learned from invasive plant control experiments: a systematic review and meta-analysis. *Journal of Applied Ecology* 48:970-979.

Kral, K., Limb, R., A. Ganguli, T. Hovick, and K. Sedivec. 2018. Seasonal prescribed fire variation decreases inhibitory ability of *Poa pratensis* L. and promotes native plant diversity. *Journal of Environmental Management* 223:908-916.

McLaren, D. A., M. Whattam, K. Blood, V. Stajsic, and R. Hore. 1999. Mexican feather grass (*Nassella tenuissima*) a potential disaster for Australia. In 12th Australian Weeds Conference, West Point Convention Centre, Hobart, pp. 658-662.

Russell, M.L., and R. Q. Landers Jr. 2017. Mexican needlegrass. ERM-038.

Russell, M.L., and B. S. Rector. 2017. Mexican feathergrass. ERM-039

SAS [SAS Institute Inc.] 2007. JMP user's guide. Version 7.0 Cary, NC, USA: SAS Institute Inc. 487 p.

Texas Invasives: http://www.texasinvasives.org/ plant_database/detail.php?symbol=ACCL7

Whisenant, S.G., 1999. Repairing Damaged Wildlands: Biological Conservation, Restoration, and Sustainability. Cambridge University Press, Cambridge, UK. 309 pages.

BIOGRAPHY

Lindsay Morgan Anglin is a second-year graduate student at Angelo State University in San Angelo, Texas where she is seeking a Master of Science in Animal Science and plans to graduate in December of 2018. Lindsay was born in San Antonio, Texas and was raised in Marion, Texas. Her family has a farming and ranching background raising cattle and growing coastal hay. Lindsay became an active member in the Guadalupe 4-H Goat Club, and in high school she joined the Marion FFA showing goats, and participating on livestock judging and skills teams. After graduating high school in Marion, Lindsay attended college at Angelo State University where she received a Bachelor of Science in Natural Resource Management in May of 2016. As an undergraduate senior, Lindsay was a member of the Delta Tau Alpha Honor Society. After Lindsay graduates from the master's program, she wants to pursue a career with the Texas Game Wardens.