Controlling meadow knapweed with manual removal, mulching, and seeding

2008 Interim Report

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Institute for Applied Ecology

A Challenge cost Share Project between the
Institute for Applied Ecology, Corvallis, Oregon *and the*
Eugene District Bureau of Land Management

PREFACE

This report is the result of a cooperative Challenge Cost Share project between the Institute for Applied Ecology (IAE) and a federal agency. IAE is a non-profit organization whose mission is conservation of native ecosystems through restoration, research and education. Our aim is to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems, species, and effective management strategies and by conducting research, monitoring, and experiments. IAE offers educational opportunities through 3-4 month internships. Our current activities are concentrated on rare and endangered plants and invasive species. Questions regarding this report or IAE should be directed to:

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Cover photographs and all photos within, except where noted: Andrea S. Thorpe, IAE

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Figure 1. Meadow knapweed.

Meadow knapweed (*Centaurea ×moncktonii* Britt., synonyms include *C. debeauxii* Gren. & Godr. ssp. *thuillieri* Dostál and *C. pratensis* Thuill, nom. illeg., non Salisb.; Asteraceae; Figure 1) is an invasive forb that is a fertile hybrid between two European species that are also invasive in the United States: black knapweed (*C. nigra*) and brown knapweed (*C. jaceae*). Meadow knapweed has been found in 47 counties in Oregon, Washington, Idaho, and Montana and is considered noxious in Oregon, Washington, and Idaho (http://invader.dbs.umt.edu). Particularly in western Oregon, populations of meadow knapweed have been rapidly expanding and new infestations are frequently found. Although meadow knapweed appears to first colonize roadsides, river and stream banks, and disturbed pastures, it is also capable of invading native prairies and meadows.

Meadow knapweed can form monocultures in invaded areas (Figure 2). Although meadow knapweed was originally introduced as a forage plant (Roché and Johnson 2003), its palatability and quality decline as the plant matures, and its presence ultimately reduces forage production. There are also concerns that meadow knapweed reduces the cover and richness of native plant species in invaded forests and meadows and adversely affects the growth of tree seedlings.

Meadow knapweed is a perennial that grows from a woody crown. Plants usually grow 20 to 40 inches tall with the main stems branching near the middle. Meadow knapweed leaves can grow up to 6 inches long and 1.25 inches wide and have entire margins to small lobes or teeth. Leaves on the stems are progressively smaller; the uppermost leaves are quite reduced and linear. The rose-purple (occasionally white) flowers are held in round to urn-shaped capitula about the size of a nickel. Flowering peaks in July and August, but can continue into November and December

Figure 2. A field invaded by meadow knapweed near Horton, Oregon. Cover of meadow knapweed in this field was greater than 90%.

west of the Cascade Mountains, particularly on damaged plants. The capitula are surrounded by light to dark brown bracts that have a papery fringed margin (Figure 3). At the time of flowering, these bracts reflect a metallic golden sheen. Cypselae (the type of fruit in Asteraceae) are about 1/8 inch long, ivory-white to light brown, and sometimes bear a row of short hairs (*pappus*) opposite the point of attachment (*hilum*). Seedlings are taprooted; mature plants develop a cluster of somewhat fleshy roots below the woody crown. Meadow knapweed appears to have three life stages: seedling, rosette, and the reproductive bolting stage. Plants appear to be able to reproduce for several years and may flower multiple times during a year, particularly if the plant has been disturbed (e.g. grazed or mowed).

Figure 3. Meadow knapweed capitulum. Note dark brown bracts with a papery, fringed margin. Photo: Wes Messinger/USACE

The Meadow Knapweed Working Group, a multi-agency, multi-disciplinary team, has been formed to address concerns and needs for this species, particularly in the Horton area of Lane County where there is a high level of invasion. Their recommendations include reducing the spread of the species from invaded areas through containment as well as developing new methods for control, especially on roadsides. As meadow knapweed reproduces and spreads by seed, containment of this species must include reducing or eliminating seed production. While herbicides have been relatively effective at controlling meadow knapweed, this control method is not available in many situations. Unfortunately, effective and efficient alternatives to herbicides have not yet been identified. Mowing, grubbing, and tilling have been anecdotally reported to having varying levels of success, yet these methods have not been compared in a replicated, controlled setting. The purpose of this project was to examine the efficacy of combinations of mechanical removal methods and mulching and seeding to control and suppress meadow knapweed. Specifically, this project addresses the following questions:

- How effective are several non-chemical methods of removing meadow knapweed?
- Does mulching inhibit germination of meadow knapweed seeds after removal of plants?
- Does sowing of native species inhibit reinvasion by meadow knapweed after removal treatments?
- Is one year of treatment sufficient to control meadow knapweed?

We are testing three methods commonly used to control invasive weeds: mowing, grubbing, and solarization. Many knapweed species respond to mowing with low stature compensatory growth, resulting in increased seed production that is close to the ground. Local land managers have reported a similar response by meadow knapweed. However, mowing knapweed repeatedly over a growing season at

progressively shorter heights has not yet been tested in a replicated manner. Grubbing has been effective in removing invasive knapweeds in some areas and is particularly useful in prairies where sensitive native species are present. However, in comparison to some other control methods, the utility of grubbing may be limited due to the time required to grub sites and the ability of workers to remove the extensive taproot of the species. Solarization (covering with heavy black plastic) has the potential to not only kill the living plants, but it may also kill seeds in the seedbank.

Mulch has the potential to inhibit seed germination and seedling growth. Native blue wildrye (*Elymus glaucus*) straw has been used effectively in previous studies for limiting the re-emergence of the invasive grass, false-brome (*Brachypodium sylvaticum*), after mowing. The Oregon Department of Transportation reported that in one area with a thin layer of mulch, meadow knapweed appeared to re-invade more slowly than in areas not similarly treated. We will test the effectiveness of two different types of straw, blue wildrye straw and wood straw (http://www.woodstraw.com/). While blue wildrye straw is more typical of the litter in the meadow habitats that are frequently invaded by meadow knapweed, it is expensive and may be difficult to obtain. In contrast, wood straw, which is designed to mimic the size and texture of grass straw, is relatively inexpensive and readily available.

Effective control of meadow knapweed will likely require several years of knapweed removal. Seeds of related species have been reported to be viable for up to eight years and mangers have reported that treated sites are frequently reinvaded by meadow knapweed the year following treatment. Thus, we are planning to evaluate all treatments in 2008 and either reapply or add treatments in future years.

METHODS

Two sites were selected for this experiment. The Fire Station site was located in an unused field at the Lake Creek Fire Station in Horton, Oregon (Figures 4 & 5). This site was chosen because it is characteristic of pastures that are invaded by meadow knapweed and it is easily accessible to the public, making it a good demonstration site. The Spur Road site was located along the side of BLM road 15-6-19.1.

Plots were established and initially monitored in June 2007. Subsequent monitoring followed the same procedure outlined below and was conducted in July 2008. At the Fire Station site, we set up a 50 meter transect to serve as the edge of the plots (Figure 5). At the Spur Road site, we set up a 48 meter transect as the edge of the plots and used rebar to mark 0, 20, and 50 meters (Figure 6). Eight inch spikes and/or conduit were used at both sites to permanently mark every 2 meters along the transect. In the center of each 2 x 2 meter treatment plot we set up a 1 square meter sampling plot. In each sampling plot we counted the total number of individual meadow knapweed seedlings, rosettes, and bolting plants and measured the heights of ten randomly selected individuals in both the rosette and bolting stages. Individual plants were determined by probing for underground root connections between crowns located in close proximity. We also documented the percent cover of all vascular plant species, litter, bare ground/rock, and moss. Appendix C lists the species present at each site and their native/invasive status.

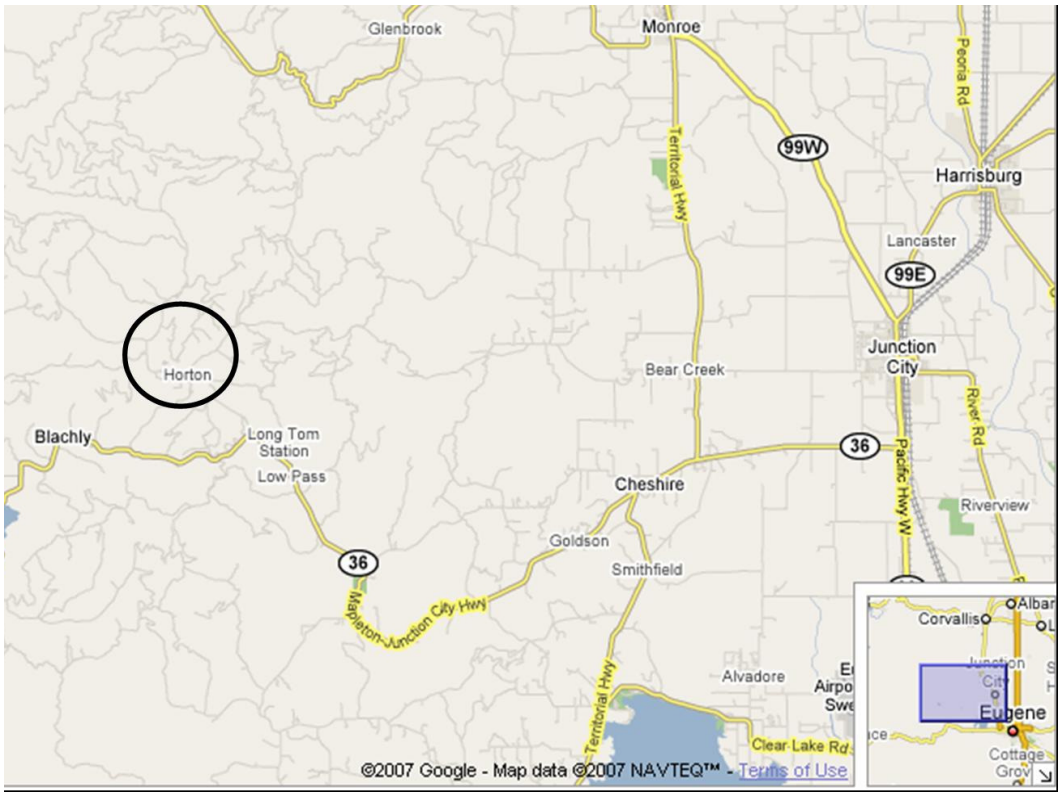

Figure 4. General location of meadow knapweed study sites (in and near Horton, Oregon, circled on map).

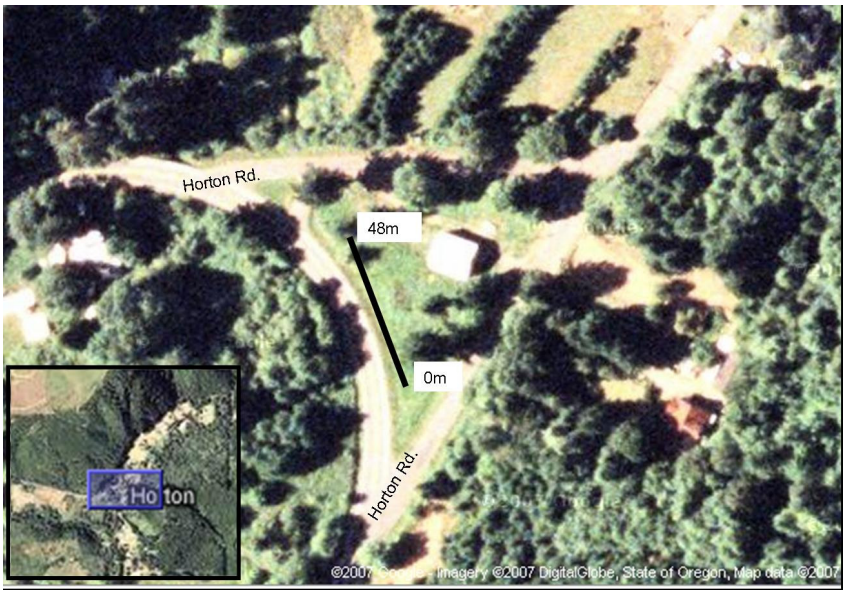

Figure 5. Fire station study site. Location and orientation of the transect is marked in black.

Table 1. Study design (incomplete factorial) for examining the effects of mechanical removal, mulching and native grass seeding on meadow knapweed and the number of plots at each site. FS = Fire Station, SR = Spur Road.

		Removal			
		Mow twice in season at two different heights	**Grub before seed-set**	**Mow then Solarization**	**No treatment** (full-control)
Mulching and seeding	**No mulch**	yes FS: 3 SR: 4	yes FS: 3 SR: 4	yes FS: 4 SR: 3	yes FS: 4 SR: 5
	Mulching and seeding	yes FS: 3 SR: 4	yes FS: 4 SR: 3	no	yes FS: 3 SR: 2

Treatments were randomly assigned to plots so that there would be at least three replicates of each treatment at each site (Table 1, Appendix B). One mulch/seed control plot was missed at the Spur Road site, resulting in 5 control plots neither mulched nor seeded and 2 control plots that were seeded and mulched. Treatments were applied to plots initially in July 2007. A weed whacker was used to cut all plants in the plots needing mowing to approximately 8 inches above the ground.

Plots assigned to the mow/solar treatment were then covered with black 0.24 inch polyethylene sheeting secured to the ground by large garden staples (Figure 11). Plots assigned to the mow and mow/mulch/seed treatments were mowed again approximately 2 months after the first treatment to approximately 6 inches above the ground (Figure 11). All meadow knapweed plants in the grub and grub/mulch/seed plots were removed to a depth greater than 3.94 inches using pulaskis. Approximately 3 inches of blue wildrye straw or wood straw was applied to the mulch/seed, mow/mulch/seed, and grub/mulch/seed plots at the Fire Station and Spur Road sites, respectively. At both sites,

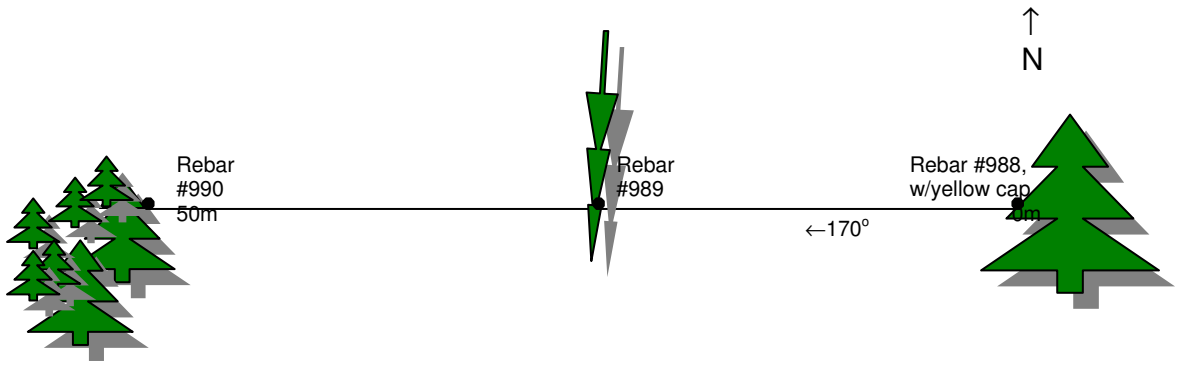

Figure 6. Diagram of the Spur Road study site.

85 grams each of blue wildrye and Columbia brome (*Bromus vulgaris*) seed were combined and spread evenly over the appropriate plots.

Treatments were repeated in July 2008 (Appendix B). Mow/solar plots were uncovered and checked for active plant growth; no plants were growing in any plot except one and the plastic was therefore completely removed and the plots were mulched and seeded. The plastic blew up off of half of one mow/solar plot at the Fire Station site, allowing meadow knapweed to grow back. This plot was mowed again and resolarized. Plots requiring mowing or grubbing were treated the same as they were in 2007, except that all plants were grubbed in each grubbing plot. Additionally, two control plots requiring no treatment were accidently mown at the Spur Road site. Approximately 2 inches of blue wildrye straw or wood straw was applied to all plots requiring mulching at the Fire Station and Spur Road sites, respectively. All plots requiring seeding were seeded with 85 grams of blue wildrye.

The sites were revisited in October 2008. Plots requiring mowing were mowed again to a height of approximately 6 inches with a weed whacker. Approximately 89 grams of a seed mix (Table 2) were evenly spread over each plot requiring seeding. Annual forb components of the seed mix will germinate quickly in the spring and provide high immediate cover to compete with the meadow knapweed seedlings and new early growth. The perennial forbs generally provide high ground cover once established and will hopefully preclude and/or suppress knapweed growth. The perennial grass species have high fidelity to prairie plant communities and are likely to be more resistant to the negative impacts of meadow knapweed.

Table 2. Components of seed mix added to seeded plots in October 2008.

Form	Scientific Name	grams/plot	% of mix
Annual forb	*Epilobium densiflorum*	9.1	10
Annual forb	*Lotus purshianus*	5.4	6
Perennial forb	*Achillea millefolium*	5.4	6
Perennial forb	*Prunella vulgaris* var. *lanceolata*	5.4	6
Perennial grass	*Bromus sitchensis*	18.2	20
Perennial grass	*Danthonia californica*	9.1	10
Perennial grass	*Elymus glaucus*	36.3	41
	Total:	**89.0**	**100**

RESULTS

Data collected in July 2008 allow us to make initial assessments of the effectiveness of the treatments conducted in 2007. Meadow knapweed cover generally responded similarly at both the Fire Station and Spur Road sites with respect to treatment type (Figure 7). The mow/solar and grub/mulch/seed treatments were the most effective, reducing relative knapweed cover 100% and at least 50% respectively. All other treatment types led to an increase in total knapweed cover except for the much/seed treatment at the Spur Road study site, where cover remained little changed (Figure 7). The only difference between sites regarding the mulching treatment was

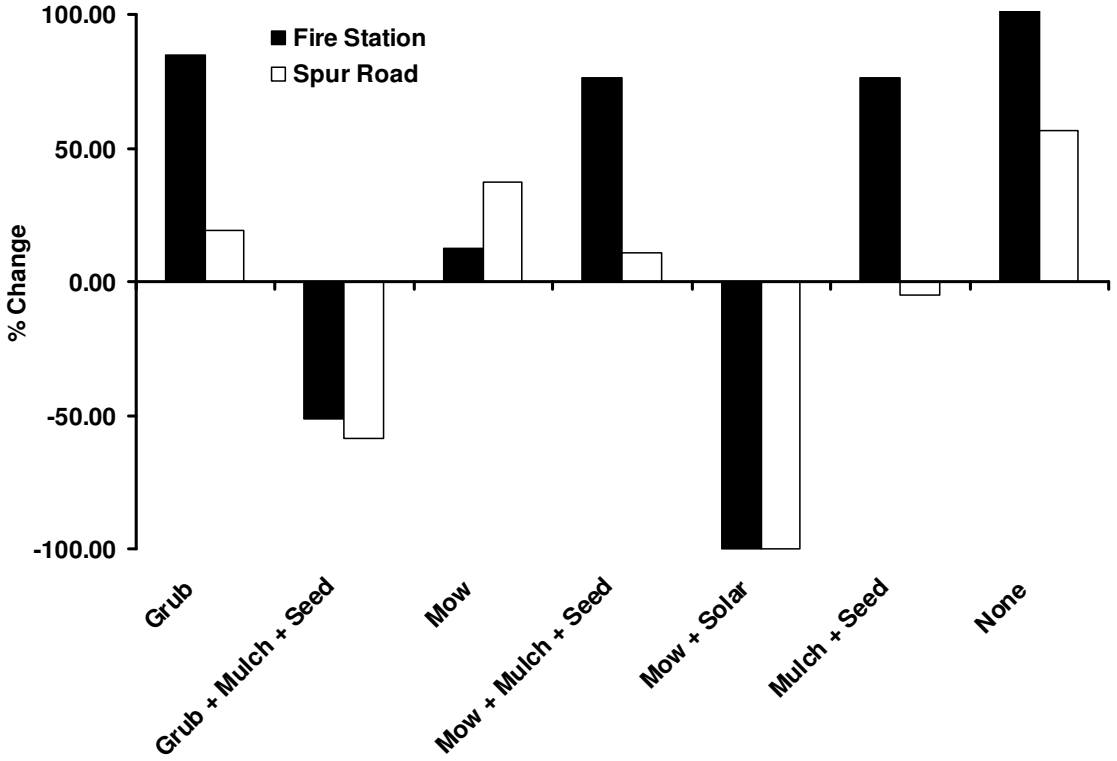

Figure 7. Percent change in meadow knapweed cover from 2007 to 2008 in the Fire Station and Spur Road study sites. Treatment types are listed along the x-axis.

the type of mulch used; additional plots would need to be installed to determine the effectiveness of the different mulch types on reducing total knapweed cover.

Meadow knapweed demographics changed fairly consistently between treatment types and study sites (Figure 8). Knapweed seedlings fell 50 to 100% relative to their total numbers in 2007 in all treatments and at both sites except the Fire Station untreated plots, where a smaller decrease was recorded. The grub/mulch/seed, mow/mulch/seed, and mow/solar treatments generally decreased the total number of individuals in every category relative to their 2007 levels (Figure 8). The grub treatment resulted in an increase in the number of rosettes at both sites. There were inconsistent effects of the mow, mulch/seed, and control treatments on the different life stages of meadow knapweed.

The general increase in knapweed cover (Figure 7) can be reconciled with the general decrease in total individuals (Figure 8) by looking at the average cover of individuals (Table 3). Average plant heights for rosettes and bolts increased within every plot and treatment type. Rosette heights ranged from 18.86 to 29.73% larger while bolt heights ranged from 51.95 to 88.59% larger. The grub and grub/mulch/seed treatments had the largest percent increase in plant heights. Larger knapweed individuals may be indicative of more favorable spring growing conditions in 2008 or may be a compensatory growth response to mechanical disturbance and will have to be reassessed in 2009.

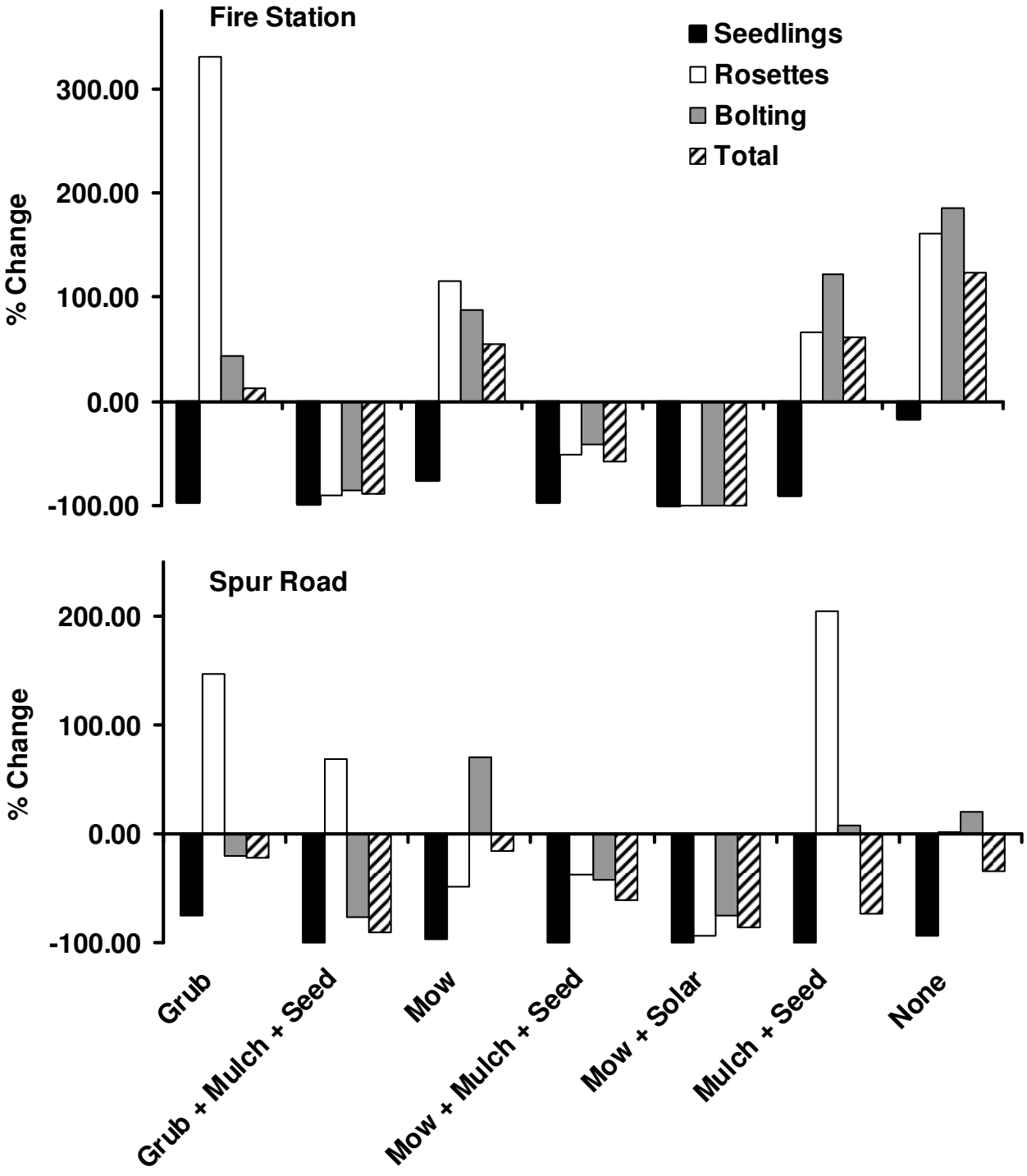

Figure 8. Relative increase or decrease in meadow knapweed seedlings, rosettes, and bolting individuals between 2007 and 2008 at the Fire Station and Spur Road study sites. Treatment type is listed along the x-axis.

Table 3. Percent increase in meadow knapweed rosette and bolt heights between 2007 and 2008. Values are averages of 2 to 5 plots with up to 10 plants in each plot. No decreases were recorded

Treatment type	% increase in rosette height	% increase in bolt height
grub	29.73	79.38
grub/mulch/seed	28.41	88.59
mow	27.99	62.59
mow/mulch/seed	18.86	51.95
mow/solar	21.20	54.06
mulch/seed	26.65	77.67
none (control)	20.39	60.79

Treatment type affected species richness within plots similarly between sites (Figure 9). Total species richness declined between 2007 and 2008 except in the Spur Road mow plots, where it remained the same, and in the untreated Spur Road plots, where it increased. Species richness results in the untreated plots were ambiguous, increasing in the Spur Road site and decreasing in the Fire Station site. The general decrease in total species richness is contrasted with an increase in the relative native species richness in many of the treatment types and between sites (Figure 10).

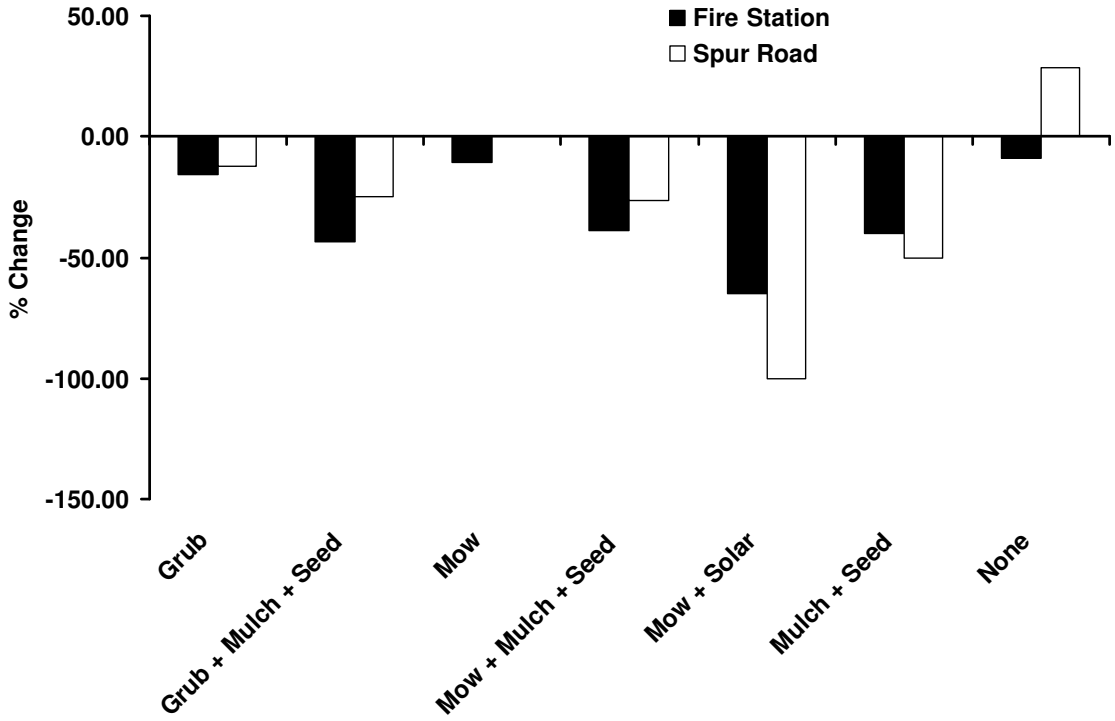

Figure 9. Average percent change in species richness between 2007 and 2008. The Spur Road mow treatment has a value of 0%. Treatment type is listed along the x-axis.

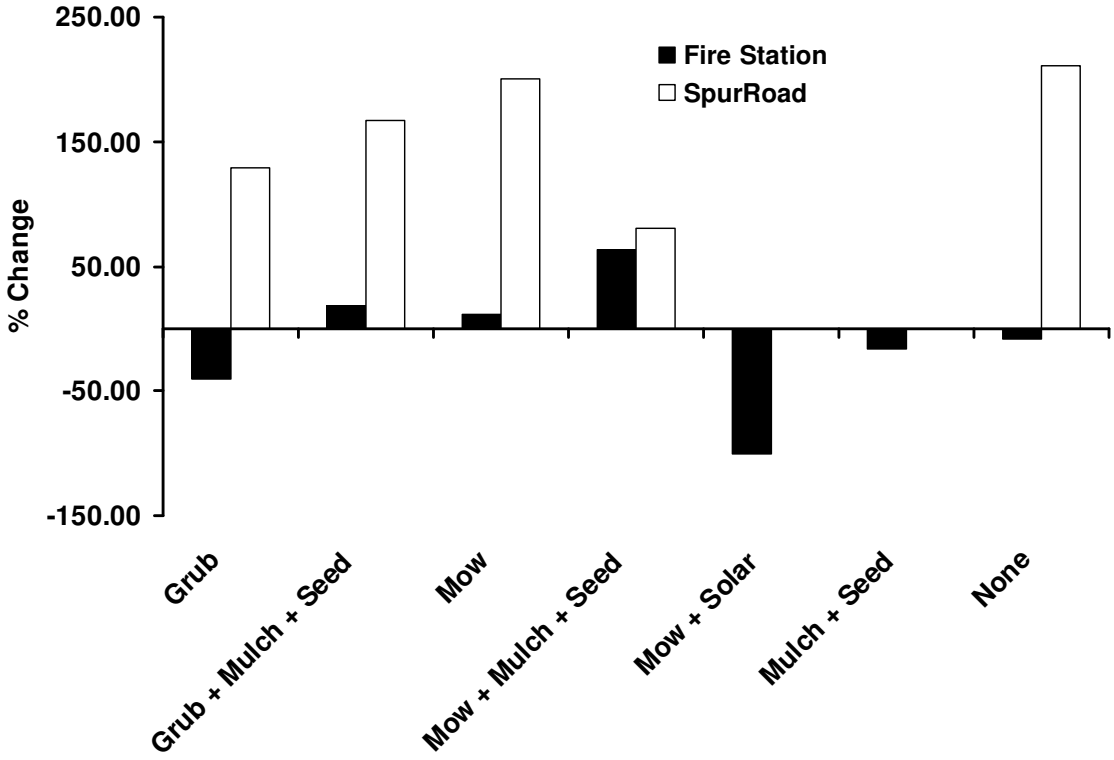

Figure 10. Average percent change in native plant species from 2007 to 2008. There was no change (0%) in the Spur Road mow/solar and mulch/seed plots. Treatment type is listed along the x-axis.

DISCUSSION

The preliminary data collected in 2007 indicate effective methods for controlling meadow knapweed. The grub/mulch/seed and mow/solar treatments each significantly reduced the cover of knapweed and the total number of individuals present. The mow/solar treatment effectively reduced the respective piece of ground to a blank slate where bare ground cover predominated. In 2008 these plots were mulched and seeded. If the supplementary native seed can compete with the seeds of knapweed and other invasive plants both in the seed bank and raining down from adjacent areas, this method may have great potential. The grub/mulch/seed method proved effective in reducing knapweed but does not affect any of the other invasive plants. We will be able to assess the effectiveness of this method as a treatment for all invasive species after we collect data in 2009.

Despite the seeding that took place in 2007, blue wildrye was only present at one Fire Station plot (20% cover) and one Spur Road plot (0.1% cover) in July 2008; Columbia brome was only found in the same Spur Road plot (0.1% cover). Blue wildrye was germinating with varied success at the Spur Road site after the July 2008 seeding. Much of the success in controlling meadow knapweed will depend on the establishment of native graminoids and forbs that can effectively compete with knapweed.

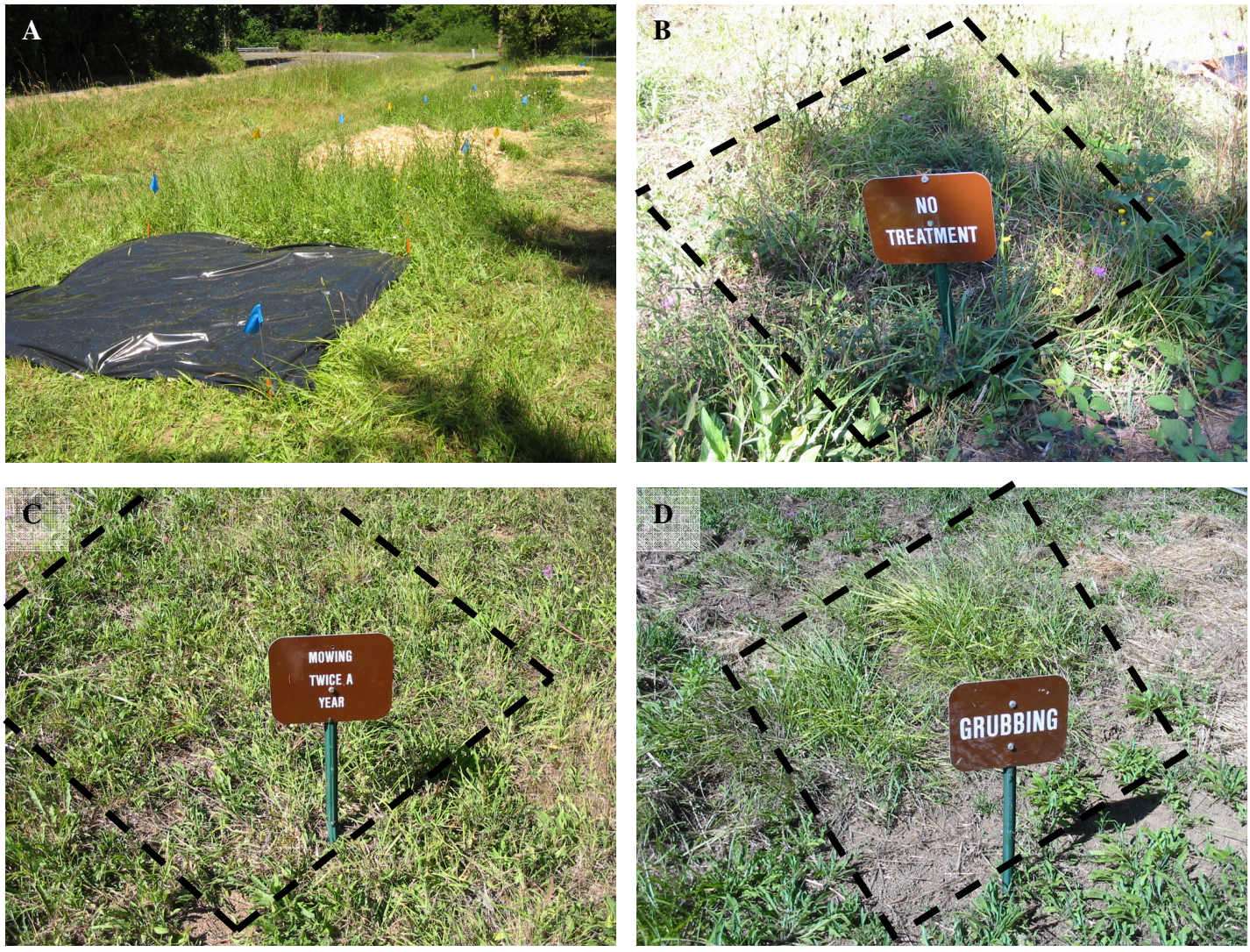

Figure 11. Treatment plots at the Fire Station site. In photos B-D, black lines have been added to clarify treatment plot boundaries. **A**. Plots immediately after 2007 treatment. A solarization plot is in the foreground, followed by a mulch/seed plot and a grub/mulch/seed plot. **B.** Control plot in August 2007. **C.** Mow plot in August 2007 after second treatment. Note the absence of pink flowers that are present outside of the plot and in the control plot in photo B. **D.** Grubbing plot in August, 2007.

LITERATURE CITED

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APPENDIX A. DIRECTIONS AND CONTACTS.

Directions

Take 99S to Monroe, turn right on Territorial Highway.
At intersection, turn right on Highway 36.
Turn right on Horton Road.

To Fire Station plots
Follow Horton Rd. to Y-intersection with High Pass Rd. Plots are located in field at Y next to Fire Station. Park in Fire Station lot.

To Roadside plots
At Fire Station, stay left on Horton Rd. At the market, turn right onto Lake Creek Rd.
At the beginning of the lake, turn right onto Rd. 15-7-26
Right onto 15-6-19.1

Contacts

Horton Fire Station
Erik Goetsch, Assistant Chief, Lake Creek Fire-Rescue
captain2602@yahoo.com
call (all call's) 541-914-3934

BLM Eugene
Theresa Coble, South Valley Resource Area Manager, 541-683-6257
Nancy Sawtelle, Botanist, 541-683-6111

APPENDIX B. TREATMENT ASSIGNMENTS AT FIRE STATION AND SPUR ROAD SITES

Fire Station			
Plots	**Meter**	**Treatment, 2007**	**Treatment, 2008**
1	0-2	mow + solar	much + seed
2	2-4	mow	mow
3	4-6	mulch + seed	mulch + seed
4	6-8	none	none
5	8-10	mulch + seed	mulch + seed
6	10-12	mow	mow
7	12-14	none	none
8	14-16	grub + mulch + seed	grub + mulch + seed
9	16-18	grub	grub
10	18-20	grub + mulch + seed	grub + mulch + seed
11	20-22	mow + solar	mow + solar*
12	22-24	mow	mow
13	24-26	mulch + seed	mulch + seed
14	26-28	grub + mulch + seed	grub + mulch + seed
15	28-30	grub + mulch + seed	grub + mulch + seed
16	30-32	none	none
17	32-34	none	none
18	34-36	mow + solar	mulch + seed
19	36-38	mow + mulch + seed	mow + mulch + seed
20	38-40	grub	grub
21	40-42	grub	grub
22	42-44	mow + mulch + seed	mow + mulch + seed
23	44-46	mow	mow
24	46-48	mow + mulch + seed	mow + mulch + seed

*Half of plastic sheet blew up between August 2007 and July 2008. Meadow knapweed plants continued growing in the uncovered portion and hence the plot was mowed again and resolarized.

Spur Road			
Plots	**Meter**	**2007 Treatment**	**2008 Treatment**
1	0-2	mow + mulch + seed	mow + mulch + seed
2	2-4	mow	mow
3	4-6	grub + mulch + seed	grub + mulch + seed
4	6-8	mow	mow
5	8-10	grub	grub
6	10-12	grub	grub
7	12-14	mow	mow
8	14-16	mow + mulch + seed	mow + mulch + seed
9	16-18	grub + mulch + seed	grub + mulch + seed
10	18-20	mulch + seed	mulch + seed
11	20-22	mow + solar	mulch + seed
12	22-24	grub	grub
13	24-26	none	none
14	26-28	mow	mow
15	28-30	none	none
16	30-32	none	none
17	32-34	mulch + seed	mulch + seed
18	34-36	mow + mulch + seed	mow + mulch + seed
19	36-38	mow + solar	mulch + seed
20	38-40	mow + solar	mulch + seed
21	40-42	grub	grub
22	42-44	mow + mulch + seed	mow + mulch + seed
23	44-46	none	mow (1x)
24	46-48	grub + mulch + seed	grub + mulch + seed
25	48-50	none	mow (1x)

APPENDIX C. SPECIES FOUND AT THE FIRE STATION AND SPUR ROAD STUDY SITES.

Table C-1. Species found in meadow knapweed treatment plots at the Fire Station and Spur Road study sites. "x" indicates that a species was present

Species	Fire Station	Spur Road	Invasive
Agrostis capillaris	x	x	x
Agrostis sp.	x		
Aira caryophylla		x	x
Anthoxanthum odoratum	x		x
Brassicaceae sp.		x	x
Bromus mollis	x	x	x
Bromus sitchensis	x		
Bromus vulgaris		x	
Carex sp.	x		
Centaurea pratense	x	x	x
Centaurium erythraea		x	x
Cerastium sp.		x	x
Chrysanthemum leucanthemum	x	x	x
Circium sp.	x		x
Crepis sp.		x	x
Cynosurus echinatus		x	x
Cytisus scoparius		x	x
Dactylis glomerata	x		x
Daucus carota	x		x
Elymus glaucus	x	x	
Equisetum arvense	x		
Festuca arundinacea	x		x
Festuca idahoensis	x		
Fragaria virginiana	x		
Geranium dissectum	x		x
Holcus lanatus	x	x	x
Hypericum perforatum	x	x	x
Hypochaeris radicata	x	x	x
Linum bienne		x	x
Lotus micranthus		x	
Lupinus sp.		x	
Luzula sp.		x	
Myosotis sp.	x	x	x
Plantago lanceolata	x	x	x
Poa cf. *annua*	x		x
Poa compressa	x		x
Poa pratensis	x		x
Poa sp.	x		
Poaceae sp.	x		

Table C-1, cont. Species found in meadow knapweed treatment plots at the Fire Station and Spur Road study sites. "x" indicates that a species was present

Species	Fire Station	Spur Road	Invasive
Poaceae sp. (short grass)	x		x
Poaceae sp. (smooth grass)	x		
Prunella vulgaris	x		
Pseudotsuga menziesii	x	x	
Rubus discolor	x		x
Rubus laciniatus	x		x
Rubus sp.	x		x
Rubus ursinus	x	x	
Taraxacum officinale	x	x	x
Trifolium dubium		x	x
Trifolium pratense	x	x	x
Trifolium repens	x		x
Unknown forb		x	x
Veronica arvensis	x		x
Vicia sativa	x	x	x
Vinca major	x		x
Vulpia bromoides		x	x