Adaptive approaches to managing cheatgrass in rangelands of south-west Montana and the north-eastern regions of the sagebrush steppe.

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Lisa J. Rew, Jane Mangold, Bok Sowell and Cathy Zabinski

Goal:

This framework is designed to assist land managers in deciding how to manage cheatgrass on their rangelands, often with the aim of increasing perennial grasses and sometimes forbs. Because there is no single way to manage weeds, adapting management to local conditions and objectives is necessary, however having some recommendations can help. Our recommendations are based on studies completed in south-west Montana (Beaverhead, Gallatin, Madison and Park counties) between 2017-2023. These studies were carried out on sites where cheatgrass was the dominant weed and no noxious weeds were present. The perennial grasses and forbs were mainly native, but desert alyssum, Kentucky bluegrass and small amounts of smooth brome were present. The sites were lightly to moderately grazed by cattle and wildlife but were not highly disturbed otherwise.

Knowing your land and monitoring changes in cheatgrass and perennial grasses is key. Plant biomass and community composition can vary annually based on weather, but long-term monitoring can help determine when to act. Also important is where you find cheatgrass - it invades warm south-facing slopes and places where the soil is disturbed, for example by cattle or other animals and vehicles, so such areas should be monitored more often. Monitoring can be as simple as walking through areas that you would treat (e.g., south facing slopes) and recording how much cheatgrass, perennial grass and other vegetation you found on your phone or field notebook (see explanation at end for more detail[1]). Monitoring should be performed every year or two so that you can determine if the cheatgrass is increasing or, staying similar but fluctuating with the weather.

Having monitored, you will know the state of cheatgrass invasion and how much perennial grass there is - both of which help determine your potential management actions (Figure 1) at your areas of interest. Cheatgrass can be classified into 5 levels (<1, 1-5, 6-25, 26-50, >51 %) for management actions (Figure 1). Understanding when to act and the likely response of the other vegetation will help you decide when to take action (Table 1) and which management approach or approaches are best for you (Table 2 and 3). Generally using more than one management approach increases the chance of reducing cheatgrass and getting more desired grasses and other species. We include the results we obtained in our studies as well as a combination we haven't yet tried (Table 3). For full benefit of your management actions, you should minimize grazing pressure and any disturbances that cause bare ground (e.g. driving vehicles randomly over the land particularly when wet, fire, etc.) for a couple of years after management. Weeds, cheatgrass particularly, thrive on freshly disturbed ground because these areas have more moisture, nutrients, and light, which the weedy species can take advantage of more quickly than perennial species.

Cheatgrass is not as prevalent in Montana or the north-eastern portion of the sagebrush biome as it is in some areas; here most places have no cheatgrass, or a trace to mild infestations (Level 1-3). Areas where cheatgrass reaches Level 4 and 5 are generally smaller acreages in highly disturbed areas, for example around water tanks or along roadsides where there has been recent disturbance. Deciding when to take action is your choice, but we would recommend taking action at level 3, particularly when cheatgrass cover is over 15%. Spot treatments of small, high-density patches is encouraged to keep cheatgrass seeds from moving into less infested areas.

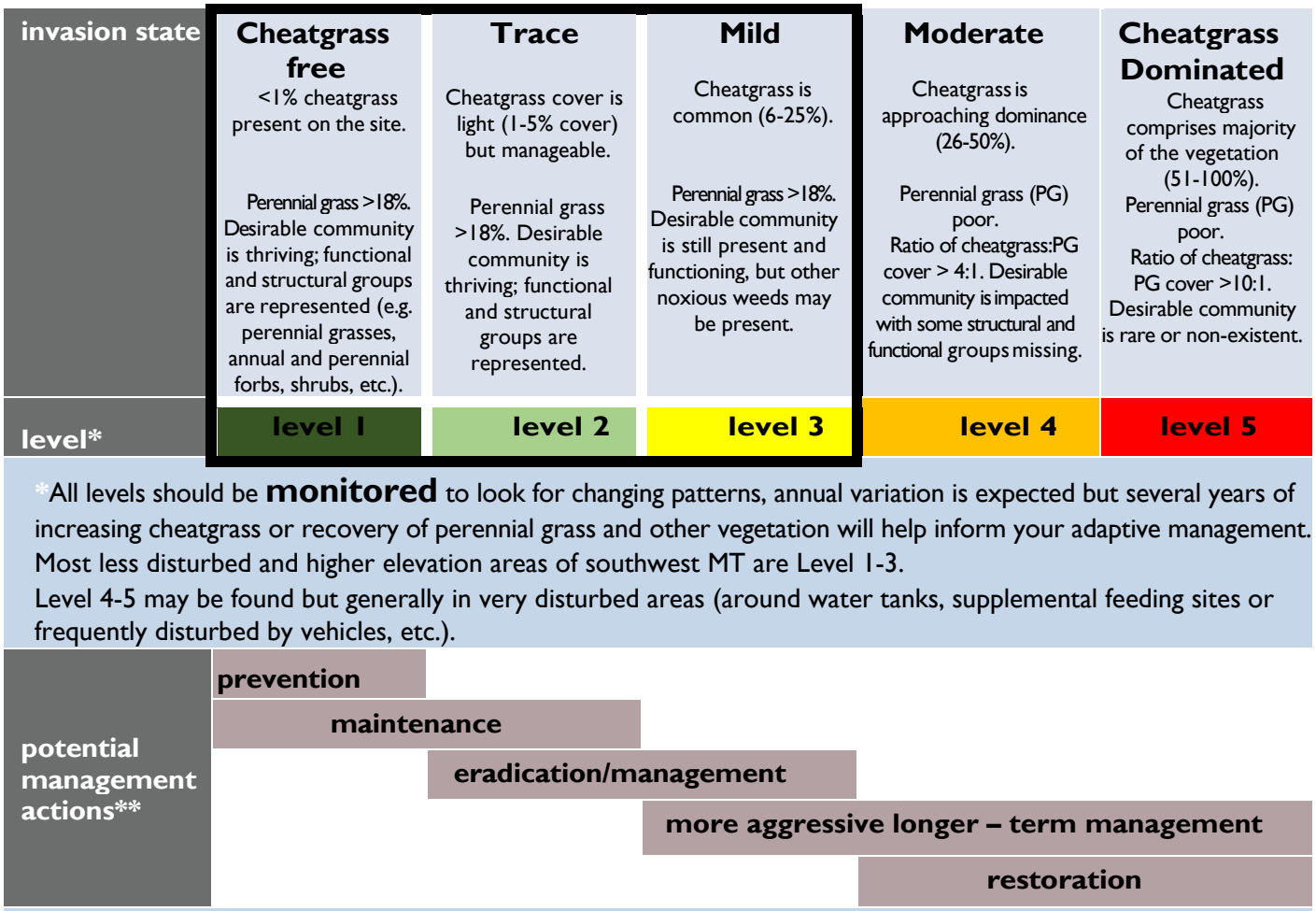

Figure 1[2]. Cheatgrass cover can be classified into 5 levels which respond to the invasion state. Knowing the level of invasion helps to determine which management action should be taken.

In areas where cheatgrass is absent or very rare, continued monitoring and prevention tactics should be implemented. On a site where cheatgrass has had relatively minor impact on the native plant community, recovery potential is likely high and effort needed for successful control may be low. At level 3 and above, cheatgrass may affect land use goals (such as a reduction in forage production and loss of other species). Once cheatgrass effects surpass an acceptable level, the incentive to implement control actions increases and so do investments of time, energy and money. Management actions can be more effective when you have more perennial grass (>18%) because they compete for resources and help further reduce cheatgrass abundance[3]. When the ratio of cheatgrass:perennial grass is equal or more than 4:1, there can be greater response from the perennial grasses which will increase[4]. When cheatgrass reaches sufficient abundance (level 4-5) to alter the system functions (reduced diversity, reduced perennial forage production, increased fire frequency), the system may have crossed an ecological threshold. At this point, the cheatgrass to perennial grass ratios are very high (likely to be ≥10:1) and restoration seeding is needed[4]. Even so, recovery potential may decrease because desirable components of the system have been lost. At this stage (level 5) it is likely very difficult to remove all cheatgrass, so minimizing spread but otherwise focusing on areas at level 1-3 may be best.

Table 1. Suggested actions for each of the five levels of cheatgrass cover, along with observations and likelihood of recovery based on our results at sites in levels 1-4, and other regions for levels 4- 5.

Level	level 1	level 2	level 3	level 4	level 5
Cheatgrass cover (%)	<1	1-5	6-25	26-50	>51
Action	Monitor	Monitor	Monitor, and Act especially if cover is over 15%	Monitor and Act	Monitor and Act
Observation	Our sites remained at this level for the duration of our longest study with no treatment (6 years)	Our sites remained at this level for the duration of our longest study with no treatment (6 years). Treatments reduced cheatgrass for some years (2-4), but it returned to pre-treatment levels, so re-treatment would be necessary.	Treatments reduced cheatgrass for some years (2-4), but it returned to pre-treatment levels, so re-treatment would be necessary. *This is certainly the level where action should start, particularly at or above 15% cover.*	We had no sites consistently at this level, though there were small level 4 patches which were controlled for 2-4 years. Action will be necessary over a long period and disturbance should be minimized for several years after treatment.	We had no patches at this density. Strong action will be necessary over a longer period and further disturbance should be minimized.
Likelihood of desired vegetation recovery	Already high	Perennial grass cover was > 18%, but we did not observe an increase in cover or biomass after treatment. Other species did not increase either. This may be because when cheatgrass is at lower levels, it is not competing strongly with the other vegetation.	Perennial grass cover was > 18%, but we did not observe an increase in cover or biomass after treatment. Other species did not increase either. This may be because cheatgrass is still not competing strongly with the other vegetation.	If the ratio of cheatgrass is $\geq$4:1 and <10:1, high recovery of perennial grasses has been observed at high elevation sites in Wyoming[4].	We had no sites in this level. In other regions there hasn't been much success recovering from such high abundance, particularly if the area is large. Some degree of success is possible with considerable effort.

Table 2. Possible management actions or approaches that can be used, how to apply them and the general response of cheatgrass and other vegetation, taken from information at our sites which were mainly levels 1-3.

Actions	**Herbicide**		**Vegetation removal**		**Soil amendment**	**Seeding**
	Rejuvra (indaziflam)	Plateau (Imazapic)	Mowing/Weed eater	Targeted grazing	Nutrafix, Edaphix[5]	
How	Apply before fall emergence, mid-July to mid-August. See herbicide label for application recommendations.	Apply after fall emergence, best at the 2-3 leaf stage[4]. See herbicide label for application recommendations.	Trim when cheatgrass actively growing and other vegetation senescing (dried off), late fall or early spring.	High intensity, short duration grazing when cheatgrass actively growing and other vegetation senescing (dried off), late fall or early spring.	Apply before fall emergence, around mid-August. Aims to increase perennials and reduce non-native annual grasses.	Use NRCS for seeding recommendations[6]. Fall or early spring seeding recommended.
Response of cheatgrass	Reduced cheatgrass for 2 years though intended to last 3-4 years.	Reduced cheatgrass for 1-2 years[3], but we observed 3-4 years reduction after fall applications two years in a row.	Neutral to negative impact on cheatgrass after couple months. Needs to be repeated 1-2 times per season.	Good forage. Neutral to compensatory response of cheatgrass after couple months. Needs to be repeated 1-2 times per season.	Reduced cheatgrass, for 1-2 years of our 3-year study. Newer product, few published reports.	Should only be used with other approaches (note, not within 24 months of using Rejuvra).
Response of other vegetation (PG is perennial grass)	PG biomass should increase, but bluegrass, fescue and ryegrass species are sensitive. Our PG increased for 2 of 3 years. Other vegetation and number of species did not increase.	PG and other vegetation should increase if cheatgrass at higher levels - we did not observe an increase in cover, biomass nor number of species.	Variable. PG and other vegetation did not increase, neither did number of species.	Variable. PG and other vegetation did not increase, neither did number of species.	PG and other vegetation did not increase, neither did number of species.	Variable. Seedlings were observed and did impact cheatgrass cover, but were not large enough to increase perennial grass abundance in first 3 years.
Number of sites	3 (5 trials)	12	11	11	3 (5 trials)	11

Table 3. Integrating different approaches to manage cheatgrass and rangeland production, possible combinations and results from our studies. ↓ represents lower amount of cheatgrass compared to the no action control/check, = means the treatment did not differ from the no action control. The years the site was evaluated after the last treatment is provided. H = Herbicide.

Primary Treatment (fall)	H, Rejuvra	H, Plateau	H, Plateau	H, Plateau	H, Plateau	H, Plateau	H, Plateau	Soil amendment, Nutrafix	Soil amendment, Nutrafix + seed	Soil amendment + Rejuvra
Secondary treatment (2nd fall)		H, Plateau	Seed	Mow	Mow + seed	Targeted grazing	Targeted grazing + seed			Did not test but should reduce cheatgrass & increase PG and other vegetation
1 yr post	↓	↓	↓ + lower with seed than without	↓	↓ + lower with seed than without	=	= but lower with seed	↓	↓ no extra benefit with seed	
2nd yr post	↓	↓	=	=	= but lower with seed	=	= but lower with seed	↓	↓ no extra benefit with seed	
3rd	=	↓						=	=	
4th		↓ or = depending on site								
Years assessed post 2° treatment (sites)	3 (3,5 trials)	4 (12)	2 (11)	2 (11)	2 (11)	2 (11)	2 (11)	3 (3,5 trials)	3 (3,5 trials)	

Further resources

Easy monitoring method. The easiest way to do this is to either look at the ground in front of you or slowly turn 360 degrees, estimating the cover of cheatgrass, noxious weeds, perennial grass, forbs, bare-ground, and litter. You can do this as a percentage, and your total should add to 100. If you keep measures more precise, for example, don't round to the nearest 5%, you will more easily be able to determine if anything is changing. Do several of these estimates (5-18), assessing the same size area (3'-6' radius from where you are standing, depending on how far you can see all the vegetation) each time. Record your observations somewhere you will find them each year (e.g., your phone or field notebook). Doing this will determine if the cheatgrass is increasing or staying similar with fluctuations from year to year depending on the weather.

[1] Figure 1 is adapted from Figure 4-2 Mealor et al. (2013) Cheatgrass Management Handbook. https://www.nrcs.usda.gov/sites/default/files/2022-09/cheatgrass_management_handbook_0.pdf

[2] Rew unpublished data from these studies. All in the process of being published.

[3] Wood and Mealor (2022) Identifying structural thresholds in annual grass-invaded rangelands. Rangeland Ecology and Management, 1550-7424. https://bioone.org/journals/rangeland-ecology-and-management/volume-83/issue-1/j.rama.2022.02.010/Identifying-Structural-Thresholds-in-Annual-GrassInvaded-Rangelands/10.1016/j.rama.2022.02.010.full

[4] Mangold, J., H. Parkinson, C. Duncan, P. Rice, E. Davis, and F. Menalled. 2013. Downy brome (*Bromus tectorum*) control with imazapic on Montana grasslands. Invasive Plant Science and Management **6**:554-558. https://bioone.org/journals/invasive-plant-science-and-management/volume-6/issue-4/IPSM-D-13-00016.1/Downy-Brome-Bromus-tectorum-Control-with-Imazapic-on-Montana-Grasslands/10.1614/IPSM-D-13-00016.1.full

[5] *NRCS – https://www.nrcs.usda.gov/conservation-basics/conservation-by-state/montana*

[6] https://www.nutrafixsoils.com/