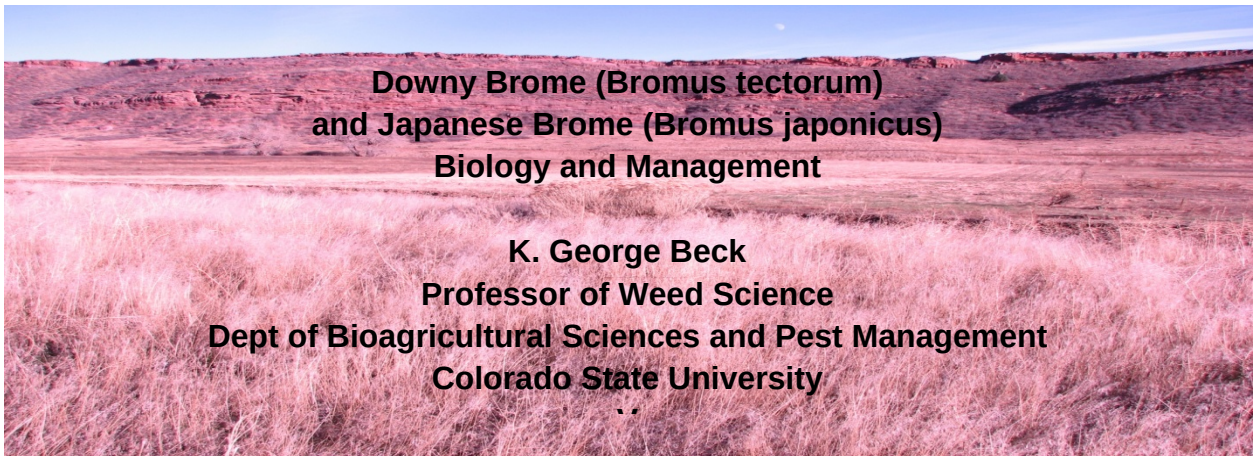

Downy Brome (Bromus tectorum) and Japanese Brome (Bromus japonicus) Biology and Management

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Introduction

Downy brome, or cheatgrass, is a winter annual member of the grass family that typically germinates in late summer or fall following precipitation and overwinters in a vegetative state. Japanese brome also is a winter annual member of the grass family. It too germinates in fall and survives the winter in a vegetative state. Both plants resume growth in late winter or early spring, flower in May and June, then die after producing seed.

Description

Downy brome

- Grows 4-30 inches tall
- Leaf blades and sheaths light green; covered with fine, soft hairs
- Flowers or inflorescence is a panicle 2-6 inches long, dense, soft, drooping spikelets (seedheads)
- Awns 0.38-0.6 inches long, attach to hair and clothing aiding seed dispersal
- Entire panicle may be purplish
- Whole plant may turn purplish after exposure to low temperatures or low moisture

Japanese brome

- Grows 8-48 inches tall
- Leaf blades hairy or not, sheaths are hairy
- Panicle is 4.5-8 inches long with 3-5 branches that usually droop
- Spikelets (seedheads) 0.25 inches wide, 0.5 inches long
- Awns 0.25-0.75 inches long

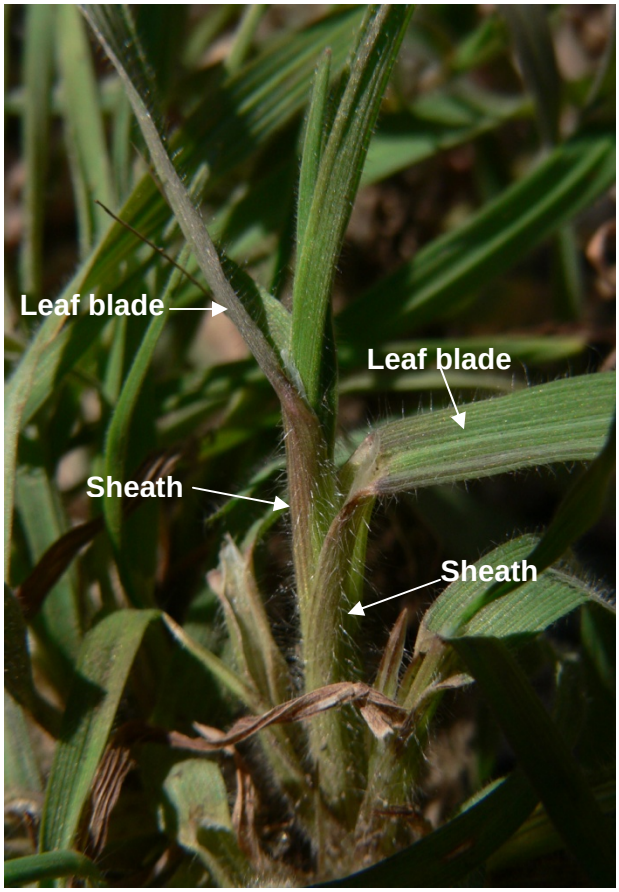
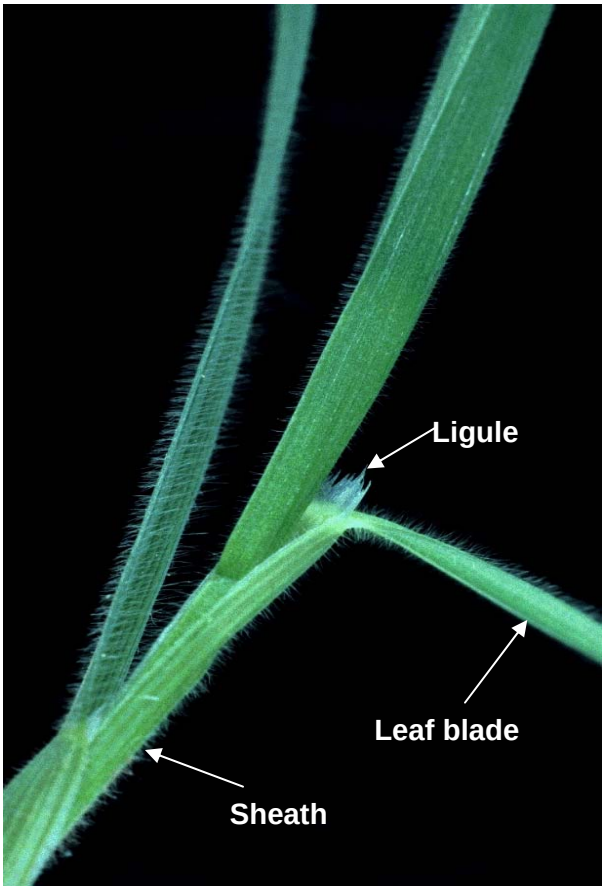


Figure 1. Downy brome in mid-winter; note reddish color to leaf blades and sheath; leaf blades and sheaths are hairy

Figure 2. Downy brome leaf blade, sheath, and ligule; note light green color, jagged ligule and hairy leaf margins.



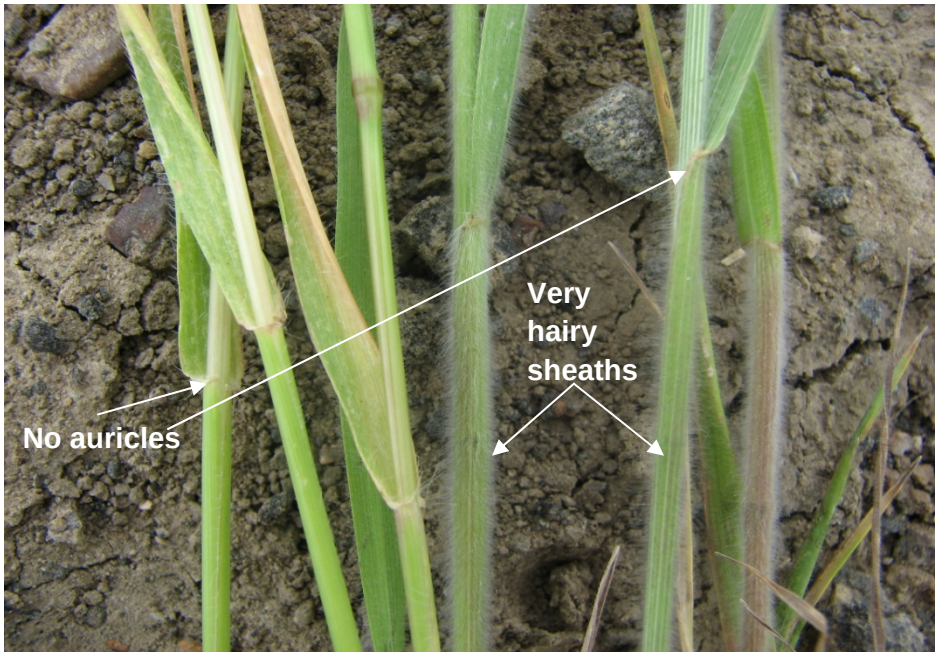


Figure 3. Downy brome shoots; those on right have hairier sheaths; no auricles present

Figure 4. Downy brome in bloom; panicles with spikelets (seedheads) beginning to droop.

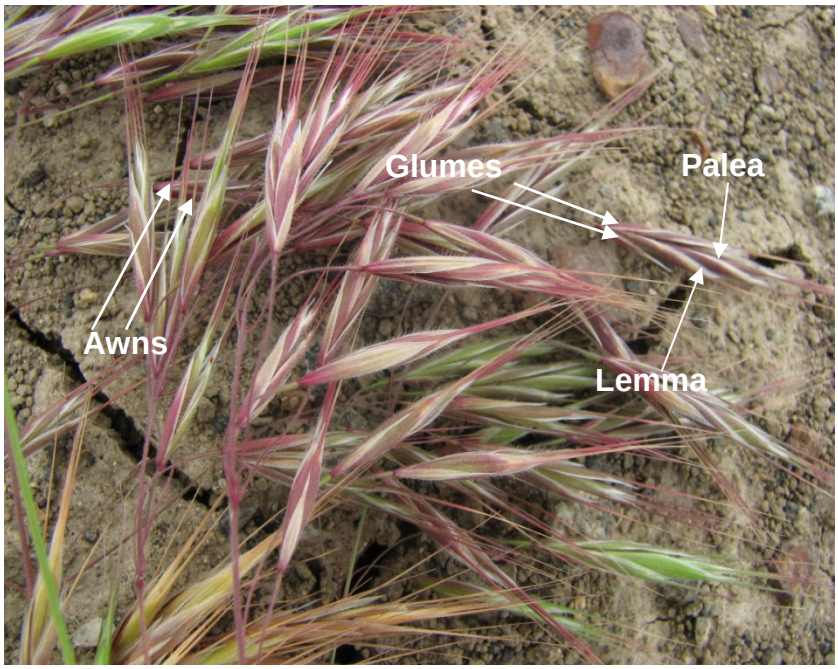


Figure 5. Downy brome spikelets or seedheads; note reddish color and long awns

Figure 6. Downy brome drooping panicle near seed dispersal.

Figure 7. Japanese brome; note hairy sheaths

Figure 8. Japanese brome foliage; note these leaves lack hairiness.

Figure 9. Japanese brome panicle; spikelets (seedheads) may droop.

Figure 10. Japanese brome panicle; note short awns and scale-like glumes

Biology and Ecology

Downy brome seasonal development (phenology)

- Self-pollinating, annual or winter annual, reproduces only from seed
- Germinates late-summer into fall following precipitation
    - Can germinate in spring also following precipitation
- Fall germinating plants overwinter in vegetative state
    - Resume vigorous growth in spring onset of warmer weather
- Flowers in late April into early May
    - May be delayed at higher elevation
- Plants turn purplish from early May into June
    - Plants turn brown as seeds continue to ripen
- Seeds mature mid- to late-June
    - Seeds fall from parent plant mid-June to early-July, plants dead at this time
- Seed populations over 70 million/acre
- Seeds survive in soil up to 5 years

Japanese brome phenology

- Winter annual
- Germinates in fall (September or October) following precipitation
    - From seed produced the previous year
- Overwinters in vegetative growth stage
- Resumes vigorous growth in spring onset warmer weather
- Begins flowering early-May seeds ripe late-June into early-July
    - Mature plants then die
- Seed remains on plants over summer and shed in fall
- Produces over 380 million seeds/acre
- Soil seed longevity is unknown

Management

Weed management strategies

There are three general weed management strategies:

- ***Prevention*** includes steps taken to avoid acquiring a weed problem
    - Cleaning vehicles (especially undercarriages), implements, and other equipment free of weed seeds and other propagules
    - Sow only certified, high quality, weed-seed-free desirable plant seeds
    - Only use certified weed-seed-free mulch

    - Vigilance to detect new and/or small infestations, controlling them to avoid large acreage problems
- ***Eradication*** is the complete removal of a weed species from a defined area not to occur again unless re-introduced
- ***Control*** is the decrease of weed populations in an area such that land management goals and objectives can be achieved

Prevention and control are the most often practiced weed management strategies.

Control methods

There are four general categories of weed control methods:

- **Chemical control** is the use of herbicides or growth regulators to directly suppress, kill, or inhibit weeds
- **Mechanical control** employs physical methods to disrupt weed growth
    - Hand-pulling
    - Hoeing
    - Tillage
    - Mowing
    - Fire
    - Flooding
- **Biological control** involves using organisms to suppress or decrease weeds
    - Evolved natural enemies; insects, pathogens
    - Livestock managed for weed control rather than production of food and fiber
- **Cultural control** are steps taken to introduce and/or enhance competition from desirable plants to keep weeds from re-invading
    - Seeding or transplanting
    - Fertilization where necessary
    - Irrigation where possible
    - Introduction of naturally occurring arbuscular mycorrhizal fungi

Successional weed management

Ecologically-based weed management, sometimes referred to as successional weed management, is an approach where land managers determine the composition of the existing plant community and decide upon a species composition that will allow achievement of land management goals and objectives and to determine what changes are necessary to arrive at the desired plant community. ***Successional weed management and mine site reclamation are similar processes – but successional weed management will complement mine site reclamation.*** Successional weed

management is a process to develop weed management programs based upon our current understanding of succession. This approach recognizes that:

- Plant communities are constantly changing
- Uses technology to enhance natural processes that regulate vegetation change
- Direct weed infested communities on a trajectory to yield desirable plant communities

Successional weed management exploits the three primary drivers of succession:

- Site availability
- Differential species availability
- Differential species performance

The corresponding management components are:

- Designed disturbance (correlates with site availability)
- Controlled colonization (correlates with differential species availability)
- Controlled species performance (correlates with differential species performance)

Management input over time (Table 1) and monitoring results allows for an adaptive management approach (using the successional weed management framework) to keep the undesired plant community moving forward to ultimately achieve the desired plant community to meet land management goals and objectives. The desired plant community will replace the weed infested plant community and be resistant to re-invasion by the same weed or suite of weeds and resistant to replacement by other more aggressive weed species. Successional weed management is a very comprehensive approach and typically involves:

a. Suppression or control (*designed disturbance*) of the weed or suite of weeds that currently occupies the plant community;
b. Ameliorating any soil conditions (*controlled species performance*) that would prohibit successful establishment of a desired plant community;
c. Seeding and/or transplanting propagules or whole plants (*controlled colonization*) of the desired plant community;
d. Continued weed suppression/control and soil amendments where and when necessary (*controlled species performance*).

Table 1. Successional weed management treatments for mine sites.

Designed Disturbance	**Controlled Colonization**	**Controlled Species Performance**
Tillage	Seed bed preparation	Irrigation
Herbicide; Plateau Matrix Roundup Journey Landmark XP Oust	Seeding Drill Broadcast Hydroseed Transplanting Herbicide	Soil amendments Micronutrients Macronutrients Herbicide
	Mulching	Mulching
Fire		AMF inoculation Transplant native plants

A comprehensive weed management plan

- Weed management is complex; must become organized
- Comprehensive weed management is a component of reclamation process
- Comprehensive weed management includes:
    - Mapping
    - Developing successional weed management approach
    - Systematically implement the plan
    - Monitor and evaluate results
    - Keep detailed records

Mapping

- Map annual brome infestations on the mined site to become organized
    - Continuously monitor stockpiled soils for presence and location of annual bromes
    - Map annual bromes (and other noxious weeds) and planted desirable species (seed mix) on reclaimed areas
    - Map annual bromes (and other noxious weeds) on roads, conveyances, and all other areas on the mined site
- Map should include size, location, and type of weed infestations
    - Size is important to determine where eradication is possible compared to controlling, or decreasing, weed populations
    - Location refers to proximity to the core infestation – is it part of the core or on the perimeter?
    - Type refers to the developmental stage of the infestation
        - Small infestation – 500 to 1000 ft^2 or less
            - Can be eradicated in one or two attempts

        - Moderate infestation – larger but once weed populations decreased sufficiently, seeding and establishing desirable species will keep weeds from re-invading
        - Large or core infestation
            - Multiple control treatments necessary
            - Seeding desirable species will keep re-invasion in check
            - Aggressive control treatments necessary after desirable species establish

Generally, a map should be sufficiently detailed so it can serve as an appropriate reference to evaluate progress at any moment during reclamation – more information usually is best!

Develop a successional weed management approach

Using the map as a reference, develop a successional weed management approach that dovetails into the reclamation plan for the mined site. Tool choices for decreasing (controlling) downy brome or Japanese brome infestations are somewhat limited at this time and reliance upon developing a desirable plant community is of paramount importance to preventing re-invasion and successfully reclaiming the mined site.

Implement the approach systematically

- Use map as a reference to guide where to begin and then progress
    - Vectors – roads, creeks, wildlife corridors must be monitored regularly for annual bromes and exert control when and where necessary
    - Control small infestations first
        - Proceed to moderate then large/core infestations

Knowing where to exert control efforts in a logical and systematic way will help foster success.

Monitor and evaluate progress keeping detailed records

It is imperative to regularly monitor the progress being made – whether weeds remain controlled or not, whether new weeds arrive, whether seeded/transplanted species are establishing, and similar responses – to determine whether to adhere to or alter the current plan. A good, detailed record of events that includes all actions and evaluations also is imperative so successful components of the plan can be repeated and unsuccessful ones can be altered.

Specific Recommendations for Downy Brome and Japanese Brome

The key to effectively managing downy brome or Japanese brome is to prevent seed formation and deplete the soil seed reserve.

- Both are annual species with short seed longevities
    - 5 years for downy brome
    - Possibly less for Japanese brome
- Target depletion of soil seed reserve for small infestations
    - Eradication is a lofty goal but possible on a small scale for annual bromes
    - Vigilance would be necessary to prevent re-invasion if eradication is successful
- Most often depleting soil seed reserve not possible for moderate or large/core infestations
    - Eliminating soil seed reserve moderate to large infestations impractical
        - Neighboring infestations constant source of propagules

The best defense to avoid reinvasion is to establish a robust desirable plant community that outcompetes downy brome and Japanese brome and keeps their populations from surging and dominating.

Control tools and methods

Mechanical/physical

- Tillage will control annual bromes because have simple root systems
    - Use tillage to create designed disturbance
    - Annual bromes will not emerge from 5 to 6 inches deep
- Most hand-operated methods not practical on most mine sites because of the scale of the problem
- Controlled burns will control annual bromes
    - Eliminates litter that aids annual brome establishment
    - *Should not be used* on mine sites because of fire risk to neighboring areas

Cultural

- Seeding or transplanting desirable species (seed mix) to reclaim area
    - Must decrease weed populations first
    - Seeding stockpiled soils with very competitive species – perennial grasses primarily – will help control annual bromes
        - Helps avoid planting annual brome seeds during reclamation

- Irrigation where possible will aid establishment of seeded/transplanted desirable species
- Fertilization where necessary
    - Needs determined by analyzed representative soil samples
- Carefully match seed mix and transplant species to site being reclaimed
    - USDA-Natural Resource Conservation Service outstanding source of reclamation species
    - Neighboring, undisturbed reference area also indicative of reclamation species to plant
- Arbuscular mycorrhizal fungi (AMF) are beneficial to most native plant species
    - Transplanting small desirable plants from reference area is good source of appropriate AMF
        - AMF will be moved with transplanted species
    - Commercial inocula not as successful as native AMF

Biological

There currently are no classical biocontrol agents available for either downy brome or Japanese brome. Livestock can be used to manage downy brome but a recommended system of management to successfully decrease its populations has not been developed.

Chemical

There are several herbicides registered to use in non-crop areas, natural areas, and rangeland that will control downy brome and Japanese brome. Herbicides should be used in a successional weed management approach as a designed disturbance when reclamation is being executed or to control colonization of brome species during mining operations to keep the site as free of downy brome or Japanese brome as is possible. Herbicides can also be used to control colonization of the target weed or to control species performance; these uses primarily would be after seeding/transplanting desirable species to keep downy brome and Japanese brome from producing seed or to negatively influence their performance by killing the targets or suppressing their growth such that desirable plant growth is favored. **Annual bromes should be aggressively managed on stockpiled soils.** Herbicides should be used on stockpiled soils to control downy brome or Japanese brome populations so they do not infest soil that later will be placed on reclaimed areas. Controlling weeds on stockpiles will decrease the number of available seeds in the replaced topsoil minimizing brome reinvasion and dominance.

Table 2. Herbicides to control downy brome and Japanese brome at mine sites.

Herbicide	Rate (Product/A)	Application timing	Comments
Plateau	6 to 12 fl oz/A	Mid-summer into early fall as a preemergence or early postemergence application	Use the higher rates (10-12 fl oz/A) for dense stands, or where litter is abundant; 6 to 8 fl oz/A are typical use rates. Include a methylated seed oil at 1 pt/A. Can be used on any location at a mine site including during reclamation.
Roundup	12 to 24 fl oz/A	Late winter for best selectivity; fall, winter, or spring if selectivity not an issue (e.g. brome monocultures with no other plants present)	Use lower rates (12 to 16 fl oz/A) for smaller downy brome and up to 24 fl oz/A for plants 12 inches tall or more. Can be used on any location at a mine site including during reclamation.
Journey	16 fl oz/A	Late winter for best selectivity; fall, winter, or spring if selectivity not an issue (e.g. brome monocultures with no other plants present)	Include a methylated seed oil at 1.5 to 2 pt/A. Can be used on any location at a mine site including during reclamation.
Matrix	3 to 4 oz/A	Fall as a preemergence or postemergence application or postemergence in late winter into spring	Use the higher rate for most situations, especially for large plants. Include a non-ionic surfactant at 0.25% v/v, which is equivalent to 1 qt of surfactant per 100 gallons of spray solution. Can be used on any location at a mine site including during reclamation.
Landmark XP	0.75 oz/A for downy brome; 1.5 oz/A for Japanese brome	Fall as a preemergence or postemergence application or postemergence in late winter into spring.	Include a non-ionic surfactant at 0.25% v/v. Can be used on any location at a mine site including during reclamation.
Oust	0.75 to 1.5 oz/A	Fall as a preemergence or postemergence application or postemergence in late winter into spring.	Use the lower rate for sparse stands or small plants and higher rates for dense stands or large plants. Include a non-ionic surfactant at 0.25% v/v. Use only along roadsides, around buildings, conveyances and other structures, and similar non-crop locations.

Caution should be exercised, however, to allow enough time to pass between weed control and topsoil replacement to allow herbicides to break down and dissipate so as not to injure sensitive, desirable species that will be sown or transplanted. Most herbicide labels provide adequate information concerning appropriate time intervals from treating to planting but intervals are highly dependent upon the species planned to be sown.

During reclamation, herbicides should be used as a designed disturbance before seeding to control existing weeds to aid seeded species establishment. Some annual brome herbicides can be applied to young desirable plants that are establishing without causing excessive injury. During this desirable plant establishment period, herbicides can be used to *control colonization* (seed production by either weed species) or *control species performance* and further aid desirable plant establishment. All the herbicides that are registered to control annual bromes in mined sites inhibit protein synthesis and may decrease viable seed formation by these weeds although this has not been demonstrated for downy brome or Japanese brome. Carefully using appropriate brome herbicides during the desirable plant establishment phase of reclamation will impact their growth (*species performance*) and allow precious soil moisture to be allocated to planted species rather than used by either weed species.

Herbicides should be used to aggressively manage annual bromes along roads, conveyances, and similar corridors that are vectors for weed movement. This will decrease downy brome and Japanese brome propagule levels that otherwise would be available to infest reclaimed areas at the mined site.

Plateau

Plateau (imazapic) is an imidazolinone herbicide manufactured by BASF and is registered to use on pastures, rangeland, non-crop areas, and natural areas (Table 2). Plateau can be used to control downy brome at any location at a mined site – along roads, around buildings and conveyances, on stockpiled soils, and during reclamation. While Japanese brome is not listed under the weeds controlled section of the Plateau label, it can be used for that purpose at a mine site because it is registered to use on that site.

Fall applications of Plateau readily control downy brome and Japanese brome when applied at the appropriate growth stage. All the imidazolinone herbicides, such as Plateau, have a similar mechanism of action (the biochemical process in plants that is disrupted by the herbicide) and inhibit an enzyme that catalyzes the biosynthesis of three amino acids thus, inhibiting protein synthesis, and susceptible plants die over time. Plateau should be applied preemergence to either annual brome species or very early postemergence when the weeds have three or fewer leaves. Plateau will not break down if applied onto the soil surface in mid-summer and will be available to control germinating seedlings in late summer, fall, and through the winter. This

herbicide requires water to breakdown and will remain stable on the soil surface in sunlight (it breaks down quickly in water exposed to sunlight). Precipitation (or irrigation where possible and appropriate) will move Plateau from the soil surface into the soil where it remains in the soil solution and is absorbed by seedling downy brome and Japanese brome and subsequently, they perish. Plateau can be applied from 2 to 12 fl oz/A; 2 fl oz/A usually is insufficient and while 12 fl oz/A controls annual bromes very well for a long period, this rate is most injurious to cool season perennial grasses (Grass, forbs, shrubs, and tree species sensitivity to Plateau information can be found on the Plateau label). Typical use rates are from 6 to 8 fl oz/A plus 1 pt/A of a methylated seed oil (MSO) especially when applied postemergence. Including a methylated seed soil with Plateau as part of the spray solution is of paramount importance to effect desirable weed control!

Downy brome and Japanese brome establishment is favored by litter that acts as a mulch to protect seedlings from desiccation and litter interferes with herbicide performance. Higher Plateau rates overcome the negative effect on herbicide performance but caution should be exercised concerning injury to cool season perennial grass species and other susceptible species. On stockpiled soil where downy brome is established and a thick litter layer exists, for example, 10 to 12 fl oz/A could be used initially to control annual bromes then repeat treatments could be made at the 6 to 8 fl oz/A rate in subsequent years. Plateau often controls annual bromes for 2 years, especially when applied at 8 or more fl oz/A, but a repeat treatment(s) will have to be made to control those seedlings that emerge from longer lived seed in the soil or those that escaped the initial control attempt.

Research by Colorado State University Weed Science showed that when Plateau was applied in early fall preemergence or early postemergence (three or fewer leaves present), downy brome control ranged from 70 to 100% late the following spring and most often 90 to 100% was controlled. Variation in control was most often related to herbicide rate and size of weeds at application. Large downy brome is much more difficult to control with Plateau than small downy brome; when it was 1 to 3 inches tall and had from 3 to 6 tillers at application in fall, control the following spring ranged from 6 to 30% from rates ranging from 2 to 12 fl oz/A plus MSO. Plateau should only be applied in summer or fall. CSU research also showed that when Plateau is applied in spring, downy brome control ranged from 14 to 30% at rates ranging from 2 to 12 fl oz/A and cool season perennial grass injury was excessive. Washington State University research showed that fall applications of Plateau at 4 or 8 fl oz/A plus MSO controlled 65 and 95% of Japanese brome, respectively, the following spring.

Roundup and other glyphosate products

Glyphosate (Roundup and numerous generic products) also readily controls downy brome. Roundup (Table 2) is manufactured by Monsanto and most glyphosate

products can be applied on pastures, rangeland, non-crop areas, and natural areas where restoration or reclamation is planned (the latter due to the non-selective nature of glyphosate). Roundup can be used to control downy brome and Japanese brome in any location at a mine site. Glyphosate too is a protein synthesis inhibiting herbicide but it operates on a different metabolic pathway in plants than do products like Plateau, Telar, and Oust. Using herbicides with different mechanisms of action is crucial to avoid developing herbicide resistant weed populations.

Roundup applied at 8 to 16 fl oz/A in CSU research controlled 96 to 99% of downy brome in one experiment and 100% in another – downy brome is very susceptible to glyphosate and size does not affect its performance nearly as much as Plateau. Glyphosate is non-selective and will kill most vegetation it contacts; however, application timing can be manipulated to provide selectivity. In the above experiments, applications were made in early spring (April 4, 1988 and April 11, 1990) and crested wheatgrass (*Agropyron cristatum*) was growing at application and subsequently was killed. Sand dropseed – a warm season species – by comparison was dormant at application and survived with no injury. Pubescent wheatgrass was found at one of the sites and was injured 16 to 36% (mostly cosmetic injury with minor stand loss) from Roundup applied at 8 to 16 fl oz/A when the herbicide was applied on March 25, 1988. No injury occurred, however, in a repeat experiment when Roundup was applied on March 14, 1991. If applications of glyphosate are made in late winter – no later than March 15 in most years - when cool and warm season species (grasses, forbs, and shrubs) are still dormant, injury will be minimal.

Roundup should be applied at 16 fl oz/A for downy brome or Japanese brome plants up to 6 inches tall. Rates up to 24 fl oz/A may be necessary to control larger plants that are 12 inches tall or more. CSU research found no difference between 12 and 16 fl oz/A in the experiments reported above but downy brome plants were 2 to 4 inches tall with four to five leaves and up to three tillers and Roundup was applied in early spring. Typically in Colorado, downy brome will be small enough during late winter applications of glyphosate that these lower rates can be used.

Journey

Imazapic (Plateau) + glyphosate (Roundup) is manufactured by BASF and sold as Journey and can be used on pastures, rangeland, and non-crop areas (Table 2). Journey can be used in any location at a mine site. It will control downy brome or Japanese brome when applied in fall or spring. Journey at 16 fl oz/A applied in late winter (applications should be made by mid-March in most years to avoid excessive cool season grass injury) will control large downy brome or Japanese brome - up to 4 inches in height. The glyphosate component will control the existing downy brome or Japanese brome and the imazapic component will remain in the soil to control the next generation of either brome species that will germinate the following fall. Journey is

essentially non-selective (primarily because of the glyphosate component) and application made after mid-March may severely injure established cool season grasses and forbs.

Matrix

Matrix (rimsulfuron) is a sulfonylurea herbicide manufactured by DuPont and the supplemental label for Matrix "For selective weed control and invasive species management on non-crop sites" can be used to control downy brome and Japanese brome on non-cropland that is to be restored or reclaimed, including reclaiming mine sites (Table 2).

All sulfonylurea herbicides have the same mechanisms of action as the imidazolinone herbicides, such as Plateau. Matrix has excellent postemergence activity on downy brome and Japanese brome with some soil residual activity as well. Matrix will control fairly large downy brome and should be applied from 3 to 4 oz/A plus 1 qt/A of a MSO. It can be applied in fall preemergence to annual bromes or postemergence in fall or spring. ***The highest use rate must be applied when making spring applications or control will be unacceptable.*** If applying preemergence to the bromes, precipitation must follow to move the herbicide into the soil where it can be absorbed by germinating downy brome or Japanese brome seedlings and cause their demise.

CSU research compared preemergence applications (September 21, 2005) of Matrix to very early postemergence applications (October 16, 2005), both at 2 oz/A, to control downy brome. There were no plants present at the September application and plants were 0.5 to 0.75 inches tall with one leaf in October. Preemergence applications controlled 100% of downy brome in April, 2006 – about 6 months later - while postemergence applications controlled 76%. Both application timings provided about 50% residual control of the next generation of downy brome that germinated in fall 2006 and 25% residual control in fall 2007.

In another CSU experiment, Matrix was applied in fall (November 19, 2007) and compared to a spring application (March 26, 2008). Downy brome was large at application - 2 to 3 inches tall with 2 to 5 tillers at both dates. The fall application of Matrix at 2 oz/A controlled 60% of downy brome by the end of its life cycle in early summer while the 4 oz/A rate controlled 83%. The 2 oz/A rate applied in spring controlled 15% of downy brome by early summer while the 4 oz/A rate controlled 70% of downy brome. The highest use rate must be applied when making spring applications or control will be unacceptable. The 4 oz/A rate in the above experiment also provided residual downy brome control in fall 2008 by decreasing populations 60 and 40% from fall and spring applications, respectively.

Matrix provides a longer window of opportunity to control downy brome or Japanese brome than Plateau and may control larger plants. Matrix selectivity for

desirable grasses, forbs, and shrubs still must be determined, however, while much of that is known for Plateau and expressed on the label. There are planting intervals on the Matrix label for eight desirable grass species.

Landmark XP

A mixture of sulfometuron (Oust) and chlorsulfuron (Telar) is manufactured by DuPont and sold as Landmark XP. It is registered to use in non-crop areas such as along roadsides, around buildings, and for non-crop site restoration/reclamation and a supplemental label allows Landmark XP to be used to restore or reclaim degraded rangeland (Table 2). Landmark XP can be used at any location at a mine site including during reclamation. Caution should be exercised when treating stockpiled soils or during reclamation to be certain that enough time has passed (planting intervals) for the herbicide to break down so planted desirable species are not injured. Planting interval information is on the Landmark XP label and the supplemental label.

Landmark XP can be used to control downy brome or Japanese brome although, a higher rate must be used to control the latter. Landmark XP is very active on large downy brome. This herbicide can be applied in fall (preemergence or postemergence) or spring to control either species and 0.75 oz/A will control downy brome while 1.5 oz/A will control Japanese brome. A non-ionic surfactant at 0.25% v/v (equivalent to 1 qt of surfactant per 100 gallons of spray solution) must be added or control will be dramatically decreased from postemergence applications. The Oust and Telar components of Landmark XP have the same mechanism of action to control susceptible weeds as Plateau and Matrix. The major advantage of Landmark XP is its activity on large weeds compared to Plateau in particular. It is, however, not as selective primarily due to the Oust component.

CSU research compared Landmark XP applied preemergence to downy brome in fall 2005 to postemergence applications shortly thereafter when emerged plants were 0.5 to 0.75 inches tall with one leaf. Landmark XP at 0.75, 1.0, and 1.5 oz/A controlled 100% of downy brome the following spring (April, 2006). Residual control also was evident where the 0.75 oz/A rate controlled 55% of the fall 2006 generation while the 1 oz and 1.5 oz/A rates controlled 75 and 86% of downy brome, respectively (all data collected at the end of their life cycles in early summer 2007).

Residual control from Landmark XP is another advantage. It is important, however, to keep in mind that applications of Landmark XP (especially preemergence applications) must be followed by precipitation to move the herbicide from the soil surface into the soil where it can be absorbed by roots (Landmark XP also is absorbed by foliage during postemergence applications). ***This also decreases off-site movement of the herbicide caused by wind moving soil with the herbicide attached (the Oust component), which can injure recipient plant communities that contain susceptible species.*** This has been a significant issue with Oust in particular.

Oust

Sulfometuron is Oust and is manufactured by DuPont. It is a sulfonylurea herbicide with the same mechanism of action as Matrix, Landmark XP, and Plateau. Oust is registered to be used on non-crop sites and can be used along roadsides, around buildings and conveyances, and similar areas (Table 2). It should ***not*** be used during the reclamation process. Oust controls downy brome and Japanese brome very well. Apply Oust from 0.75 to 1.5 oz/A plus 0.25% v/v of a non-ionic surfactant in fall or in spring either premergence or postemergence. Oust has excellent activity on large downy brome and will control plants up to 12 inches tall.

In the same experiment reported above for Landmark XP, Oust at 1 oz/A applied preemergence in fall controlled 100% of downy brome the following spring and residually controlled 83% of the next generation. Oust has very effectively and consistently controlled downy brome in CSU research projects and the residual control it offers is very advantageous. ***There is a risk, however, of off-site movement after an Oust application on wind-blown dust and this is especially the case when soils are very dry.*** Precipitation shortly after application will move Oust from the soil surface into the soil - where it still can be absorbed by downy brome roots – and this decreases the risk associated with off-site movement from wind-blown soil.

Herbicide resistance management

Repeated use of highly effective herbicides, such as the sulfonylureas and imidazolinones, can select for individual weeds that are resistant to the herbicide and will not be controlled regardless of rate. This has occurred with both these herbicide classes. Downy brome resistance to sulfonylurea herbicides was found in Oregon under intense crop production. Therefore, care must be exercised in Colorado (and elsewhere) to manage against development of a population of resistant downy brome. Rotation over time among herbicides with different mechanisms of action will help thwart such development. This should not be a significant issue for mine sites in Colorado but caution nonetheless should be exercised.

Glossary

Annual; a species that completes its life cycle in one year or one growing season.

Auricle; a small ear-shaped lobe or appendage that occurs at the base of a grass leaf blade.

Awn; a slender typically terminal bristle; growing out of the end of distal glumes on grass seedheads.

Glume; bract at the base of a grass spikelet; outermost flowerless bract.

Lemma; outermost bract of a floret

Palea; second bract of a floret

Panicle; loose, irregularly compound flowering part of the plant with flowers borne on individual stalks.

Preemergence; typically refers to application of a herbicide before the target species has emerged through the soil surface.

Postemergence; typically refers to application of a herbicide after the target species has emerged through the soil surface.

Sheath; lower part of the leaf that surrounds the shoot or stem.

Spikelet; flower cluster in grasses usually consisting of two glumes and one or more florets. Sometimes referred to as a seedhead.

Steppe; vast grass or shrub covered plain with a semiarid climate.

Winter annual; a species that begins its life cycle in fall and completes it during the following spring or early summer.