Weed Technology 2013 27:184–189

Note

Shrub Control in Conservation Reserve Program Lands in Interior Alaska

Steven S. Seefeldt, Phil N. Kaspari, and Jeffery S. Conn*

In Alaska Conservation Reserve Program (CRP) lands, succession of fields planted with grass and clover to shrubs and small trees is resulting in program compliance problems related to ease of reconversion to crop lands. Standard practice for slowing this succession is mowing every 2 to 3 yr, which does not kill the woody vegetation. A field study was conducted at three sites over 2 yr to determine if 2,4-D (2.2 kg ae ha^{-1} 2-ethylhexyl ester) or triclopyr (2.2 kg ae ha^{-1} butoxyethyl ester) applied broadcast or 2,4-D (2.2 kg ae ha^{-1} 2,4-D dimethylamine salt) or triclopyr (1.7 kg ae ha^{-1} triclopyr triethylamine salt) applied with a Diamond Wet Blade™ mower (DWB) would result in longer shrub control compared to mowing. Mowing was conducted at both 15 and 45 cm above ground level and herbicides were applied with the DWB at three rates. Measurements 2 yr after treatment (YAT) confirmed that both herbicides reduced shrub cover about 50% compared to controls. Reduced rates of the herbicides applied with the DWB did not result in decreased shrub control. Grass cover was negatively correlated with shrub cover. Typically, mower height did not alter treatment effects. Treatments had little impact on forb cover and composition 2 YAT, with the exception of fireweed, which was generally reduced where herbicides were applied. Application of 2,4-D and triclopyr does not decrease the frequency of shrub control in CRP lands in Alaska. Use of 2,4-D and triclopyr with or without mowing resulted in no widespread improvement over the current practice of mowing to 15 cm every 2 to 3 yr.
Nomenclature: 2,4-D; triclopyr; fireweed, *Chamerion angustifolium* (L.) Holub ssp *angustifolium.*
Key words: Brush control, Conservation Reserve Program, Diamond Wet Blade mower, herbicide.

En tierras del Programa de Reservas para la Conservación (CRP) de Alaska, la sucesión de campos sembrados con zacate y trébol a arbustos y árboles pequeños está resultando en problemas para el cumplimiento del programa en relación con la facilidad de reconversión a tierras agrícolas. La práctica estándar para retrasar esta sucesión es la chapia cada 2 a 3 años, la cual no mata la vegetación leñosa. Se realizó un estudio de campo en tres sitios durante 2 años para determinar si 2,4-D (2.2 kg ae ha^{-1} 2-ethylhexyl ester) o triclopyr (2.2 kg ae ha^{-1} butoxyethyl ester) aplicados con aspersión generalizada o 2,4-D (2.2 kg ae ha^{-1} 2,4-D sal dimethylamine) o triclopyr (1,7 kg ae ha^{-1} triclopyr sal triethylamine) aplicados con una chapeadora Damon Wet Blade ™ (DWB) resultarían en un control más duradero de arbustos en comparación con la chapia. Se chapeó a 15 y 45 cm sobre la superficie del suelo y los herbicidas se aplicaron con el DWB a tres dosis. Mediciones 2 años después del tratamiento (YAT) confirmaron que ambos herbicidas redujeron la cobertura de arbustos en cerca de 50% en comparación con los testigos. Dosis reducidas de los herbicidas aplicados con DWB no resultaron en reducciones en el control de arbustos. La cobertura de zacates estuvo negativamente correlacionada con la cobertura de arbustos. Típicamente, la altura de la chapeadora no afectó el efecto de los tratamientos. Los tratamientos tuvieron un impacto menor en la cobertura y composición de plantas herbáceas de hoja ancha a 2 YAT, con la excepción de *Chamerion angustifolium*, la cual fue generalmente reducida cuando se aplicó herbicidas. La aplicación de 2,4-D y triclopyr no reduce la frecuencia de control de arbustos en tierras del CRP en Alaska. El uso de 2,4-D y triclopyr con o sin chapia no resultó en una mejora en comparación con la práctica actual de chapear a 15 cm cada 2 ó 3 años.

CRP was established as part of the 1985 Food Security Act with a major goal of reducing soil erosion (U.S. Department of Agriculture 1986). Over 14 million ha of erosion-prone cropland in the United States has been converted into grasslands through the CRP, which is administered by the U.S. Department of Agriculture (Osborn et al. 1992). Typically, croplands are enrolled in the program for 10-yr periods and land owners receive an annual rental fee for planting and maintaining perennial vegetation that prevents erosion and can be readily returned to cropping (U.S. Department of Agriculture 1986). Alaska farmers have enrolled over 10,000 ha in the CRP (Osborn et al. 1992), most of which is located near Delta Junction, to control topsoil losses due to wind erosion (Schoephorster 1973).

Management of land under CRP regulations is not simple abandonment with subsequent secondary succession that typically follows (Seefeldt et al. 2010). Instead, there is active management of these lands starting with the initial seeding of selected grasses forbs, or both; fertilization; and weed control. Region-specific CRP guidelines are developed by the Natural Resources Conservation Service. In Alaska, there were two enrollment periods (1986 and 1996). For the first CRP enrollment, guidelines called for planting fields with a mix of 10 kg ha^{-1} smooth brome (*Bromus inermus* Leyss.) and 6 kg ha^{-1} red fescue (*Festuca rubra* L.). For the second enrollment,

DOI: 10.1614/WT-D-12-00052.1

* First and third authors: Research Agronomists, U.S. Department of Agriculture–Agricultural Research Service–Subarctic Agricultural Research Unit, University of Alaska Fairbanks, Fairbanks, AK 99775; second author: Extension Agent, Cooperative Extension Service Delta District, University of Alaska Fairbanks, P.O. Box 349, Delta Junction, AK 99737. Current address of senior author: Cooperative Extension Service, Tanana District, University of Alaska Fairbanks, P.O. Box 758155, Fairbanks, AK 99775. Corresponding author's E-mail: ssseefeldt@alaska.edu

fields were typically planted with 4.4 kg ha^{-1} smooth brome, 1.7 kg ha^{-1} timothy (*Phleum pratense* L.), 1.1 kg ha^{-1} clover (*Trifolium* spp.), and 1.1 kg ha^{-1} bluegrass (*Poa* spp.). For both enrollments, fields were fertilized with 110 kg ha^{-1} of nitrogen prior to planting.

CRP payments to farmers are contingent on them achieving various management objectives. Inspections are made to determine whether the vegetation meets standards of erosion prevention, wildlife habitat, and ease of conversion to cropland. Ease of conversion is the factor causing the greatest compliance problems in Delta Junction due to recruitment and growth of shrub and tree species (Seefeldt et al. 2010). CRP regulations for managing trees and shrubs consist of mowing every 2 to 3 years after bird nesting has finished (Natural Resources Conservation Service 2003). Because mowing does not kill most shrubs and trees, many fields that were part of the first enrollment period have developed thick shrub mats that would hinder efforts to convert the fields back to agricultural production (Seefeldt et al. 2010).

In Alaska, 2,4-D and triclopyr are herbicides commonly used for shrub control (S. Seefeldt, personal observation). A recently developed technology, the DWB mower (Diamond Mowers Incorporated, 27134 Parklane Drive, Sioux Falls, SD 57106), was designed to apply herbicide to the blade of the mower so that cut stems would be coated with herbicide, which would be pulled into the xylem as a response to the subsequent loss of pressure potential, an idea similar to the design of the Burch Wet Blade™ (Burch Company, 1515 Mockingbird Lane, Suite 820, Chalotte, NC 28209) (Henson et al. 2003; Hixson et al. 2007). It was hypothesized that the DWB might provide shrub control with reduced rates of herbicide compared to standard broadcast applications and that raising the height of the cutting blade would spare shorter forbs normally controlled with broadcast applications of triclopyr and 2,4-D.

The goal of this study was to compare management strategies for woody vegetation control in CRP fields. The objectives were to (1) compare mowing, broadcast herbicides, and herbicides applied with the DWB for control of shrubs and trees in CRP fields; (2) determine treatment effects on grass and forb cover among the treatments; (3) observe treatment impacts on forb community dynamics; and (4) determine if mowing height altered herbicide efficacy.

Materials and Methods

The research sites were in the Interior Bottomlands ecoregion of the Alaska boreal forest (Gallant et al. 1995) on or adjacent to the outwash plain of the Tanana River from 64°0′30″N, 145°39′13″W to 63°58′53″N, 145°4′29″W. Elevation ranges from 330 to 385 m. Soils are silt loam occurring on flat (0 to 3% slopes) outwash plains and terraces (Natural Resources Conservation Service, 2010). Average annual temperature is between –2 to –4 C and average July temperature is about 16 C. Annual precipitation varies from 250 to 300 mm. The frost free period is 80 to 120 d.

Field experiments were begun in 2007 on two fields (K7 and B7). K7 had been in the CRP for almost 20 yr and B7 was cleared and planted to grasses in 1979 as part of a bison control project. Treatments are listed in Table 1. Broadcast herbicides were applied at 140 L ha^{-1} at 186 kPa with a 4.5-m boom and 8002 VS flat fat nozzles (Tee-Jet Spraying Systems Co., Wheaton, IL 60139) spaced at 0.6-m intervals, all mounted on the back of a 1-ton truck traveling at 8 kph. All broadcast herbicide treatments included the nonionic surfactant Activator 90 (Loveland Products, Incorporated, P.O. Box 1286, Greeley, CO 80632) at 0.25% v/v. The DWB applied herbicide at a volume of 23 L ha^{-1} with the blade set at either 15 or 45 cm above the ground. Salt formulations of triclopyr and 2,4-D were used with the DWB because these formulations may improve uptake in a cut stem compared to an ester formulation (Henson et al. 2003). Following label recommendation, the triclopyr rate for the DWB was 75% of the broadcast rate. The DWB has a 4.5-m wide batwing design with three pairs of blades, each cutting a 1.5-m swath. Two mowing control treatments (15 and 45 cm) were evaluated to determine if forb injury could be reduced by mowing using a higher cut. Standard mower height for cutting shrubs in CRP fields in Delta Junction is 15 cm. Plot size was 19 by 61 m on the K7 field and 4.5 by 61 m on the B7 field. Treatments were applied to K7 on July 24, 2007, and to B7 on July 25, 2007. In the B7 field-broadcast herbicide applications were not done correctly so those treatments in B7 were not measured.

In 2008 the same treatments were applied to a grassy area on the University of Alaska Fairbanks Field Research Site near Delta Junction (U8) where shrub invasion was underway. Plots were 4.5 by 61 m and treatments were applied August 6, 2008. In each of the three field sites there were four replications of each treatment and the experimental design was a randomized complete block.

Except for B7, when these fields were cleared the trees were pushed into long rows and burned. Vegetation growing over these burned areas was typically denser (S. Seefeldt, personal observation). Therefore, to reduce variability all plots were set perpendicular to the direction of the burn rows. Vegetation was estimated visually by three people. Each person estimated vegetation cover and abundance in a third of the plot. Before treatments were applied the plant species in the study area were rated for abundance using the following scale: abundant ($>$ 20% of plants), common ($<$ 20 to 5% of the plants), occasional ($<$ 5 to 1% of the plants), rare ($<$ 1% of the plants), and patchy (occasional dense stands). Average plant height and phenology (vegetative, flowering, fruiting, and senescing) were also recorded. Estimates of shrub, forb, and grass cover were also made with each person estimating the cover in a third of the plot. Observer variability was reduced through calibration exercises at the start of sampling day, in which each person rated the same areas and estimates were compared.

Two YAT (in late July or early August) percentage of cover of shrubs, forbs, and grasses and the abundance of each plant species was visually estimated in all plots using the scale described above. Data were analyzed using the general linear models of SAS (version 9.1, SAS Institute, Cary, NC 27513).

Table 1. Treatment list for shrub control study in Delta Junction, AK.

Treatment	Abbreviation	Rate
Broadcast 2.2 kg ae ha^{-1} triclopyr butoxyethyl ester	BT	1×
Broadcast 2.2 kg ae ha^{-1} 2,4-D ethylhe×yl ester	BD	1×
Wet blade 1.7 kg ae ha^{-1} triclopyr triethylamine salt	WT	1×
Wet blade 0.85 kg ae ha^{-1} triclopyr triethylamine salt	WTH	1/2×
Wet blade 0.425 kg ae ha^{-1} triclopyr triethylamine salt	WTQ	1/4×
Wet blade 2.2 kg ae ha^{-1} 2,4-D dimethylamine salt	WD	1×
Wet blade 1.1 kg ae ha^{-1} 2,4-D dimethylamine salt	WDH	1/2×
Wet blade 0.55 kg ae ha^{-1} 2,4-D dimethylamine salt	WDQ	1/4×
Control	C	0
Mow control	MC	0

Data were determined to be normal using a UNIVARIATE procedure of model residuals with the Shapiro-Wilk statistic of SAS. A least significant difference means test (Fisher's Protected LSD) was used when the *F* test probability was < 0.05.

Results and Discussion

In the analyses, there were no differences between mowing high (45 cm) or low (15 cm) in the mow control plots, so these data were grouped into a mow control treatment. Analyses determined that there were interactions among the treatments and fields for shrub ($P = 0.0009$), forb

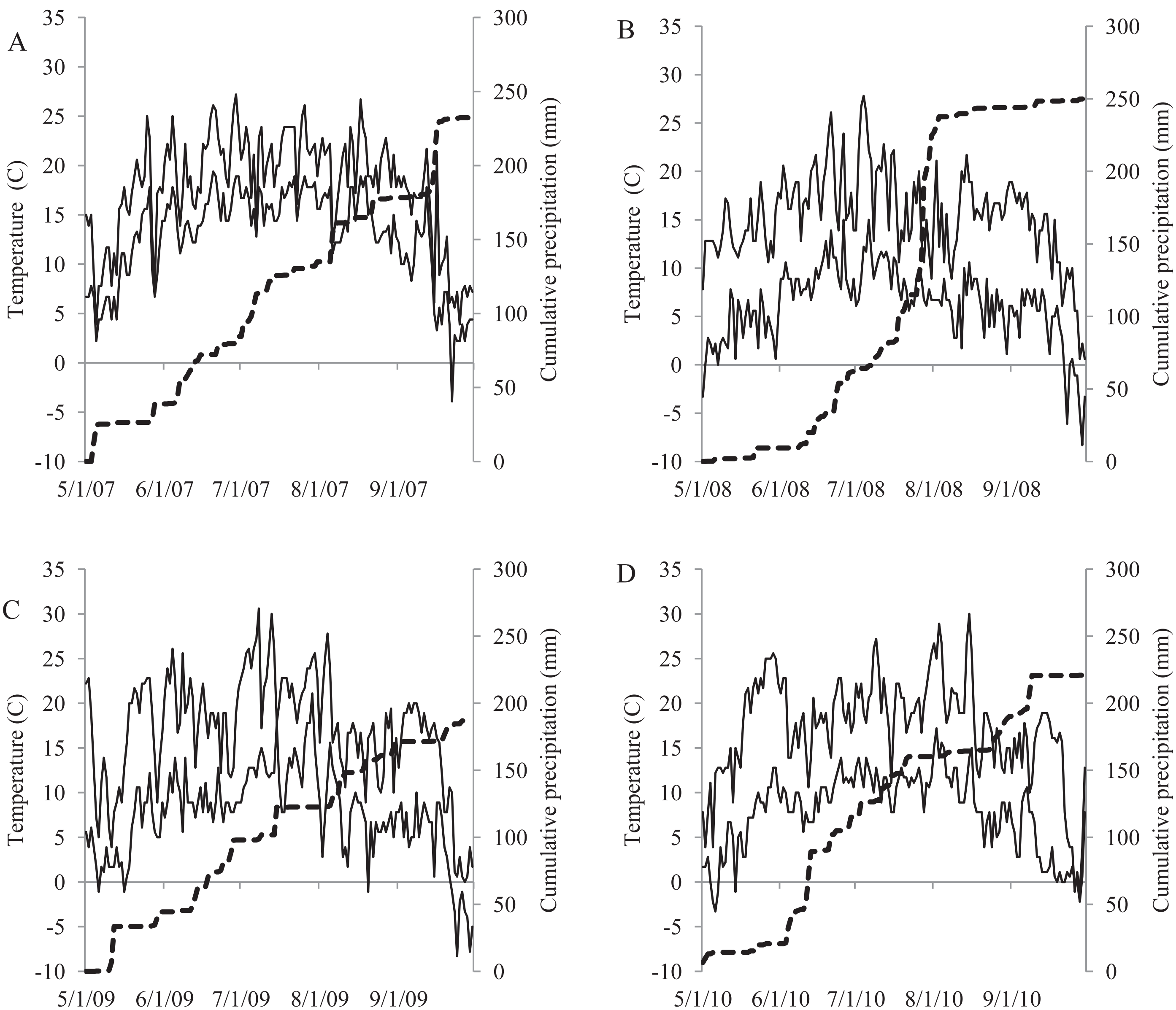

Figure 1. Maximum and minimum daily temperatures (solid lines) and cumulative precipitation (dashed line) during the growing season in Delta Junction, AK, from 2007 to 2010.

https://doi.org/10.1614/WT-D-12-00052.1 Published online by Cambridge University Press

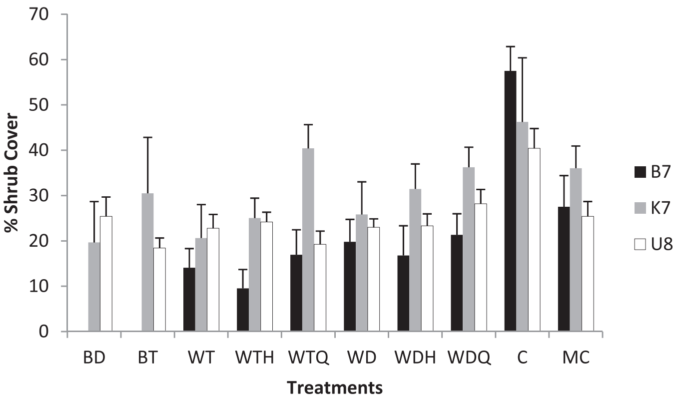

Figure 2. Shrub control at K7, B7, and U8 fields near Delta Junction, AK, 2 yr after treatment. Please see Table 1 for definitions of abbreviations. Bars represent SE. Broadcast treatment results are not shown for B7.

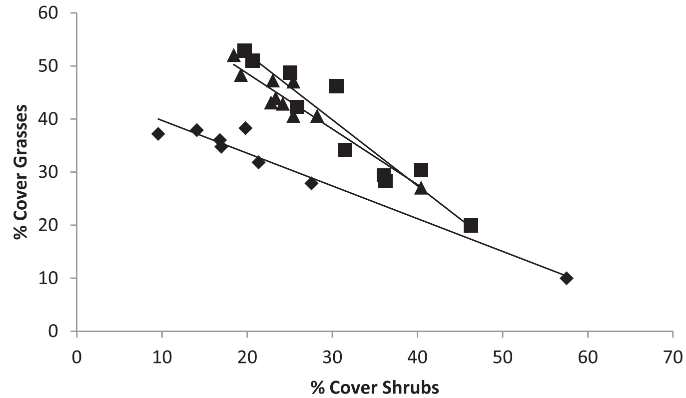

Figure 4. Regression of grass cover compared to shrub cover 2 YAT in K7, B7, and U8 fields near Delta Junction, AK. Each point is the mean of four replications. Diamonds represent the B7 field ($y = -0.62x + 46$; $R^2 = 0.95$), squares represent the K7 field ($y = -1.2x + 77$; $R^2 = 0.9$), and triangles represent the U8 field ($y = -1.0x + 70$; $R^2 = 0.9$).

(P < 0.0001), and grass (P = 0.0027) covers. There are several reasons for these differences among fields including variable weather, plot size, and differences in starting vegetation. The weather differed each year over the course of the study with a dry and hot summer in 2007, a dry and cool summer in 2008, a very dry summer in 2009, and a moist and cool summer in 2010 (Figure 1). The starting vegetation on the K7 field (which was on CRP ground) was approximately 40, 30, and 20% shrubs, grasses, and forbs, respectively, based on visual cover estimates. The starting vegetation on the B7 field (which was cleared and planted at the same time as the K7 field but was not part of the CRP) was dominated by fireweed, with cover often exceeding 70%; however, cover was generally 25, 20, and 50% shrubs, grasses, and forbs, respectively, across the entire site. The U8 field was not a CRP field, but vegetation has developed that makes it similar to a CRP field that is about 10 yr old (Seefeldt et al., 2010). This experiment marked the first time vegetation was mowed in the U8 field, with shrubs and small trees up to 3 m tall present at study initiation compared to less than 1.5 m on the other fields. Average cover on the U8 field was 30, 50, and 15% shrubs, grasses, and forbs, respectively.

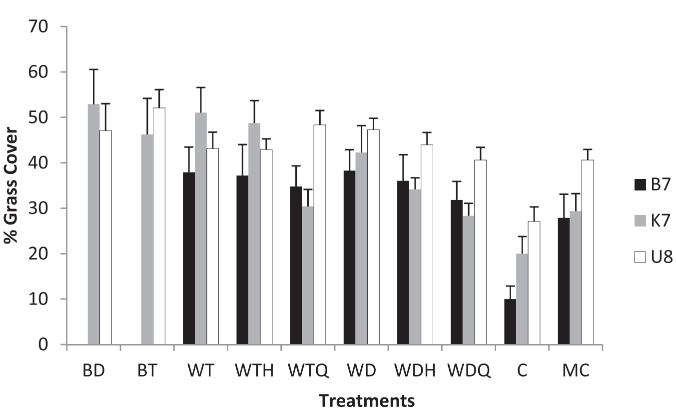

Figure 3. Grass control at K7, B7, and U8 fields near Delta Junction, AK, 2 yr after treatment. Please see Table 1 for definitions of abbreviations.Bars represent SE. Broadcast treatment results are not shown for B7.

Shrub Cover 2 YAT. In the K7 field, shrub cover was greatest in the control compared to all treatments except for the mow control and the one-quarter rate of triclopyr (Figure 2). The full rate of triclopyr applied with the DWB reduced shrub cover compared to the one-quarter rate of triclopyr and the mow control; otherwise all herbicides reduced shrub cover similarly and were no different than the mow control in K7. In the B7 field, again shrub cover was greatest in the control compared to all other treatments (Figure 2). The one-half rate of triclopyr applied with the DWB reduced shrub cover more than the mow control; otherwise all herbicide treatments resulted in shrub cover equivalent to the mow control in B7. In the U8 field, shrub cover was greatest in the control compared to all other treatments (Figure 2). Shrub cover was greater in the plots treated with a one-quarter rate of 2,4-D compared to a one-quarter rate of triclopyr and the broadcast application of triclopyr; otherwise shrub cover in all herbicide treatments was equivalent to the mow control (Figure 2). Generally, shrub cover following herbicide application with the DWB was similar to a broadcast spray application.

Alaska growers typically mow their CRP fields every 2 or 3 yr based on shrub cover (Seefeldt et al. 2010). By 2 YAT shrub cover had largely returned to levels measured before treatments were applied. There was an expectation that herbicide use would extend the mowing interval, but only the full and one-half rates of triclopyr applied with the DWB in B7 resulted in plots having less than 20% shrub cover 2 YAT.

Grass Cover 2 YAT. In the K7 field, grass cover was greatest in the plots treated with broadcast applications and those receiving DWB applications of triclopyr (full and half rate) and 2,4-D (full rate) (Figure 3). The control, mow control, and one-quarter rate of triclopyr resulted in the least grass cover in K7. In the B7 field, herbicide treatments and mowing resulted in greater grass cover than the control treatment. In the U8 field, the control had the least amount of grass cover compared to all the other treatments (Figure 3) and the broadcast application of triclopyr resulted in greater grass cover compared with the control, mow control, and one-quarter rate of 2,4-D applied with the DWB.

https://doi.org/10.1614/WT-D-12-00052.1 Published online by Cambridge University Press

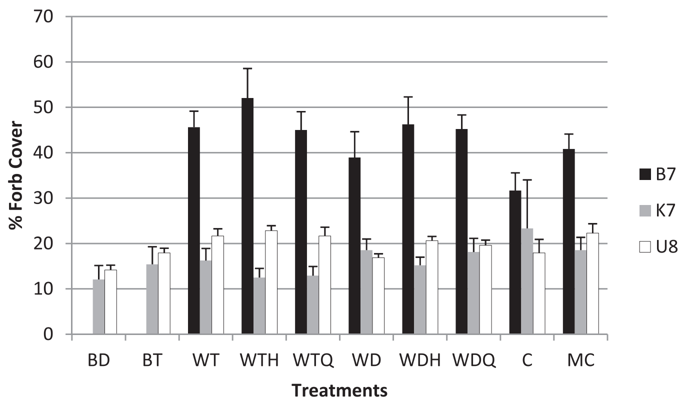

Figure 5. Forb control in K7, B7, and U8 fields near Delta Junction, AK, 2 yr after treatment. Please see Table 1 for definitions of abbreviations. Bars represent SE. Broadcast treatment results are not shown for B7.

At all sites, treatments that reduced shrub cover resulted in increased grass cover. A linear regression of grass cover based on shrub cover resulted in an inverse correlation (Figure 4) with slopes of −1.2 ($R^2 = 0.9$) and −1.0 ($R^2 = 0.9$) for K7 and U8, respectively and –0.62 ($R^2 = 0.95$) for B8, where there was a denser, more competitive forb component. Increased grass cover probably resulted from a competition release when shrub cover was reduced (Haas and Streibig 1982). Two areas treated with triclopyr and 2,4-D in a preliminary study in 2006 were still easily identified 4 YAT due to greater grass cover. A similar conclusion of grass positively responding with control of other vegetation was measured in a study comparing the Burch Wet Blade mower for control of bahiagrass (*Paspalum notatum* Fluegge) on roadsides (Gannon and Yelverton 2011) and for control of dogfennel [*Eupatorium capillifolium* (Lam.) Small], lespedeza [*Lespedeza striata* (Thumb.) Hook. & Arn.], and clover (*Trifolium pretense* L. and *Trifolium repens* L.) on rough turf study (Henson et al. 2003).

Forb Cover 2 YAT. Overall forb cover in K7 and U8 was less than half the forb cover in B7 (Figure 4) mostly due to the fireweed populations in B7. By 2 YAT, forb cover was uniform throughout all treatments in K7 and B7 (Figure 5). In the U8 field, forb cover was greatest for the following treatments: control, mow control, broadcast triclopyr, and high rate of 2,4-D applied with the DWB (Figure 5). In addition, the highest rate of 2,4-D applied with the DWB resulted in less forb cover than the mow control. Our hypothesis was that forb cover would be significantly reduced with herbicide treatments 2 YAT, especially broadcast applications. This hypothesis was only partially supported for the broadcast application of 2,4-D in U8. Otherwise forb cover was not impacted negatively by treatments in this research.

Plant Abundances 2 YAT. Forb species were variable among the three fields. In K7, at the start of the study there were 24 forb species in the experimental area. By 2 YAT five of those species had disappeared but five more were identified. In B7 there were seven forb species in the study area before treatments were applied. Two YAT, one of these species was gone but five new forb species were identified. In U8 there were 19 forb species in the study area before treatments were applied. Two YAT, one of these species was gone but seven new species were identified. These changes were not the result of applied treatments.

However, among the species that remained over the course of the study, a few changes in abundance were observed due to treatment: In B7 yarrow (*Achillea millefolium* L.) declined in the control plots (common to rare), in K7 fireweed declined (abundant to occasional) in the broadcast plots, and in U8 bitter fleabane (*Erigeron acris* L.) disappeared in plots treated with broadcast 2,4-D. In K7 dwarf dogwood (*Cornus canadensis* L.) abundance declined (occasional to not found) in all control and mow control treatments (suggesting competition influences); however, in U8 dwarf dogwood disappeared in broadcast herbicide plots and plots treated with full rates of triclopyr or 2,4-D applied with the DWB at 15-cm height (suggesting herbicide impacts).

Among the three fields, forb cover was rarely altered by the different treatments 2 YAT, which was counter to our expectations. Fireweed populations were reduced in K7 when triclopyr and 2,4-D were applied with the DWB at the highest rates, but this treatment effect was not observed in B7 or U8. This differential fireweed response among the fields could be due to the decreased width of the plots in B7 and U8 compared to K7 (4.5 vs. 19 m). Fireweed has wide-spreading rhizomes (Clark 1976), which could have reoccupied the plots 2 YAT. Dwarf dogwood abundance declined in control and mow control plots in K7, but declined only in plots treated with highest rates of herbicide using either application method in U8. In contrast, dwarf dogwood abundance in B7 declined from occasional to rare and absent in the control plots. Competition with other plants in control plots could have caused loss of dwarf dogwood abundance. In U8 dwarf dogwood populations were rare at the beginning of the study and received the same score 2 YAT except where the higher rates of herbicide were applied with either method. Dwarf dogwood was not a component of any of the other fields, except for two plants that were identified in B7 2 YAT.

There was an expectation that herbicide treatments generally (and broadcast treatments specifically) would reduce overall forb cover and the abundances of several forb species. Waiting for 2 yr to measure abundance responses of forbs to treatments may indicate that any negative herbicide effects on nontarget plant species were transitory. Additionally, climatic conditions from year to year may have had a larger impact on forb species and abundance than treatment effects (Le Houerou et al. 1988).

Impact of Mower Height. Our hypothesis was that mowing at 45 cm aboveground with the DWB would reduce the impact of herbicide treatment on the shorter forbs compared to mowing at 15 cm or using a broadcast application because these plant species would avoid the herbicide on the mower blade. Surprisingly, no differences were observed. However, in two fields (B7 and U8), reduced mower height increased shrub control (P = 0.0002 and 0.01, respectively); additionally, reduced mower height increased grass cover (P = 0.0001) in B7 as well. This shrub control with lower mowing heights is most likely the effect of initially removing more shrub canopy, resulting in a longer interval for shrub canopy recovery and increased light for grasses.

Results of this research indicate that use of triclopyr or 2,4-D is effective for reducing shrub cover and increasing grass cover in CRP fields with little impact on forb species. However, use of these herbicides with or without mowing resulted in no widespread improvement over the current practice of mowing to 15 cm every 2 to 3 yr.

Acknowledgments

The authors express their appreciation to Erin Carr, Elizabeth Andringa, Jennifer Kapla, Trista Saunders, and Richard Ranft from the U.S. Department of Agriculture–Agricultural Research Service for data collection; Alan Tonne from the University of Alaska Fairbanks; Chuck Mancuso and Tammie Kovalenko of the Delta Soil and Water Conservation District; Ron Riesgaard of the Alaska Department of Fish and Game; and the landowners. The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture, the Agricultural Research Service, or the University of Alaska Fairbanks of any product or service to the exclusion of others that may be suitable.

Literature Cited

Clark, L. J. 1976. Wild Flowers of the Pacific Northwest. Vancouver, BC, Canada: Evergreen. 604 p.

Gallant, A. L., R. F. Binnian, J. N. Omernik, and M. B. Shasby. 1995. Ecoregions of Alaska: U.S. Geological Survey Professional Paper 1567. Washington, DC: U.S. Government Printing Office. 73 p.

Gannon, T. W. and F. H. Yelverton. 2011. Application placement equipment for bahiagrass (*Paspalum notatum*) suppression along roadsides. Weed Technol. 25:77–83.

Haas, H. and J. C. Streibig. 1982. Changing patterns of weed distribution as a result of herbicide use and other agronomic factors. Pages 57–80 *in* H. M. LeBaron and J. Gressel, eds. Herbicide Resistance in Plants. New York: J. Wiley.

Henson, S. E., W. A. Skroch, J. D. Burton, and A. D. Worsham. 2003. Herbicide efficacy using a wet-blade application system. Weed Technol. 17:320–324.

Hixson, A. C., T. W. Gannon, and F. H. Yelverton. 2007. Efficacy of application placement equipment for tall fescue (*Lolium arundinaceum*) growth and seedhead suppression. Weed Technol. 21:801–806.

Le Houerou, H. N., R. L. Bingham, and W. Skerbek. 1988. Relationship between the variability of primary production and the variability of annual precipitation in world arid lands. J. Arid Environ. 15:1–18.

Natural Resources Conservation Service. 2003. National Handbook of Conservation Practices: Conservation Practice Standard, Filter Strip. Washington, DC: Natural Resources Conservation Service code 393. 4p.

Natural Resources Conservation Service. 2010. Soil Survey of Delta Junction, Alaska Area. Delta Junction, AK: Natural Resources Conservation Service. 394 p.

Osborn, C. T., E. Llancuna, and M. Linsenbigler. 1992. The Conservation Reserve Program: Enrollment Statistics for Sign-Up Periods 1–11 and Fiscal Years 1990–1992. Washington, DC: U.S. Department of Agriculture. Economic Research Service, Statistical Bulletin 843.

Schoephorster, D. B. 1973. Soil Survey of Salcha–Big Delta Area, Alaska. Washington, DC: USDA – Soil Conservation Service, U.S. Government Printing Office.

Seefeldt, S. S., J. C. Conn, M. Zhang, and P. N. Karspari. 2010. Vegetation changes in Conservation Reserve Program lands in interior Alaska. Agric. Ecosyst. Environ. 135:119–126.

U.S. Department of Agriculture. 1986. Backgrounder: Conservation Reserve Program. Washington, DC: U.S. Department of Agriculture News Division.

Received March 29, 2012, and approved September 18, 2012.