Prescribed Fire and Invasive Plants

A Reference Guide and Manual of Best Practices

Invasive Plant Program
Ministry of Forests, Lands, Natural Resource Operations and Rural Development
Province of BC

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Cover photo: Native arrow-leaved balsam root (*Balsamorhiza sagittata*) healthy response post-fire in the East Kootenay region of BC.

1.0 INTRODUCTION

1.1 Background

British Columbia (BC) has a long history of using prescribed fire as a tool to help meet land management objectives such as reduction of fuels for public safety, cultural use, environmental stewardship, and habitat enhancement. To date, prescribed fire projects have had varying levels of integration of invasive plant prevention and management activities, however it is now recognized that invasive plants must be considered by land managers intending to use prescribed fire to achieve success.

Invasive plants are non-native species whose introduction into BC cause, or are likely to cause, significant economic, social, cultural, and environmental damage. Free from the natural pests and pathogens that keep them in balance in their native ranges, invasive plants spread rapidly, outcompeting native and desirable species, altering biological communities, reducing biodiversity, and disrupting proper ecosystem functions. The risk of introduction and spread of invasive plants increases substantially in disturbed areas, including areas disturbed by fire.

There are several reasons land managers consider the use of prescribed fire including:

- Reducing the intensity of wildfires by reducing the buildup of fuels.
- Returning ecosystems to historic fire regimes, thereby reducing encroachment, infilling of grasslands by trees, and increasing species diversity and abundance.
- Increasing forage availability for wildlife and livestock.
- Improving habitat for species at risk as well as grassland and open forest dependent species.
- Reducing excessive litter accumulation on lightly or non-grazed grasslands, particularly in cool climates (the upper grasslands) as excessive litter can sometimes suppress the native plant community.
- Attempts to manage large scale non-native invasive plant infestations.

As with any large disturbance on the landscape however, prescribed fire projects present a risk of unintentionally introducing and spreading invasive plants or causing existing invasive plant populations to increase in density and distribution. Fire management activities such as thinning, accessing the site, conducting the controlled burns, and the creation of fuel breaks can all introduce and spread invasive plants if steps are not taken to minimize the risks throughout all phases of a prescribed burn project. Once established, invasive plants can be extremely difficult and costly to manage and may prevent the land management goals that the project was designed to address from being achieved.

1.2 Returning ecosystems to historic natural fire regimes

A commonly used rationale for the use of prescribed fire is to promote increased biodiversity through returning ecosystems to their historic natural fire regimes. In BC, this usually refers to a historical regime of relatively frequent, but low severity fires. Returning ecosystems to natural fire regimes alone however is usually not a strong enough rationale alone for using prescribed fire. For a project to be successful, the specific ecosystem characteristic or species that is intended to be altered or improved must be identified and the current state of the ecosystem must be considered, as a number of disturbances may have been occurring across the landscape even while fire has been prevented or suppressed. Examples of more targeted or specific objectives include reducing excessive litter, reducing the duff (humus) layer to reduce future fire severity, reducing fire risk to communities, increasing bunchgrass density or distribution, improving habitat for a specific animal, and/or reducing density (stems/ha) of conifer encroachment in grasslands or conifer in-growth in forests.

It must also be recognized that the vast array of variables at any given location may limit the ability of land managers to confidently incorporate invasion biology and predict ecosystem response into prescribed fire projects. For example, variables such as fire frequency, burn severity, season, climatic condition pre- and post-burn, size and spatial extent of the burn, the pre-burn vegetation community, and pre- and post-burn land use patterns may all influence the response of the native plant community and invasive plants populations to fire.

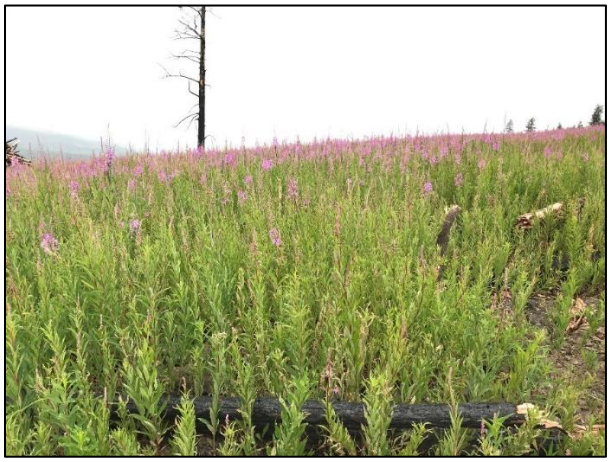
Considering the pre-burn vegetation community at the time of the burn is particularly important when it comes to predicting vegetation response (both short and long term). In addition to ensuring you know what plants are present, it is recommended that the following general observations are considered when working in these BEC zones in BC:

- BUNCHGRASS ZONE (BG): The use of prescribed fire within the BG must be very carefully considered to determine whether it is suitable or not, or whether the risk of invasion by annual grasses is too great. Within this zone, prescribed fire may be effective in reducing big sagebrush cover to promote recovery of bluebunch wheatgrass, however research plots have shown that bluebunch wheatgrass can recover even with high big sagebrush cover (albeit more slowly), therefore this should be weighed against the potential for cheatgrass invasion. In addition, in many bunchgrass ecosystems within semi-arid conditions, productivity is relatively low and there are high rates of decomposition because of the warm dry climate. For this reason, there is not the on-going accumulation of litter that (in more productive ecosystems) tends to suppress the plant community after years of light grazing or no grazing.
- INTERIOR DOUGLAS FIR ZONE (IDF): In the IDF grasslands, especially at higher elevations and more northern latitudes accumulation of litter can suppress the native bunchgrasses. Low-severity fire in the spring can be used on these types of sites to reduce litter. This will have the effect of making the site a bit more xeric and favouring native bunchgrasses, as they are more drought tolerant. For the same reason, prescribed fire is probably beneficial for grasslands that

are being invaded by smooth brome. In situations where litter cover is reduced by livestock grazing, prescribed fire may not be required. If the objective to use prescribed fire is to reduce tree encroachment on grasslands, in heavily grazed areas it may be most beneficial to ecosystem function to leave felled trees on site or to pile and burn them rather than introduce a prescribed burn.

- PONDEROSA PINE ZONE (PP): Prescribed fire for reduction of stem densities in dry IDF or PP forests is often considered as the scale of work can be too large to do with mechanical treatments. If there is a healthy pinegrass component and low cover of invasive plants, there is low risk of invasive plant takeover because pinegrass has such a strong response to fire disturbance.

Figures 1-4 below demonstrate some of the significant variation of responses that can be seen following a burn.



Figures 1 and 2: Healthy, native fireweed (*Epilobium angustifolium*) (photo on L) and pinegrass (*Calamagrostis rubescens*) regeneration following fire (photo on R).

Figures 3 and 4: Severe invasive yellow salsify (*Tragopogon pratensis*) infestation one year post wildfire (photo on L) and cheatgrass (*Bromus tectorum*) invasion along a fire guard represented by the band of reddish-brown in the middle-left of the picture (photo on R).

In many areas of BC, if practices for invasive plant prevention and management are not included in prescribed fire projects, there is a risk of increased invasive plants in the area post-burn. Invasive plants can create an increase in fine fuels and/or exceptionally flammable fuel establishing in the area. These fuel changes can alter fire behaviour and regimes even further away from the historic low severity, high-frequency fires to ones that are of higher intensity and that occur even more frequently than historic fires (Fusco et al. 2019; Brooks et al. 2004; Potts & Stephens, 2009; Keeley, 2006). Altered fire regimes may further reduce native species diversity, alter ecosystem functions, and increase the threat of fire to human communities and wildland ecosystems. In the Pacific Northwest, including BC, this is a particular risk with cheatgrass (*Bromus tectorum*) and other annual invasive grasses most often found within the bunchgrass Biogeoclimatic (BEC) zone – more information on this in Section 2.1, below. The altered fire regimes often favour the growth of the invasive plants that caused them, compounding the issue and promoting the continued spread and dominance of invasive plants and thus, an increased occurrence of very frequent, high-severity fires. This is known as the invasive plant/fire cycle (Zouhar et al. 2008; Keeley, 2006). Table 1 below demonstrates some of the ways invasive plants alter fire regimes in the following table (adopted from Brooke et al. 2004).

Table 1: From Brooks & Lusk (2008), effects of fire on plants with similar biological or functional characteristics.

Table 1. Effects of fire on different plant life forms (modified from Pyke et al. in prep).

Life Form (Raunkiaer type)	Regenerative tissue	Exposure of regenerative tissue to damage from fire
Annual plants	Seeds that reside on or under the soil surface, or on dead plants	Depends on if seeds are located above-ground on the parent plant, or at or below the soil surface after they have dispersed from the parent plant.
Bulbs or corms	Living tissue well below the soil surface	Protected from fire due to soil insulation above them.
Rhizomatous plants	Living tissue just above or below the soil surface	Depends on the percentage of litter burned and the amount of smoldering combustion.
Shrubs	Living tissue just above the soil surface	Non-fire-adapted shrubs can be killed by fire due to their positioning directly in the flame zone of surface fires.
Trees	Living tissue well above the soil surface	Can be killed by crown fire that passes though the plant canopies, or by surface fire that girdles the trees.

As invasive plant/fire cycles continue, native plant communities are unable to persist under the new regimes. This can lead to the extirpation of some plants, and a reduction in native plant propagules able to recover after fires. With fewer native plants producing propagules each year, this can eventually lead to conditions that become increasingly difficult and costly to manage and restore (Brooks et al. 2004; Brooks & Lusk, 2008).

The link between fire and invasive plants is becoming increasingly recognized in BC and adjacent jurisdictions and highlights the need to incorporate invasive plant considerations when planning to use fire as a management tool for any objective. It is hoped this document will provide land managers with a practical resource to do so.

1.3 How to use this document

The goal of this document is to provide land managers with practical ways to incorporate invasive plant prevention and management actions into prescribed fire projects so that project objectives can be met, while ensuring negative impacts of invasive plants are prevented or minimized.

Best practices to prevent the spread of invasive plants throughout all phases of a prescribed fire project are summarized in Appendix 1. Appendix 2 contains a table comparing general pre-burn site conditions and expected post-burn results. Species-specific best practices and information for many priority invasive plants in BC are included in Appendix 3.

Recommendations contained in the document below should only be carried out when there is no immediate threat to human life and/or property.

2.0 UNDERSTANDING THE RELATIONSHIP BETWEEN FIRE AND INVASIVE PLANTS

As outlined in the US Fish & Wildlife Service's "Fire Management and Invasive Plants" handbook (Brooks & Lusk, 2008), consideration of invasive plants must be integrated with fire management for three general reasons:

1) Fires and fire management practices can promote invasive plant invasions.
2) Invasive plant invasions can alter fuel characteristics, fire behaviour, and natural fire regimes.
3) Fire can, in some circumstances, be used as a tool to control invasive plants.

Experience with prescribed fire projects and post-wildfire vegetation monitoring in BC also supports these statements and underscores the need for prescribed fire project managers and prescribing professionals to consider invasive plants throughout all phases of developing, implementing, and monitoring a prescribed fire project. If consideration of invasive plants is not incorporated into burn plans correctly, they have the potential to significantly impact and even negate the original objectives of the prescribed fire project. With new invasive plant species continuing to be introduced to BC amid changing climatic conditions, invasive and native plant compositions are likely to continue to change across the landscape, requiring constant vigilance and ever-expanding management approaches for ecosystem restoration projects that include prescribed fire.

Invasive plants compete aggressively with native species after disturbances for resources like space, light and nutrients. Fires also increase the available nutrients in the soil and create bare patches of soil where invasive plant propagules can establish, free of competition from native plants that are slower to recover after fire (Brooks & Lusk, 2008; NRCS, 2001; Newman & Hamilton, 2018). The increase in resources created by fire along with the temporary decrease in biomass and competition by native species may have the greatest potential to facilitate invasion (Ridder, 2019; Brooks & Lusk, 2008; Newman & Hamilton, 2018; Dodson & Fiedler,

2006). Although these conditions are favourable for invasive plants, it is important to remember that establishment of invasive plants cannot occur without the presence of reproductive propagules (i.e., seeds, roots, rhizomes, or other vegetative reproductive parts). Therefore, if invasive plants are not known to exist in the project area or adjacent lands, preventing the introduction of invasive plants is the most effective and least costly method of managing invasive plants and should be given the highest priority for implementation. Figure 5 below reproduced from the US Fish & Wildlife Service's Fire Management and Invasive Plants Handbook (2008) shows how the management response should change depending on whether invasive plants are present, and the expected change in resource availability resulting from the prescribed fire project activities.

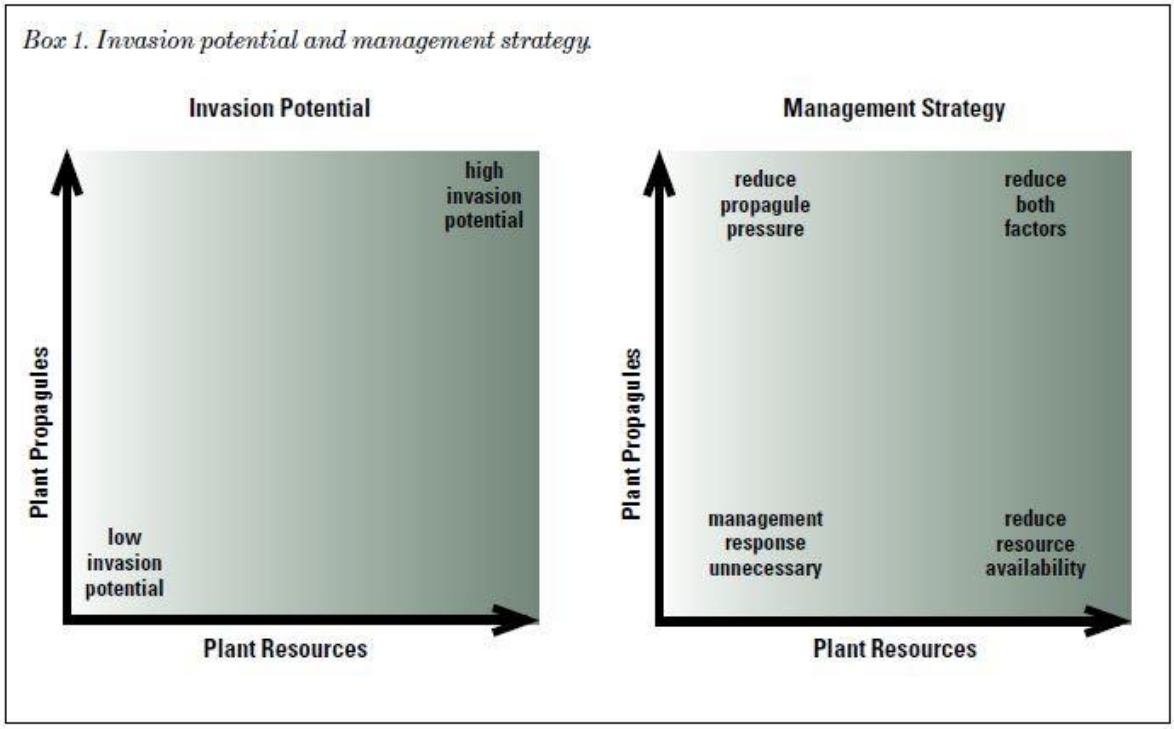


Figure 5: From Brooks & Lusk (2008) illustrating invasive plant potential and subsequent management strategies based on the relationship between invasive plant propagule and resource availability.

Even project areas that only have low abundance of one or several invasive plant species before the fire can see distribution and dominance of invasive plants expand post-fire. This expansion can be a result of a variety of factors including:

- the competitive ability of invasive plants over native or desirable vegetation to survive and spread throughout the area during and after the fire,
- removal of the other vegetation which exposes an existing invasive plant seedbank allowing it to germinate,
- post-fire land uses such as grazing may put selective pressure on the non-invasive species only, and

- introduction of invasive plants into disturbed areas on vehicles, equipment or in contaminated materials.

In some regions of BC, there are areas where one or more species of invasive plants are well established, and an abundance of invasive plant propagules exist that could prevent the recovery of the native or desirable vegetation after a fire. To address this, prescribed fire project managers and prescribing professionals need to ensure the invasive species present and the extent of propagule availability for each of invasive plant species present is determined both within proposed burn areas and in adjacent areas (that could reach the burn sites) before implementing any prescribed fire activities. Furthermore, the size and historical duration of the invasive plant infestation and the expected response of the invasive plant species present (see Appendix 2) should be taken into consideration when deciding whether the project area is even suitable for a prescribed fire. If a decision is made to proceed with a prescribed fire project where invasive plants are already present, project managers and prescribing professionals will need to determine the steps required throughout all phases of the prescribed fire project to address the invasive plants and ensure that the necessary resources are secured to accomplish them.

Answering the following questions will help prescribed fire project managers and prescribing professionals make informed decisions on potential interactions between prescribed fire project activities and invasive plants:

- What is the current, pre-project vegetation community?
- Are invasive plants present? Where, what species, how many, and how long have they been there?
- What are the pre-project land uses, and how will those change after the project in the short term or long term?
- Will the canopy be opened, altering the light regime? Will there be an increase in light to the understory vegetation?
- Will the moisture regime change as a result of thinning the trees or introducing the fire?
- Is the current nutrient regime expected to change? (Release of nutrients; Change of C:N ratio)
- What will the fire intensity be? Will there be a mosaic expected due to fuel loads?
- How do the invasive plant infestations relate spatially to the expected fire intensities?
- Will bare soil be created? When, where, and can it be minimized?
- Will installation of new fire guards be required? Can this be accomplished without creating bare ground?

- Where will personnel, equipment be hired from? Where was equipment working last? Is it clean?
- Will revegetation be required?
- What is the post-fire monitoring plan and how will any invasive plant infestations be managed after the burn?
- Are the necessary resources in place to achieve success before continuing with the project?

Recommended best practices to address these issues are discussed in more detail below and summarized in Appendix 1 and within the invasive plant species-specific pages in Appendix 3.

2.1 How fire can be used to control invasive plants

While control of invasive plants is not usually the initial goal of land managers when prescribing fire, it should be incorporated into the process of prescribed fire planning. Fire may be effective at controlling invasive biennial and perennial species at times; however, it has shown to be more effective at controlling late season annual grass and forb invasive species (Brooks & Lusk, 2008; Davies, 2010). This is a generalization however and the individual characteristics of each invasive plant present must be considered along with the site conditions and burn variables to determine the expected response(s) to fire (see Appendix 3). Many annual invasive plants like cheatgrass, have relatively short, and early season life cycles. Cheatgrass matures in mid- to late-spring before fuel loads are sufficient or dry enough to carry a fire. As a result, the seeds are dropped to the ground before any burns occur, and where heat from a fire is less destructive. Compare this to longer lived annuals or perennials which would develop seed later in the season and not yet have dropped the seeds to the insulating ground, therefore being more readily controlled by fire (DiTomaso & Johnson, 2006).

Invasive Annual Grasses all have similar impacts on fuel characteristics, fire behaviour, fire regimes and the resulting negative impacts on native plant communities and ecosystem functions (Brooks *et al.,* 2004; D'Antonio & Vitousek, 1992). They are an example of a group of plants that facilitate an invasive plant/fire cycle (see Section 1, above). However, while fire often promotes these species' distribution and dominance on the landscape, it can also be used as a tool in an integrated management approach to control these species if done correctly (Brooks & Lusk, 2008). In fact, effective control has been achieved for annual grasses by applying early spring- or fall-burns followed by herbicide treatments and subsequently followed by revegetating with competitive native species in some cases (Davies, 2010; Davies & Sheley, 2011). In these studies, prescribed fire and herbicide treatments on their own were less effective at controlling annual grasses even when followed by revegetation. While burning followed by herbicide and revegetation is shown to be effective, there can be logistical

limitations to this approach. There are also biological variations between species within this functional group that may require land managers to alter aspects of their management plan (e.g., season of burn). Several invasive annual grasses are currently known to be present and spreading in BC including cheatgrass (*Bromus tectorum*) and North Africa grass (*Ventenata dubia*).

More information on presence/absence of invasive plants in BC can be found on the Province of BC Invasive Plant website at: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species/priority-species/priority-plants and within the Provincial Invasive Species Database at: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species

Figure 6 below shows a 2020 photo taken within the Thompson Nicola region of BC showing an example of an increasingly common situation where a fire guard has become almost 100% covered by of cheatgrass, posing a linear fire hazard risk as described above.

Figure 6. Fire guards following the "Elephant Hill" wildfire near Cache Creek, BC, showing the establishment of cheatgrass, a highly aggressive and flammable invasive annual grass.

Additionally, the response of the native plant community to fire must also be considered in the context of using fire to control invasive plants. The intensity or frequency of fires needed to control invasive species may be unfavourable for the regeneration or successes of the native plant community. Most studies find that fire on its own is insufficient to control invasive plants long-term, but the addition of prescribed fire as part of an integrated management approach combining with other management techniques may be often more effective at controlling invasive plants (Brooks & Lusk, 2008; Davies, 2010).

3.0 INCORPORATING INVASIVE PLANTS INTO PRESCRIBED FIRE PROJECTS

Invasive plants must be considered throughout all phases of a prescribed fire project to help reduce the risk of introducing or spreading invasive plants. To support project managers and prescribing professionals in successfully completing this task, best practices have been developed to help prevent the introduction and spread of invasive plants throughout each of the following four phases of a prescribed fire project and are summarized in Appendix 1.

Phase 1: Planning
Phase 2: Site preparation
Phase 3: Development and implementation of the Burn Prescription and Burn Plan
Phase 4: Post-burn monitoring and adaptive management

Best practices for all four phases were designed based on the following three overarching principles:

Principle 1: Project managers and prescribing professionals must understand the density, distribution and biological characteristics of invasive plants present in the area. Plants that share similar morphological and regenerative properties can sometimes be expected to behave similarly in any given fire. For example, plants with deep-rooted reproductive or regenerative tissue are likely to have high survival and recovery rates following a fire since even the most severe fires typically only damage plant tissue in the top 10 cm of soil (Brooks & Lusk, 2008; Zouhar, 2003). More information on the effects of fire on species with similar characteristics is shown in Table 1, above. For species-specific biological characteristics for many priority invasive plants in BC, see Appendix 3.

Principle 2: The potential for invasive plants to be introduced into or spread throughout an area must be minimized or eliminated through all phases of a prescribed fire project. Preventing invasive plant introduction into burn areas is the most effective and least costly means of control. This requires awareness and training to ensure that all equipment, personal protective equipment (PPE) (including boot treads), and vehicles are clean before entering burn areas, and that any soil, mulch, seed, gravel or any other materials brought on site are free of invasive plants. All known areas of invasive plants should be mapped and flagged on site and all project personnel should be aware of their location(s). Avoid entering areas dominated by invasive plants, if possible, and only use invasive plant free areas when installing fire guards, staging areas, heli-bases, parking lots, equipment storage areas, etc. Limit access points to the project area and minimize soil disturbance as much as possible. Monitoring is key throughout all phases of the project to detect invasive plants that have been introduced earlier, enabling treatment before vegetative spread and/or seed dispersal into the sensitive burn area as it recovers. Ongoing monitoring and management of invasive plants within, or adjacent to, the

project area is critical to prevent the introduction of invasive plant propagules before and during the project, as well as after the completion of the burn, until the native or desirable plant community has recovered. Incorporating costs of invasive plant prevention and management into prescribed fire project budgets is required to ensure that this critical work is accomplished before, during and for up to 5 years following a burn.

Principle 3. Limiting the number of resources available to invasive plants (i.e., exposed soil, moisture, light, nutrients) after an area is burned will help slow the spread. Limiting the areas available for invasive plants to become established and spread is an important part of prevention. The following recommendations are made for all phases of a prescribed fire and should be used when applicable:

- Re-establish vegetation on exposed soil during the first spring or fall possible following disturbance.
- Natural succession (with monitoring to ensure the desired species are recovering) is preferred in areas where invasive plants are not present and burn intensity is low to moderate.
- Seeding is recommended when invasive plants are present or burn intensity is high.
- Avoid use of fertilizers in post-fire rehabilitation and restoration.
- As an alternative to vegetation removal for fire guards, consider replacing highly flammable vegetation with less flammable vegetation when creating a managed fuel zone.
- Acquire restoration funding and ensure project timelines incorporate the necessary post-burn timeframes to continue with monitoring, revegetation and invasive plant control efforts as necessary.
- Minimize soil disturbance and remove only enough vegetation to accomplish management objectives during fire suppression and rehabilitation activities.
- Minimize the use of retardants that may alter soil nutrient availability such as those containing nitrogen and phosphorus.
- Regulate or prevent human and livestock entry into burned areas until desirable site vegetation has recovered sufficiently to resist invasion by undesirable vegetation.

AN IMPORTANT NOTE ON REVEGETATION: While revegetation may not result in complete prevention of invasive plant establishment on site post-burn, it can at the very least work to provide competition to invasive plant establishment. *As vegetation recovers in an area, resources are taken up and the desirable vegetation provides some competition against the invasive plants.* In areas that had high invasive plant cover pre-burn and/or that suffered very severe fires, revegetation is typically recommended as these areas will likely have low desired plant survival and pre-burn cover. Additionally, areas that have had invasive plant infestations

for long periods of time may no longer contain sufficient native plant propagules for natural revegetation and succession to occur passively. In contrast, areas that had low cover of invasive plants and adequate native vegetation cover pre-burn and that experienced low- to medium-severity fires typically do not require revegetation for successful control of invasive plants post-burn. It has been demonstrated that revegetation, when integrated with additional control methods (e.g., prescribed fire -> herbicide treatments -> revegetation) has been effective in reducing invasive plant re-establishment post-fire (Davies, 2010; Davies & Sheley, 2011).

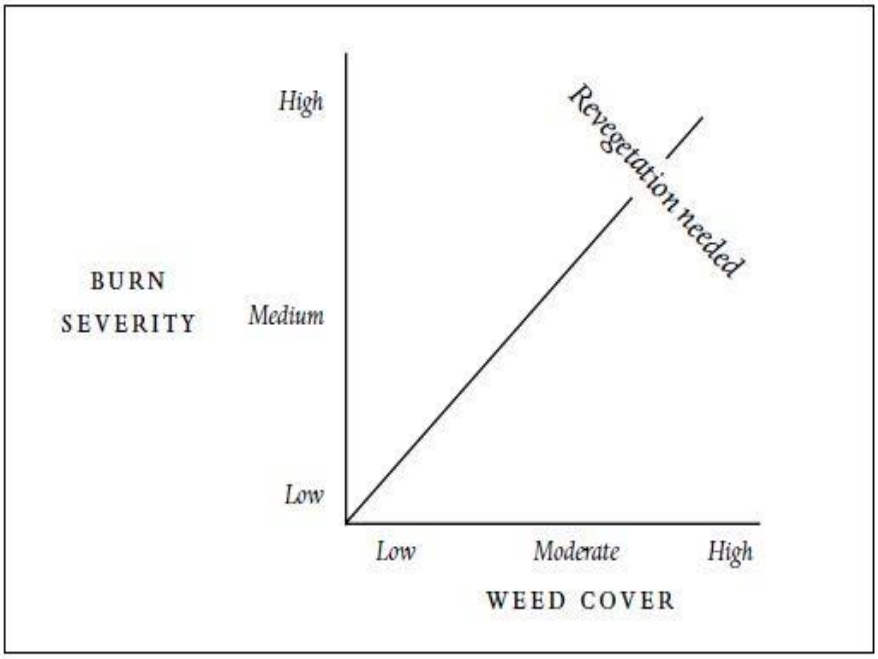


Figure 7: From NRSC (2001). Image showing the potential need for revegetation following a wildfire or prescribed fire. Burn severity and pre-burn weed cover and positively related to require revegetation after a burn.

Degree of noxious weed cover	Burn severity—		
	Low	Medium	High
Absent to low—up to 20% weed cover (i.e., rare to regularly scattered weed occurrence) *High pre-burn cover of desired vegetation*	Revegetation not necessary; ecological effects generally beneficial; regularly monitor for new weeds until community reaches recovery, then monitor occasionally	Revegetation not necessary; ecological effects generally beneficial; regularly monitor for new weeds until community reaches recovery, then monitor occasionally	Revegetation and regular weed management recommended
Moderate—20 to 80% weed cover (i.e., frequent to fairly dense weed occurrence) *Moderate pre-burn cover of desired vegetation*	Revegetation may be necessary if desired vegetation cover is below 30%; frequent weed management recommended; high survival of most weed species	Revegetation may be necessary if desired vegetation cover is below 30%; frequent weed management recommended; high survival of most weed species	Revegetation and frequent weed management recommended; weed survival varies among species*
High—80 to 90% weed cover (i.e., dense weed occurrence to monoculture) *Low to absent pre-burn cover of desired vegetation*	Revegetation and intense weed management recommended; high survival of most weed species*	Revegetation and intense weed management recommended; weed survival varies among species*	Revegetation and intense weed management recommended; weed survival varies among species*

* Rhizomatous weeds have high survival as underground reproductive structures capable of reproduction. Weed survival as crowns or viable seeds varies among species.

Table 2: Reproduced from NRCS (2001). Table used to determine the necessity to revegetate an area after a wildfire or prescribed fire.

Seed mixes used to revegetate an area should be locally adapted, non-invasive, and certificates of seed analysis MUST be requested from the seed supplier for all lots of all species in a mix and checked PRIOR to blending the seed mix to ensure that no invasive plants are present as contaminates in the seed. More information on checking the certificates of analysis can be found at: https://www2.gov.bc.ca/assets/gov/driving-and-transportation/environment/invasive-species/invasive_plant_hiding_in_seed.pdf and in Chapter 7 of the British Columbia Rangeland Seeding Manual (2001) https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/rangelands/bc_rl_seeding_manual_web_single_150dpi0904.pdf. More information on developing an appropriate seed mix for a specific burn area can be found in the BC Rangeland Seeding Manual as well. If the prescribed fire project is within BC Provincial Parks, the Seeding Guidelines for BC Parks and Protected Areas (Jan 2015 Draft) should also be consulted.

When developing a seed mixture, it is important to consider the short- and long-term land uses of the area. For example, forb species should not be included in the seed mix if land managers plan to treat newly establishing invasive plants in the area with broadleaf herbicides, as these herbicides will damage or destroy the seeded forbs as well as the invasive plants targeted if they are within the target treatment area. Revegetation plans should incorporate all areas of exposed soil, including access roads, where possible. For example, Figure 8 shows a historical compacted, resource road that was not seeded and the resulting St. Johns-wort (*Hypericum perforatum*) infestation persisting years later.

Figure 8. Historical compacted, resource road that was not seeded and the resulting St. Johns-wort (*Hypericum perforatum*) infestation.

3.1 Phase 1: Planning

Prior to performing any site preparation activities (e.g., thinning, establishing fire guards, etc.), a careful assessment of invasive plant presence and abundance on the proposed burn site and surrounding lands should be conducted through both a desktop review of existing vegetation data, as well as at least one complete field survey during the late spring to early fall months conducted by a qualified environmental professional with experience identifying and mapping invasive plants. The spatial distribution and relative abundance of invasive plants within the project area can dictate what management actions should occur before, during and after site preparation and/or prescribed fire activities to prevent the re-establishment of invasive plants and promote successful recovery of the site. Ensuring the history of invasive plants in the area

is critical because understanding how long any invasive plant infestations have been present for, can inform land managers on how the invasive and native plant communities may respond after a fire. For example, if an infestation has occurred on a site for a long time (e.g., 20 years) and the current density and distribution of the species on the site is high, it can be assumed that there will be an abundance of invasive plant propagules that could generate after the fire along with a lack of native propagules as a result of sustained exclusion by invasive plants. In this case, prescribed fire project managers and prescribing professionals may need to rely heavily on active post-fire management techniques such as revegetation of native or short-lived agronomic plants (via seeding, etc.) to limit re-invasion rather than allow for passive recovery of the native plant community. At minimum, the Province's Invasive Species Database (https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species) database should be reviewed to determine the history of invasive plants and management actions on the proposed burn site and surrounding area, but local Provincial, District or Regional FLNRORD or BC Parks offices may also have historical vegetation data to support pre-burn analysis. Reviewing the invasive species database in addition to a field-based survey is also important as it can indicate whether any invasive plants previously existed on the site which are no longer actively growing in the current plant community. This can be important if seeds or other propagules of such species are long-lived and may be present in the soil [e.g., St. John's-wort (*Hypericum perforatum*)]. In this case, seeds which have remained dormant will likely have ideal conditions to establish post-fire and a flush of invasive plants should be expected in the first or second year following the burn and treated as soon as they appear. Prescribed fire project managers and prescribing professionals may also need to incorporate management strategies into burn prescriptions and burn plans for pre-existing invasive plants on a site before site preparation or burning occurs, depending on their biological traits (see Appendix 3 for more information on species specific information).

Adjacent lands to the proposed burn sites should also be assessed for invasive species as invasive populations outside of the burn area could supply invasive plant propagules into the burn site post-burn, especially if spread by windborne seed or if wildlife or livestock frequent both areas, etc. In such cases, actions should be taken to decrease the possibility that these species will spread to the prescribed fire project area. The first 100m perimeter outside of the proposed project site is the preferred area to survey, but managers may wish to increase this area if obvious infestations exist outside the first 100m of species that have a high likelihood of long-distance propagule dispersal (i.e., wind-dispersed seeds, rangeland with cattle vectors, etc.).

As with any phase of a prescribed fire operation, any surveyors entering the burn site and surrounding areas should follow the general recommendations for invasive plant prevention by

keeping vehicles, equipment and gear clean, and not parking or driving through invasive plant infestations, where possible. See Appendix 3 for species-specific best practices.

Once the assessment of the current and historical plant communities is complete, with a focus on documenting the known invasive plants density and distribution through the proposed project areas, refer to Appendix 2 below to determine the site type. There may be a combination of site types in one burn unit and different actions may be required in different zones within a single prescribed fire project area.

3.2 Phase 2: Site Preparation

Pre-burn work such as thinning, brushing, tree removal/fuel reduction, creating fire guards, etc. are essential to ensure that prescribed fire projects objectives are met while ensuring that human lives and infrastructure remain safe, and that the structure and function of the burned ecosystems are improved over time. However, these activities cause disturbances on the landscape that can increase resource availability and promote invasion and/or expansion by invasive plant species before the actual burn is even conducted. Removal of vegetation through activities such as thinning and brushing may also result in increased light and moisture, even without complete soil disturbance. Since disturbances causing increased resource availability from these activities is inevitable and often part of the project goals, the best way to ensure plant invasions do not occur is to reduce or eliminate the presence of invasive plant propagules first. When that cannot be done, as in the case where a multi-year seed bank is likely present, actions can be taken to reduce resource availability for invasive plants, such as seeding or mulching, in areas that have been disturbed by site preparation activities. In general, the greater the percentage of existing vegetation that is removed, the greater the risk of spread of invasive plants. Ongoing monitoring and the ability to respond quickly is key to detecting and responding to invasive plants as they are found following site preparation activities. This is especially important, as burns often occur at least two or more years after pre-burn operations such as thinning, giving invasive species ample time to establish and spread (Newman & Hamilton, 2008) resulting in even more invasive plant propagules available to establish and spread post-fire.

As with any phase of a prescribed fire operation, anyone entering the burn site and surrounding areas should follow the general recommendations for invasive plant prevention by keeping vehicles, equipment and gear clean, and not parking, staging or driving through invasive plant infestations, where possible. See Appendix 1 for a summary of best practices for each phase of a prescribed fire project.

Apart from the general recommendations of preventing invasive establishment, additional work may need to occur such as performing treatments (e.g., mechanical and/or chemical) on invasive plants to reduce or eliminate their propagule output before pre-burn operations

commence. Keeley (2006) recommends removing livestock from burn areas for an extended period before [and after] a burn as they are often a vector for invasive plant spread. Livestock grazing too early following a fire may also slow or prevent recovery of native or desirable vegetation, providing the invasive plants with a further competitive advantage. Additionally, Brooks & Lusk (2008) recommend that land managers should consider replacing highly flammable vegetation with less flammable vegetation as an alternative to vegetation removal when creating a managed fuel zone (i.e., green stripping), provided these species are not themselves invasive. They also recommend incorporating pre-existing fuel breaks, manmade or natural (e.g., bare rock), into managed fuel zones. Implementing a monitoring and control plan for burn units prior to burning but after pre-burn work occurs will be necessary to ensure that any invasive removal efforts are successful and that new invasive species are not establishing in disturbed areas.

3.3 Phase 3: Development and implementation of the Burn Prescription and Burn Plan

During a prescribed fire, characteristics of the burn can be manipulated to better control invasive plants, as long as these manipulations also ensure the desired management outcomes from the burn. Different prescriptions can also be applied to different burn units within the overall burn area depending on the condition of invasive plants in each one. The following table summarizes characteristics of a burn that can be manipulated and resulting effects on invasive plants:

Table 3: Possible burn prescriptions and their effects on invasive plant control

Season of burn:	The season in which a burn occurs can be altered depending on management strategies. For example: burning seeds of annual grasses before they drop (spring burn) since higher temperatures in fine fuel canopies (i.e., while still on the plants) are more likely to kill seeds than cooler ground temperatures (i.e., after they have dropped) (Rice, 2005; DiTomaso & Johnson, 2006).
Backing fires:	The use of backing fires (slow moving fires that are burnt against the wind) exposes seeds of invasive plants in the fine fuel canopy and on the ground to high temperatures for longer periods of time increasing the likelihood of mortality (Rice, 2005; DiTomaso & Johnson, 2006).
Fuel loading:	Deferring grazing (a general recommendation in all phases of a prescribed fire) and other fuel loading practices will allow for more fuel for the burn when needed (e.g., during backing fires) and will reduce seed shatter if burning takes place after seed maturation (Rice, 2005)
Pile burning:	Pile burning, with the piles located on top of invasive plant infestations, may be necessary when reproductive or regenerative parts of a plant require exposure to high temperatures for sustained periods of time (e.g., damaging belowground

	vegetative tissue - deep tap roots, caudex, root buds, rhizomes, perennating tissue, etc. - that usually survive surface fires or exposing heat-tolerant seeds to extended high temperatures to increase mortality such as with spotted knapweed).
Repeat burning:	Repeated annual burns have been shown to be effective at controlling some annual species [e.g., yellow starthistle (*Centaurea solstitialis*)] (Brooks & Lusk, 2008). However, this may be difficult in low productivity ecosystems where more time may be needed between burns for sufficient fuel accumulation (DiTomaso & Johnson, 2006). Additionally, consideration of repeat burn effects on the native plant community must be considered.
Burn area:	Larger burn areas are less at risk from invasion from outside invaders because of its smaller perimeter to area ratio compared to small burn areas, which have a higher ratio. Invasion, however, is dependent on invasive plant distribution across the landscape, and if invasive populations are sparsely distributed then large burn areas with a greater absolute perimeter are more likely to encounter invasive populations than small ones (Keeley, 2006)

As with any phase of a prescribed fire operation, anyone entering the burn site and surrounding areas should follow the general recommendations for invasive plant prevention by keeping vehicles, equipment and gear clean, and not parking, staging or driving through invasive plant infestations, where possible.

3.4 Phase 4: Post-Burn Monitoring and Adaptive Management

Post-burn monitoring and adaptive management is essential to ensure that early detection and control efforts are effective and eliminate re-invasion by targeted or newly established invasive plants. At a minimum, sites of previous infestations within the burn area or sites with high probability of invasion (e.g., close proximity to external invasive plant infestations, areas of low native propagule availability, areas that were disturbed pre-burn such as thinned areas of fuel breaks) should be monitored closely after burning to evaluate the response of invasive plants and respond accordingly.

These elements will not only ensure adequate response to re-invasions but will inform land managers on what can be expected during future burns for species' responses in similar ecosystems. This will help increase the efficacy of invasive plant management related to prescribed fires and will make the science of weed management stronger and more effective.

The rate of monitoring will depend on species-specific characteristics (e.g., how long invasive plant propagules remain viable, how long it takes for native plant community to re-establish, etc.). Generally, long-term monitoring and data are needed post-fire to understand whether

observed or anticipated establishment of non-native species will become invasive (Gucker et al., 2012).

Early detection and rapid response efforts are necessary to prevent invasive plants from establishing post-burn and ensure the success of management goals. Dealing with invasive populations early on after a prescribed fire will save land managers resources for the long-term, as invasive plants are increasingly difficult and costly to manage when they increase in abundance. While many management efforts will be species specific (Appendix 3), the general best practices outlined in Appendix 1 should also be followed.

Post burn land uses. Regulating or excluding livestock or human traffic into burned areas is a good way to prevent the introduction of invasive plant propagules and reduce additional disturbances such as bare ground, erosion and compaction. Plant propagules can travel with livestock by attaching to animals' bodies or through their digestive tracts (NRCS, 2001). Humans generally transport plant propagules via their vehicles (e.g., seeds stuck in dirt on the undercarriage or in the wheels) or on their person (e.g., seeds stuck in the tread of footwear or attached to clothing). Grazing from wildlife and/or livestock following a burn may also be determinantal to the recovery of the native or desirable vegetation in the area, especially if it receives heavy grazing pressure during it's early "green up" recovery time in the spring. It is recommended to prevent grazing in a prescribed fire project area for at least one season following a burn to help the site to recover. It is recommended that prescribed fire project managers contact local FLNRORD range staff to help determine and implement the appropriate grazing practices. This should be accomplished during the planning phase of a project to ensure appropriate agreements and alternate plans are in place for any existing range tenure holders within the project area.

3.4.1 Invasive Plant Treatments

Invasive plant treatments may be necessary pre- or post-burn. If the site is newly established, this may only require a single treatment to control the invasive plants present, but often treatments require multiple years for successful control to eliminate a persistent seed bank or energy storage in the root system. Invasive plants can be treated with mechanical, chemical, or biological means and often a combination of treatment methods, known as integrated pest management, is the most successful option. Treatment recommendations are highly species and site dependent, and therefore specific treatment recommendations are not covered within the scope of this document. **Herbicide may not be used for invasive plant management without proper authorization and approval by the land manager to ensure compliance with relevant legislation (see text box to the right).** More information on management of invasive plants on Provincial public lands can be found within the Province's Pest Management Plans available online: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species/integrated-pest-management/pmp-pup

IMPORTANT: Herbicide use for invasive plant management on Provincial public lands MUST be pre-approved in writing by the land manager prior to application to ensure compliance with the BC Integrated Pest Management Act and coordination with local treatment programs. Contact FLNRORD's Invasive Plant Program at invasive.plant@gov.bc.ca for support with developing treatment plans for work on Provincial Public Lands under the jurisdiction of MOTI, FLNRORD or BC Parks. Land manager pre-approval will also be required.

4.0 SUMMARY AND CONCLUSIONS

Prescribed fire can be an important and effective tool to help land managers meet ecosystem restoration and fuel reduction objectives throughout BC. As discussed in this document, the link between fire and invasive plants is becoming increasingly recognized and experience with prescribed fire projects and wildfires has highlighted the need for all land managers considering the use of fire to carefully and intentionally incorporate invasive plant best practices throughout all phases of a prescribed fire project. Even at the very start when first assessing potential prescribed fire project areas, each location should be rated for the risk of invasive plant introduction and spread depending on the site characteristics, expected results of introducing fire, condition of the pre-fire plant community, land uses and location, species, and abundance of invasive plants within and adjacent to the potential project areas. This risk level needs to be assessed to develop realistic project expectations, secure appropriate budget requirements and in some cases, to decide whether it is best to even proceed with a prescribed fire project or not. It is hoped that the information included in this document will help fill information gaps and ensure future prescribed fire project objectives can be successfully achieved, while ensuring the negative impacts of invasive plants are prevented or minimized.

5.0 CONTACTS AND MORE INFORMATION

BC Government Invasive Species Website: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species

BC Invasive Species database: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species

BC Government Rangeland Restoration: https://www2.gov.bc.ca/gov/content/industry/rangelands/ecology/restoration

"Do you know what is hiding in your seed" reference document for checking Certificates of Seed Analysis prior to purchasing seed lots https://www2.gov.bc.ca/assets/gov/driving-and-transportation/environment/invasive-species/invasive_plant_hiding_in_seed.pdf

BC Rangeland Seeding Manual https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/rangelands/bc_rl_seeding_manual_web_single_150dpi0904.pdf

Best Practices for Preventing the Spread of Invasive Plants during forest activities: https://bcinvasives.ca/resources/publications/best-practices-for-preventing-the-spread-of-invasive-plants-during-forest-m

Invasive Plant Specialists with the Ministry of Forests, Lands, Natural Resource Operations and Rural Development's (FLNRORD) Range Branch Invasive Plant Program directly or via invasive.plants@gov.bc.ca for support with developing treatment plans.

More information on management of invasive plants on Provincial public lands can be found within the Province's Pest Management Plans available online: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species/integrated-pest-management/pmp-pup **IMPORTANT: Herbicide use for invasive plant management must be pre-approved by the FLNRORD Invasive Plant Program staff.**

More information on the Province's Biological Control Program: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species/management/plants/biological-control

A Strategic Overview on Invasive Species Management in BC Parks: http://bcparks.ca/conserve/invasive-species/

6.0 LITERATURE CONSULTED

Bansal, S., and Sheley, R. L. (2016). Annual grass invasion in sagebrush steppe: The relative importance of climate, soil properties and biotic interactions. *Oecologia,* 181: 543-557. Retrieved from https://agsci.oregonstate.edu/sites/agscid7/files/eoarc/attachments/884_annual_grass_invas_2016.pdf

[BC] Government of British Columbia. (2010). Wildland fire management strategy. Retrieved from https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/wildfire-status/governance/bcws_wildland_fire_mngmt_strategy.pdf

Brooks, M. L., D'Antonio, C. M., Richardson, D. M., Grace, J. B., Kelley, J. E., DiTomaso, J. M., Hobbs, R. J., Pellant, M., and Pyke, D. (2004). Effects of invasive plants on fire regimes. *BioScience*, 54(7): 677-688

Brooks, M. L., and Lusk, M. (2008). Fire Management and Invasive Plants: A Handbook. United States Fish and Wildlife Service, Arlington Virginia, 27 pp.

D'Antonio, C. M., and Vitousek, P. M. (1992). Biological invasion by exotic grasses, the grass/fire cycle, and global change. Annu. Rev. Ecol. Syst., 23: 63-87. Retrieved from https://www.annualreviews.org/doi/pdf/10.1146/annurev.es.23.110192.000431

Davies, K. W. (2010). Revegetation of medusahead-invaded sagebrush steppe. *Rangeland Ecology & Management*, 63(5): 564-571

Davies, K. W., and Sheley, R. L. (2011). Promoting native vegetation and diversity in exotic annual grass infestations. *Restoration Ecology,* 19(2): 159-165

DiTomaso, J. M., and Johnson, D. W. (eds.). (2006). The use of fire as a tool for controlling invasive plants. Cal-IPC Publication 2006-01. California Invasive Plant Council: Berkeley, CA. 56 pp.

Dodson, E. K., and Fiedler, C. E. (2006). Impacts of restoration treatments on alien plant invasion in *Pinus ponderosa* forests, Montana, USA. *Journal of Applied Ecology,* 43(5): 887-897

Fusco, E. J., Finn, J. T., Balch, J. K., Nagy, R. C., and Bradley, B. A. (2019). Invasive grasses increase fire occurrence and frequency across US ecoregions. Proceedings of the National Academy of Sciences of the United States of America, 116(47): 23594-23599.

Gayton, D. (2006). Fire-maintained ecosystems: The zone of tension. In S. Bond (Ed.), *Fire-maintained ecosystem restoration in BC's Rocky Mountain Trench: Principles, strategy, progress – blueprint for action 2006* (pg. 5-10). Retrieved from http://www.sgrc.selkirk.ca/bioatlas/pdf/Blueprint2006.pdf

Gucker, C. L. (2009). *Tanacetum vulgare*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.fs.fed.us/database/feis/plants/forb/tanvul/all.html

Keeley, J. E. (2006). Fire management impacts on invasive plants in the western United States. *Conservation Biology*, 20(2): 375-384

Kimmerer, R. W., and Lake, F. K. (2001). The role of Indigenous burning in land management. *Journal of Forestry*, 99(11): 36-41. Retrieved from https://academic.oup.com/jof/article/99/11/36/4614303

Newman, R., and Hamilton, E. (2018). Burning questions (report – 7th version). Forest Enhancement Society of British Columbia, Kamloops, BC. 49 pp.

[NRCS] Natural Resources Conservation Service. (2001). Integrated noxious weed management after wildfires. *All U.S. Government Documents* (*Utah Regional Depository*). Paper 587. Retrieved from https://digitalcommons.usu.edu/govdocs/587

Rice, P. M. (2005). Fire as a tool for controlling nonnative invasive plants. Center for Invasive Plant Management. 52 pp.

Ridder, L. W. (2019). The response of *Ventenata dubia* to prescribed fire and ungulate grazing on the Pacific northwest bunchgrass prairie (Master's thesis). Oregon State University, Corvallis, OR. 84 pp.

Zouhar, K. (2003). *Linaria* spp. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.fs.fed.us/database/feis/plants/forb/linspp/all.html

Zouhar, K., Kapler Smith, J., Sutherland, S., and Brooks, M. L. (2008). Wildland fire in ecosystems: Fire and nonnative invasive plants. Gen. Tech. Rep. RMRS-GTR-42-vol. 6. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 355 pp.

Appendix 1: Prescribed Fire and Invasive Plant BMP Summary Checklist

	Prescribed Fire and Invasive Plant BMP Summary Table			
Best Practice	**Phase 1: Planning**	**Phase 2: Site preparation**	**Phase 3: Development and implementation of the Burn Prescription and Burn Plan**	**Phase 4: Post burn monitoring and adaptive management**
PLAN AHEAD	**Determine if invasive plant are present in and around your project area** (incl. species, location and extent) and report new sites as they are discovered.Use the Provincial InvasivesBC database to gather known invasive plant data and then conduct an invasive plant inventory in all potential burn units including a 100m buffer beyond burn unit boundaries, and along access roads (for at least of 5km).	Avoid incorporating existing invasive plant populations into managed fuel zones, where possible.	Incorporate the location of known invasive plant sites into burn plans.	Ensure the project has a post-burn invasive plant monitoring plan. Plan to focus monitoring at locations where pre-burn invasive plant sites were located, all disturbed areas with bare soil and moderate to severe burn intensity, and potential pick up/deposition points such as parking or staging areas.
	Ensure invasive plant considerations are incorporated into all phases of the project design (incl. costs and scheduling requirements). Assess the risk of spread of invasive plants within the proposed burn units, surrounding buffer areas and access roads, based on species present, how they spread, and the size and estimated duration of the infestation(s).	Minimize the use of retardants that may alter soil nutrient availability such as those containing nitrogen and phosphorus, except where their use will prevent the removal of vegetation.	If the potential is high for increased invasive plant spread as a result of the prescribed fire project, either remove those areas from the burn unit or incorporate invasive plant requirements into the burn prescription and burn plan, as well as post-burn monitoring and actions.	
LIMIT DISTURBANCE	Plan to prevent livestock grazing within the burn area for at least one year, and ideally until desirable site vegetation has recovered sufficiently to resist invasion by invasive plants.	Minimize unnecessary disturbance of desirable vegetation and limit the creation of exposed soil. Remove only enough vegetation to accomplish management objectives during site preparation, fire suppression and rehabilitation activities. Construct fuel breaks no wider than necessary. Selectively thin an area to reduce fuel continuity rather than clear-cutting to avoid a rapid opening of the canopy, especially in areas with shade intolerant invasive plants.	Limit disturbance along fuel breaks/fire guards where possible (eg use pre-existing fuel breaks rather than new), carefully construct fire guards no wider than necessary, use temporary wet or foam lines instead of exposing soil, and/or replacing highly flammable vegetation with less flammable vegetation when creating a managed fuel zone.	Limit grazing and public access where possible and minimize land uses that may reduce vigor of resprouting of native or desirable plants. Limit entrance and exit points to the burn unit/project area and limit unnecessary use of vehicles or equipment.
PREVENT INVASIVE PLANT INTRODUCTION AND SPREAD	Incorporate invasive plant awareness and best practices training for all staff and contractors.	Inspect and ensure fill, erosion-control or other materials are free of invasive plants before transport and use.		
		Ensure crews do not camp, park on, or stage equipment on existing invasive plant infestations. Rope off or flag areas to ensure no entry, or cover with invasive plant free soil, mulch or gravel prior to use to avoid picking up invasive plant seed or reproductive plant parts.		
	Consider temporary closure of the area to the public if it is a high use area to avoid any introduction of invasive plants while the native or desirable vegetation is recovering.	When working in an area with known invasive plant infestations, start in clean areas first and end in areas with invasive plants.		
		Limit entrance and exit points to the burn unit/project area and limit unnecessary use of vehicles or equipment wherever possible.		
		Inspect vehicles, gear (including boot treads) and equipment entering the project area to ensure they are clean of any plant material, mud or soil before entering the project area. Clean equipment before moving to a new work site or region.		
MONITOR AND MANAGE	Develop a 3-5 year post-burn invasive plant monitoring and management plan and ensure resources are secured PRIOR to commencing with the site preparation and prescribed fire implementation phases.	Hire qualified personnel to treat invasive plant infestations that are likely to re-establish and/or spread as a result of the site preparation or prescribed fire (incl. within burn area(s), along access roads, and within a 100m buffer).	Look for opportunities to locate machine created fire guards through smaller invasive plant infestations for species that spread only by seed and not rhizomes, taking care to pile all the material in one spot at least 10m away from water and wash equipment after.	Implement the post-fire invasive plant monitoring and treatment plan for at least 3 years following the disturbance. Detect invasive plants early and promptly control infestations before vegetative spread and/or seed dispersal. Enter all survey information into the Provinical Invasive Species Database, or report using the Province's 'Report Invasives' mobile App.
RESTORE		Revegetate exposed soil and disturbed areas as soon as possible after the disturbance. Allow natural succession where possible, or reseed during the first spring or fall following the disturbance. Design seed mixes to be locally adapted and non-invasive and do not include nitrogen-fixing plants. Always check Certificates of Seed Analysis prior to purchase and blending of a seed mixture. Avoid using nitrogen or phosphorous soil amendments (eg. fertilizers) in post-fire rehabilitation and restoration.		
	Incorporate restoration planning at the start of the project, including a cost analysis and secure resources as needed. Plan to stockpile and cover invasive plant free topsoil to support revegetation efforts after the burn is complete.	Stockpile invasive plant infested materials separately from invasive plant-free soil that can be pulled back over disturbed areas.		Use carbon sources including organic mulches to reduce available soil nitrogen and prevent erosion (ie. hydromulches or weed-free straw; do not use hay). To support natural recovery of an area, pull back or scatter any invasive plant free topsoil/organic matter back over exposed soil where control lines were established. DO NOT USE soil or organic material contaminated with invasive plants.

Appendix 2: Comparison of pre-burn and post-burn site conditions to determine burn prescription and burn plan considerations required.

		POST BURN SITE CONDITIONS EXPECTED		
		Low Resource Availability **(limited disturbance, low burn severity, no change in canopy cover)**	**Moderate Resource Availability** **(some exposed soil for fire guards, removal of scattered trees prior to burn, and/or moderate burn severity)**	**High Resource Availability** **(intense burn, large areas of exposed soil, significant increase in canopy opening due to tree removal)**
PRE-BURN SITE CONDITIONS	**No invasive plants present**	No additional management recommendations; no seeding recommended unless monitoring shows natural succession unsuccessful.	Very important not to introduce invasive plants from adjacent areas, via contaminated materials or dirty equipment. Support natural succession onto disturbed areas where possible (eg. pulling back invasive plant free topsoil, roughening and decompaction). Only seed where natural succession unlikely or where seeding is required to prevent erosion or in targeted areas at higher risk of invasive plant introduction (eg. roadsides, pullouts etc).	Very important not to introduce invasive plants from adjacent areas or via contaminated materials or dirty equipment. High risk of establishment and spread if invasive plants are introduced. Plan for seeding post-burn.
	Invasive plants present	Focus on minimizing the spread of invasive plants during site preparation and prescribed fire management activities. Treatment of invasive species prior to the burn may be recommended and may require multiple years depending on the species and potential seed bank present. Timing of the burn may be important to consider depending on the species present (Appendix 3).	Consider whether land management goals are achievable with fire at this site. Reducing the invasive plant population (including seed bank) prior to burning is recommended, which may take multiple years depending on the species present. Burn design should reduce the amount of resources available post burn as much as possible. Post-burn monitoring and treatment of invasive plants will be required for at least 3-5 years post- burn.	Consider whether land management goals are achievable with fire at this site. Reducing the invasive plant population (including seed bank) prior to burning recommended and likely to take multiple years depending on the species present. Burn prescription and burn plan design should reduce the amount of resources available post burn as much as possible. Post-burn monitoring and treatment of invasive plants should be expected for 3-5 years minimum following burn.

Appendix 3: Species-Specific Best Practices for Priority Invasive Plants during prescribed fire projects.

Contents

NOTES TO THE READER:

For many species limited information was available on fire effects and more research is recommended. This appendix is intended to be a living document and updated frequently as new research and post-fire monitoring is done.

Species are organized alphabetically and not by Provincial or Regional Priority. Not all priority invasive plant species are included here. For a full list of Priority Invasive Plants to consider when assessing a burn area, please see the Provincial Invasive Species Website. Additional species pages will be added as they are completed.

For additional information on invasive plants, control methods, and species-specific best practices contact the Ministry of Forests, Lands, Natural Resource Operation and Rural Development's Invasive Plant Program at Invasive.Plant@gov.bc.ca .

Blueweed

Photo credit: BC Gov't

Photo credit: BC Gov't

Photo credit: BC Gov't

Scientific Name:
Echium vulgare

Family:
Boraginaceae

Status:
Regional Noxious Weed (Cariboo, Central Kootenay, Columbia-Shuswap, East Kootenay, Okanagan-Similkameen, Thompson-Nicola) (*BC Weed Control Regulation)*

Origin:
Southern Europe and West-Central Asia.

General Description:
Biennial to short-lived perennial, tap-rooted, growing to 1m tall; rough stems covered in stiff hairs with swollen reddish to black bases where attached to the stem. Leaves are lance-shaped, alternating, and become smaller and stalk-less moving up the stem. Bright blue, five-lobed, funnel-shaped flowers on the upper side of stem; unequally lobed corolla with protruding stamens. Has long narrow rosette leaves; reproduces only by seed.

Impacts:
Rapidly invades rangelands, pastures, roadsides, and idle areas, particularly on coarse, sandy to gravelly soils. Blueweed reduces the quality of forage production and wildlife habitat. If baled in hay crops, blueweed will spoil the forage because the succulent leaves and stems become moldy. The seeds can act as a host for viral diseases. Blueweed Also contains pyrrolizidine alkaloids which can be toxic to livestock and cause skin irritation in humans.

Habitat:
Primarily found along roadsides, drainage ditches, rights-of-way, fence lines, pastures, rangeland, and other disturbed areas. Blueweed prefers moist climates but is also somewhat drought tolerant due to the taproot.

Shade Tolerance:
Blueweed is not shade tolerant and is rarely found on closed vegetative communities.

Current BEC Range:
Bunchgrass
Coastal Douglas-fir
Coastal Western Hemlock
Engelmann Spruce-Subalpine Fir
Interior Cedar-Hemlock
Interior Douglas-fir
Montane Spruce
Ponderosa Pine
Sub-boreal Pine-Spruce
Sub-boreal Spruce

Reproductive Strategy:
Reproduces by seed. Produces 500 to 2,800 seeds per plant. The seeds are generally dropped near parent plant; however, can be transported via wildlife or human as the rough seeds can stick. Wind has also been found to transport seeds up to 5m from the parent plant. Blueweed stems break allowing plants to roll and release any of the seeds held within the flowers. Seeds can remain viable within the soil for several years.

Known Fire Response:
There is very little information available for the known fire response of blueweed. Burn trials indicate blueweed does not dry out well and therefore will not burn well under low intensity fires.

Species Specific BMPs for Prescribed Burns
For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment: Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of blueweed on the site – large,

dense populations may signify high post-fire regenerative ability or seed availability for post-fire establishment and low native propagules. Wind is not likely to transport seed into site which may be transported via wildlife or human activity.

- Check the Invasives Species database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds, it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from transported or residual seeds. Follow general recommendations regarding weed prevention.

Burn Plan Development/During Burn:

- If possible, time prescribed burn to coincide with the early flowering stage of blueweed with enough heat to scorch the foliage and stem-girdle the plants.
- Repeat burning for 2-3 consecutive years provides good control by eliminating newly germinating plants prior to seeding and further reducing the seedbank, pending if management objectives can still be achieved.
- If burning during consecutive years, seed with sterile annual wheat/wheatgrass hybrid in the fall after burning to provide enough fuel for following year burn if necessary.

Post-fire Monitoring and Management: Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).

Bull Thistle

Photo credit: Wikipedia User, Famberhorst

Photo credit: Sheldon Navie

Photo credit: BC gov't

Scientific Name:
Cirsium vulgare

Family:
Asteraceae (Aster)

Status:
Forest and Range Practices Act

Origin:
Europe, western Asia, and northern Africa

General Description:
Bull thistle is a branching, erect biennial forb that grows from 0.6 to 1.8m in height. This species has an unbranching taproot up to 0.7m deep. Stems grow from single rosettes that can grow up to 1 m in diameter in some conditions but are on average 20-30cm wide. Plants contain many leaves that are deeply lobed with coarse, rough hair on the top surface and woolly hair on the undersides. Leaves have long, sharp spines on the midrib and at the tips of the lobes. Bull thistle flowers are pink-magenta in colour and subtended by gumdrop-shaped, spiny bracts.

Impacts:
Bull thistle is known to decrease available forage in rangelands and pastures because of its lack of nutritive value and ability to outcompete desirable forage and native species. Mature plants may interfere with the growth of tree seedlings impacting timber resources.

Habitat:
Bull thistle is widespread and can grow in a wide range of habitats and climatic conditions. It is most common in disturbed areas such as overgrazed pastures and rangelands, burned and logged forests, and along roadsides, ditches and fences. Bull thistle prefers soils with intermediate moisture and is rarely found on soils with a pH less than 4.8-5.0.

Shade Tolerance:
Bull thistle is likely somewhat shade intolerant. It is largely absent from habitats with less than 40% full sunlight. Decreased light availability is also associated with decreased seed germination for this species.

Current BEC Range:
Bunchgrass
Boreal White and Black Spruce
Coastal Douglas-fir
Coastal Mountain-heather Alpine
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Interior Mountain-heather Alpine
Mountain Hemlock
Montane Spruce
Ponderosa Pine
Sub-Boreal Pine – Spruce
Sub-Boreal Spruce

Reproductive Strategy:
Sexual – Bull thistle's only means of reproduction and spread is by seed production. Though flowers can self-pollinate, fertile seeds are usually only produced from cross-pollination. Bull thistle produces many seeds, with a single plant having anywhere from 1 to over 400 flowerheads and each flowerhead producing 100 to 300 or more seeds on average. Seeds have high viability but do not remain on or near the soil surface for more than a year. Seeds contain a feathery pappus that allows for dispersal by air, although most seeds fall near the parent plant. Other means of dispersal include animal and human activities.

Vegetative – Bull thistle does not reproduce vegetatively.

BioControl:
There is a well-established and effective biocontrol agent for bull thistle that is dispersed throughout BC.

Known Fire Response:
Post-fire conditions such as bare soil and increased light availability are ideal for the establishment of Bull thistle from off-site or remnant seed sources. Seeds are likely killed in low-severity fires, especially under moist conditions. However, some seeds may survive fires under drier conditions.

Species Specific BMPS for Prescribed Burns
For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:
- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Bull thistle on the site – large, dense populations may signify high seed availability for post-fire establishment and low native propagules. External populations may supply a seed source to the burn site via wind-borne seeds.
- Check the Invasive Species database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (2 years or less), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from wind-borne or residual seeds or from increased light availability. Treat any newly established populations before setting seed.

Burn Plan Considerations:

Post-fire Monitoring and Management:
- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Limit post-fire disturbances that may expose previously buried seeds that may then germinate and establish on burn sites.
- Continued monitoring is necessary to ensure early detection and eradication of Bull thistle (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally around 85% cover of desirable species.

Canada Thistle

Photo credit: ISCBC

Photo credit: Oregon State University

Photo credit: Everybody Gardens Webpage

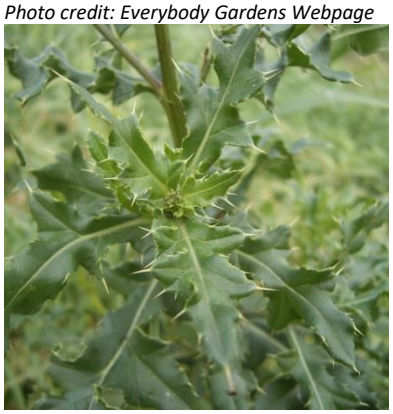


Photo credit: Weed Wise, Clackams SWCD

Scientific Name:
Cirsium arvense

Family:
Asteraceae (Aster)

Status:
Provincial Noxious Weed (*BC Weed Control Regulation*)

Origin:
Southeastern Europe and the eastern Mediterranean area

General Description:
Canada thistle is a perennial forb growing from a slender taproot and producing many far-creeping lateral roots. It can reach heights of 1.2m. Stems are many-branching with stalkless leaves that have irregular, spiny lobes. The clustered flowerheads of this species are spineless and small compared to other thistles, and flowers vary in colour from rose-purple to pink to white.

Impacts:
Due to clonal growth from lateral root buds, Canada thistle can rapidly produce dense infestations that crowd out and displace native grasses and forbs changing the structure and species composition of natural areas and reducing biodiversity. This species can limit or reduce forage for livestock and wildlife species and can limit the use of recreational areas.

Habitat:
Canada thistle can occupy a variety of habitat types and plant communities and occurs in nearly every upland herbaceous community within its range. It commonly grows in disturbed and riparian areas such as roadsides, railroads, streambanks, ditches, lakeshores, seashores, sand dunes, and clear-cuts and forest openings.

Shade Tolerance:
Canada thistle is relatively shade intolerant. It may be found growing along the edges of woods, but is rarely found under forest canopy, in undisturbed prairies, woodlands, or sites that are shaded most of the day.

Current BEC Range:
Bunchgrass
Boreal White and Black Spruce
Coastal Douglas-fir
Coastal Mountain-heather Alpine
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Interior Mountain-heather Alpine
Mountain Hemlock
Montane Spruce
Ponderosa Pine
Sub-Boreal Pine – Spruce
Sub-Boreal Spruce
Spruce – Willow – Birch

Reproductive Strategy:
Sexual – Canada thistle can reproduce via seed production. This species is dioecious, with male and female flowers occurring on separate plants and requiring pollination. Single plants typically produce 32 to 69 flowerheads per plant and flowerheads produce an average of 30 to 70 seeds. Seeds mature quickly and can remain viable for up to 22 years when buried more than 20cm but are typically only viable for less than 5 years in shallower soil. Overall seed viability is poor. Seeds mainly germinate in spring, and germination is best when seeds are buried 0.5 to 1.5cm in the soil. Seed dispersal is primarily by wind, and seeds can be carried for several hundred meters. Seeds are also dispersed by water, animals, contaminated seed, and human activities.

Vegetative – Canada thistle produces vertical and lateral roots containing adventitious buds that contribute to most of the local spread of this species. Mature plants can regenerate after top-growth is damaged and root fragments as short as 6mm can regenerate entire plants.

Known Fire Response:

Canada thistle is well adapted to survive fires and to colonize areas of bare soil created by fires with wind-borne seeds. This species is likely to survive even severe fires because of its relatively deep, extensive root system with adventitious root buds and re-sprouting ability. Canada thistle seeds are somewhat heat tolerant surviving exposure to temperatures of 262^{o}C for 2 min. and 102^{o}C for 10 min. in one study, albeit with lower viability. Additionally, Canada thistle may add to the intensity of a fire, adding abundant, flammable aboveground biomass to fuel loads of sites that it inhabits.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Canada thistle on the site – large, dense populations may signify high post-fire regenerative ability or seed bank. External populations from the burn site may supply a seed source to the site post-fire from wind-borne seeds.
- Check the Invasive Species database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (<5 years), it is possible a seed bank exists that could germinate post-fire.
- Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from wind-borne or residual seeds. Treat any newly established populations before setting seed.

Post-fire Monitoring and Management:

- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Continued monitoring is necessary to ensure early detection and eradication of Canada thistle (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally around 85% cover of desirable species.

Gap Analysis

- Canada thistle infestations are not well represented in the provincial IAPP database except in remote areas due to its widespread distribution.

Cheatgrass

Photo credit: BC gov't

Photo credit: Farms.com

Photo credit: Garden Wise

Photo credit: University of Wisconsin-La Crosse

Scientific Name:
Bromus tectorum L.

Family:
Poaceae

Status:
Unregulated invasive plant

Origin:
Europe, northern Africa, and southwestern Asia

General Description:
Cheatgrass is a rapidly growing winter annual grass, meaning it germinates in the fall, matures early the following year, sets seed and cures before most native species. Cheatgrass is bright green while growing and turns to reddish-brown when it cures. Its inflorescence is many-branched (panicle), drooping, and grows 5 to 20cm long. Spikelets have lots of straight awns attached to florets (2-8 per spikelet). Finely divided, fibrous roots spread laterally and vertically, mostly concentrated in the top 30cm of soil.

Impacts:
Cheatgrass can grow and reproduce rapidly, often dominating the landscape resulting in complete type-conversion of plant communities to vast cheatgrass monocultures. This results in a decrease in plant and animal diversity, changes to natural disturbances like fire regimes, and alters natural successional trajectories, nutrient cycling and soil attributes.

Habitat:
Cheatgrass is common in southern parts of BC at low- to mid-elevations. It can grow in a variety of climatic conditions and typically establishes on disturbed sites such as roadsides, overgrazed rangelands and grasslands, abandoned fields, and recently burned areas. Cheatgrass's ability to persist and expand on a site is dependent on disturbance regimes, moisture, temperature, soil typeand plant community characteristics.

Shade Tolerance:
Cheatgrass is intolerant to shade.

Current BEC Range:
Bunchgrass
Coastal Douglas-fir
Interior Cedar – Hemlock
Interior Douglas-fir
Montane Spruce
Ponderosa Pine

Reproductive Strategy:
Sexual – Cheatgrass only reproduces by seed production. This species is a prolific seed producer, and a single plant can produce anywhere from 25 to 5,000 seeds or more. Plants frequently produce two successive sets of inflorescences in a single growing season. Seeds typically germinate in the fall but may germinate the following spring if fall moisture is lacking. Seeds that do not germinate because of high seed density can remain viable in the soil for 2 to 3 years. Most seeds fall passively to the ground around the parent plant. Long-distance dispersal is by humans, wild and domestic animals, and machinery or equipment.

Vegetative – this species does not reproduce vegetatively.

Known Fire Response
Cheatgrass is highly adapted to frequent fire disturbances. The dense, continuous fuel created by cheatgrass populations facilitates burns that are more frequent than in historic fire regimes where the plants invade. By the time of burning, most cheatgrass seeds have shattered and reached the soil surface where temperatures during fires are relatively cool. The early germination and rapid growth of remnant cheatgrass seeds gives it a competitive advantage over native species that are not able to recover from fire as quickly. The subsequent mass seed production and germination of more cheatgrass plants facilitates even more fires that favour cheatgrass's biological characteristics over other

species. Overall, cheatgrass creates an environment where fires are ignited easily, spread quickly, cover large areas and occur frequently.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of cheatgrass on the site – large, dense populations may signify high invasive propagule availability (i.e., seeds) for post-fire recolonization and low native plant propagules.
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from wind-borne or residual seeds or from increased light availability. Treat any newly established populations before setting seed.

Burn Plan Development/During Fire:

- If possible, burn cheatgrass at the phenological stage where seeds remain in the panicle (prior to dropping on the ground). Prescribe a backing fire to ensure full consumption of plant material and seeds. This may also expose seeds on the soil surface to sustained temperatures that can result in mortalities. However, this often requires early season burning that can harm the regeneration of native forbs and grasses. Consideration of management goals is needed in making this prescription.

Post-fire Monitoring and Management:

- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Continued monitoring is necessary to ensure early detection and eradication of cheatgrass (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally at least 85% of desirable species.

NOTE ON CURRENT EXTENT OF CHEATGRASS:

- Cheatgrass infestations are not well represented in the provincial Invasive Species database. It is much more widespread that mapped, therefore it is important to confirm the presence or absence of cheatgrass at each project location.

Common Tansy

Photo credit: BC gov't

Photo credit: Ben Legler

Photo credit: BC gov't

Scientific Name:
Tanacetum vulgare

Family:
Asteraceae (Aster)

Status:
Regional Noxious Weed (*BC Weed Control Regulation*)
(Bulkley-Nechako, Central Kootenay, Columbia-Shuswap, East Kootenay, North Okanagan)

Origin:
Eurasia (specifically, subalpine river valleys in Siberia)

General Description:
Aromatic perennial forb growing to 1.8m tall; deeply divided dark green leaves; yellow "button" flowers in clusters at the top of plant; no ray flowers. Common tansy is a robust perennial with erect stems that may reach 2m tall. Stems generally branch only at the top and are somewhat woody at the base. Stems may grow singly or in clusters and are lined with alternate leaves. When crushed, leaves produce a rank smell. Leaves are finely dissected and toothed. Common tansy is rhizomatous. Flower heads are comprised of daisy-like disk florets. Within the flower head there may be as many as 100 individual florets. Rhizomes branch extensively and produce many fibrous roots. Roots can extend up to 1.3m belowground.

Impacts:
Generally, dense common tansy populations are thought to negatively impact water flow (such as in irrigation ditches), native vegetation (by crowding out other forbs, grasses and shrubs, potentially reducing forage value of pastures or rangelands, decreasing wildlife habitat, and reducing species diversity), and wildlife habitat. *Climatic tolerances mean it can invade a huge area and wide array of ecosystems.* Common tansy may affect germination of associated species (allelopathy) but not growth rate.

Habitat:
Common tansy often occupies recently disturbed sites. Common tansy is most common along roadsides, riverbanks and waste places. Common tansy occurs in rangelands and pastures, sand dunes, mires, montane steppe, subalpine grasslands, fence lines, railways, gravel pits, lakeshores, and floodplain woodlands. Common tansy is often described on recently and/or periodically disturbed sites that include vacant lots, gardens, pastures, railroads, roadsides, irrigation ditches, stream banks, and lakeshores. Common tansy is also reported in marshes, swamps, rangelands, prairies, meadows, and woodlands. Common tansy has a wide climate tolerance but also a preference for cooler continental climates.

Shade Tolerance:
Although common tansy growth may be best in full sun, it is reported on sites with full sun to partial shade, shaded riparian sites, and generally grows taller in shaded than unshaded sites.

Current BEC Range:
Boreal Altai Fescue Alpine
Bunchgrass
Boreal White and Black Spruce
Coastal Douglas-fir
Coastal Mountain-heather Alpine
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Mountain Hemlock
Montane Spruce
Ponderosa Pine
Sub-Boreal Pine – Spruce
Sub-Boreal Spruce
Spruce – Willow – Birch

Reproductive Strategy:
Common tansy flowers from July to October. Seed dispersal and seedling establishment are largely

responsible for the spread of common tansy populations. However, extensive rhizome growth can be important in the development of large plants and colonies over a small area. Most common tansy florets have both male and female reproductive organs. Cross pollination of flowers is predominant. Most self-pollinated plants fail to produce seeds. Common tansy is a prolific seed producer. A single common tansy plant can produce up to 50,000 seeds (depending on number of flower heads). Long-distance wind dispersal of seeds is unlikely. Seeds can remain in flower heads on dead stems for up to three years (but germination studies on 3-year-old seeds were not conducted). Seeds can be dispersed by water, gravity, animals and humans. Speculation suggests that common tansy produces a short-lived seed bank. Seeds may only be viable for one season. Seeds germinate best when near the soil surface, cold stratified, and then exposed to warm temperatures. Seedling establishment and growth is generally best on open sites with limited litter, little established vegetation and high light levels.

Large colonies and dense clumps are primarily the result of spreading rhizomes. New plants can sprout from rhizome fragments that can be dispersed by soil movement or equipment.

Known Fire Response:

Common tansy is likely only top-killed by fire. Rhizome survival on burned sites is likely. On sites with established plants, post-fire sprouting from rhizomes is likely the predominant regeneration method. Because common tansy seeds can be dispersed long distances and seedlings establish best on sites with bare ground, little established vegetation, and high light levels, burned areas could provide suitable establishment sites. Fire *may* result in increased abundance or facilitate spread of common tansy. Prescribed fire alone is not likely to control common tansy. However, fire may be useful in removing dead stems and litter and increasing common tansy's exposure to herbicide treatments or grazing. Fire may also be useful to dispose of stems with flowers or seeds on mowed or cut sites, because on-site destruction of reproductive stems should decrease the potential for dispersal and spread.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Limit grazing to less than 60% defoliation in proposed burn areas that already contain common tansy to prevent further spread.
- Minimize disturbance in areas with and without common tansy.
- Hand pull small common tansy populations and mow larger populations prior to flower and seed development (more effective when paired with seeding of desired species, maintaining established vegetation, and/or other control methods).
- Persistent hand-pulling may be effective at controlling small pops if most or all rhizomes are removed (seeding areas disturbed by hand-pulling with desired species may decrease potential for re-establishment – see Section 3.0 above for more information on seeding).

Burn Plan Development/During Burn:

If possible, pile debris on Common tansy infestations to burn.

Garlic Mustard

Photo credit: BC gov't

Photo credit: Eltmann

Photo credit: Phyzome

Photo credit: Eltmann

Scientific Name:
Alliaria petiolata

Family:
Brassicaceae (Mustard)

Status:
Provincial Noxious Weed (*BC Weed Control Regulation*)

Origin:
Europe and Asia

General Description:
Garlic mustard is a cool-season biennial or occasional winter annual form. It is monocarpic, meaning it dies once it sets seed.
Garlic mustard has a taproot and produces a garlic-like aroma when its foliage is crushed, hence its name. Garlic mustard grows from 0.2 to 1.2m tall. Its rosette and basal leaves are dark-green and kidney-shaped, while its stem leaves are heart-shaped. White, four-petalled flowers form racemes at the top of the stems.

Impacts:
Garlic mustard is problematic because it can invade relatively undisturbed forested areas and forms dense monocultures. It displaces native plant species and impedes their growth by interfering with the growth of fungi that bring nutrients to their roots.

Habitat:
Garlic mustard occurs in the understories of a variety of deciduous forests and woodlands but is not often associated with coniferous forests. This species can grow in a wide variety of environmental conditions including variable soil moisture, light availability, and soil characteristics, although it may be less competitive in areas with low soil pH. Most populations occur in disturbed areas such as roadsides, trails, railroads, floodplains and riverbanks.

Shade Tolerance:
Garlic mustard appears to favour partially shaded sites but may be less invasive under extreme conditions of shade or light.

Current BEC Range:
Coastal Douglas-fir
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Montane Spruce

Reproduction Strategy:
Sexual – Garlic mustard is a prolific seed producer, which is its only means of reproduction. Seed pods (siliques) each contain 12-19 seeds and a single plant can produce anywhere from 1 to 200 siliques. Both self- and cross-fertilization produce viable seeds for this species. Seeds remain dormant until they undergo cold stratification often requiring 1 to 2 overwintering seasons to break dormancy. Germination of seeds occurs at low temperatures, often in early spring before overstory vegetation leaf-out. Garlic mustard does not produce a persistent seedbank as seed viability drops substantially after the first growing season. However, a small number of seeds may remain viable for 4 to 6 years. Seeds can burst out of the siliques and generally fall within a few meters of the parent plant. Long-distance dispersal may be facilitated by human and animal activities or along waterways.

Vegetative – this species does not undergo vegetative reproduction but can sprout from the root when damaged.

Known Fire Response:

Garlic mustard plants are likely top killed with fire; however, plants may sprout from the root crown following a fire. Additionally, the availability of protected areas in forested habitats during mixed and low intensity fires may protect small populations of garlic mustard that can spread within the burned area after the fire. Post-fire conditions, such as increased exposed soil and nutrient availability, may then offer persistent populations the ability to undergo rapid population growth. Due to its ability to self-fertilize, even a single remaining garlic mustard plant may be enough to perpetuate a population. Due to its high moisture content, the presence of Garlic mustard may contribute to fire suppression by limiting the ability of forest understories to carry surface fire and potentially alter the natural fire regime of the habitats it invades.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Garlic mustard on the site – large, dense populations may signify high seed availability for post-fire establishment and low native propagules as well as areas where fire may be suppressed. External populations may supply a seed source to the burn site via water and animal activities.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (6 years or less), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- Mechanically pull or dig individuals or small populations ensuring the upper portion of the root is removed to prevent re-sprouting and that pulled plants are removed from site as seed development and dispersal can continue on pulled plants.
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from residual or nearby seed sources.

Burn Plan Development/During Fire:

- If possible, perform carefully timed spring burns (after Garlic mustard emergence but before emergence of desirable plants) or multi-year burns to effectively control Garlic mustard populations if these burns can still result in management objectives.
- Prescribe mid- to high-severity fire to top-kill and damage Garlic mustard roots if these burns can still result in management objectives.

Post-fire Monitoring and Management:

- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Continued monitoring is necessary to ensure early detection and eradication of Garlic mustard (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally at least 85% cover of desirable species. Monitor in the spring after emergence but prior to seed development for at least 6 years (lifespan of seeds) in areas with pre-existing Garlic mustard populations.

Gorse

Photo credit: F. & K. Starr

Photo credit: F. & K. Starr

Photo credit: BC Gov't

Photo credit: BC Gov't

Scientific Name:
Ulex europaeus

Family:
Fabaceae (Pea)

Status:
Provincial Noxious Weed (*BC Weed Control Regulation*)

Origin:
Central and western Europe and the British Isles

General Description:
Common gorse is a medium to tall (up to 3m), long-lived (up to 45 years) perennial evergreen shrub. Younger plants have hairy branches with alternating leaves consisting of 3 leaflets. Leaves are reduced to long (4.5-6.5cm) spines or stiff scales in high numbers on older plants. Branches on older plants are rigid, strongly angled, and intricately intertwined, arising from the base and ending in spiny tips. Plants have many persistent, pea-like yellow flowers that smell of coconut or bruised peaches and are surrounded by a velvety calyx. Flowers develop into black, flat seedpods up to 2cm long. Common gorse's extensive, multi-branched lateral root system contains nitrogen-fixing nodules. Lateral roots are supplemented by a fine mat of adventitious roots that descend from the lower branches of the plant.

Impacts:
Established Common gorse stands can exclude the establishment of and shade out native vegetation and limit the growth of conifer seedlings, potentially hindering the regeneration of logged areas. Dense stands can perpetuate for many years and exclude wildlife and recreational use in infested areas. On the BC coast, arbutus ecosystems can be threatened by this species. Common gorse also increases fire risk in areas where it is established due to the plant's high concentration of volatile oils and litter production. This species can invade and replace desirable forage vegetation in pastures and rangelands and contributes to increased soil erosion and decreased biodiversity.

Habitat:
Common gorse typically prefers open areas and clearings with full sun and low soil fertility. It is most common in open, disturbed sites such as roadsides and fence rows, abandoned or overgrazed pastures, sand dunes and gravel bars, logged areas, and post-fire communities. This species does not occur in arid climates or regions that experience extremes of heat and cold.

Shade Tolerance:
Common gorse typically exhibits low shade tolerance. Seedling establishment is usually inhibited by dense vegetation, and plants produce sparse foliage and few flowers under low light conditions.

Current BEC Range:
Coastal Douglas-fir
Coastal Western Hemlock

Reproductive Strategy:
Sexual – Common gorse typically reproduces via seed production. Flower production typically begins within the second or third growing season. While Common gorse plants can self-fertilize, outcrossing often results in higher fertility. A single Common gorse plant can produce up to 18,000 seeds, the majority of which can remain viable for up to 40 years producing an extensive, long-lived seed bank. Seeds often require scarification to germinate and cannot germinate if buried below 5cm in the soil, although deeply buried seeds survive longer than surface seeds and will germinate if disturbance brings them to the surface. Most germination occurs in the spring when soil temperatures reach about 16˚C but fall germination can exceed spring germination if preceded by late-summer fires. Seeds are borne in pods, and the majority disperse directly around the parent plant. Intermediate and long-distance dispersal can occur through animal and human

activities, water transport, and possibly wind gusts.

Vegetative – Common gorse can sprout from aboveground stem tissue following damage to stems. Root fragments can produce new Common gorse plants.

Known Fire Response:

Common gorse has been described as a pyrophytic, or "fire-loving," species. Depending on the depth of seed burial and scarification, seed germination of Common gorse is typically accelerated following a fire; however, seeds may be consumed by high-severity ground fires. Common gorse can regenerate by prolific and rapid sprouting from its basal stem region following fires. Repeated fires typically result in Common gorse dominance on the landscape due to the combination of rapid sprouting and high seed germination. However, Common gorse is typically killed by severe ground fires that consume most or all of a deep organic surface horizon.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Common gorse on the site – large, dense populations will signify high invasive propagule availability (seeds and sprouting stem tissue) for post-fire recolonization and low native plant propagules.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (40 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- If prescribing a severe ground fire, herbicide applications or mechanical crushing should be applied 15 months prior to burn to desiccate Common gorse biomass, increase surface fuel load, and increase Common gorse consumption and mortality during the burn.
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from seed banks, nearby seed sources, or due to increased light availability.

Burn Plan Development/During Fire:

- Prescribe severe ground fires to increase mortality of established Common gorse plants and seeds if desired management objectives can still be achieved.
- Follow general recommendations regarding invasive plant prevention.

Post-fire Monitoring and Management:

- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Due to the long-term viability of established seed banks, continued long-term monitoring is necessary to ensure early detection and eradication of Common gorse (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally at least 85% cover of desirable species.

Leafy Spurge

Photo credit: EKIPC

Photo credit: National Gardening Association

Photo credit: Minnesota Department of Agriculture

Scientific Name:
Euphorbia esula

Family:
Euphorbiaceae

Status:
Provincial Noxious Weed (*BC Weed Control Regulation*)

Origin:
Eurasia

General Description:
Leafy spurge is an erect, perennial forb with persistent vertical and horizontal creeping roots. It grows from 0.2 to 0.8m tall. Stems have a woody texture and are nearly shrubby when mature. Leaves of this species are lanceolate and arranged on the stem in a spiral fashion, with a whorl of leaves located at the base of the umbel formed inflorescence. Greenish-yellow flowers that lack both sepals and petals and are inserted above two leaf-like, heart-shaped yellow-green bracts. When broken, leafy spurge excretes a milky latex.

Appearance similar to Cypress spurge (*Euphorbia cyparissias*). In general, leafy spurge is larger and produces fewer and larger leaves than cypress spurge. Burning guidelines for Leafy spurge will apply equally to Cypress spurge.

Impacts:
Leafy spurge can outcompete and displace desirable native plant species. This, and the fact that the plant's milky latex deters grazing by most animals, accounts for a reduction in available forage for wildlife and livestock because of Leafy spurge infestations. Additionally, the milky latex can irritate the skin of humans and livestock that are exposed to it.

Habitat:
Leafy spurge occupies a variety of habitat types and plant communities including grasslands, riparian areas, shrublands, open woodlands and savannas. It is common in disturbed areas such as roadsides, old fields and pastures, and fences.

Shade Tolerance:
Leafy spurge can persist in shaded environments though it usually produces little or no seed under these conditions. Seedlings of this species require disturbed, open sites for establishment.

Current BEC Range:
Bunchgrass
Coastal Douglas-fir
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Montane Spruce
Ponderosa Pine
Sub-Boreal Spruce

Reproductive Strategy:
Sexual – Leafy spurge reproduces via seed production. Flowers can self-pollinate, although greater seed production typically results from cross-pollination. Plants produce about 140 seeds per main stem and patches of Leafy spurge can produce seed rain of 2,500 seeds per m^2. Seeds are rarely viable in the soil for more than 5 years with most seeds germinating the first two years after dispersal. Dormancy in Leafy spurge seeds is overcome by warm, moist conditions, and nearly all germination happens in May and June. Seeds are forcibly ejected from dry Leafy spurge capsules to distances of up to 4.5m. Seeds can pass through the guts of livestock and wildlife and remain viable, facilitating long-distance dispersal. Seeds are buoyant and can be dispersed long-distances via water.

Vegetative – Leafy spurge can spread, re-sprout, and reproduce prolifically from vegetative growth of root buds, the root crown, and root fragment, often forming dense patches. Roots can reach depths in the soil of up to 8m, and relatively small (1.3cm) root fragments can regenerate in the soil at depths of up to 3m.

Biocontrol:
Effective biocontrol exists for Leafy spurge in some areas of BC.

Known Fire Response:
Because of the deep, extensive root system with abundant adventitious buds, mature Leafy spurge plants are likely to survive and re-sprout after even severe fires. Fire can kill leafy spurge seeds, but mortality depends on the timing and severity of fire, and depth of seed burial. Seeds deeper than 10cm are unlikely to be killed.

Species Specific BMPs for Prescribed Burns
For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:
- Perform initial site surveys of proposed burn area and surrounding area (100-m) to determine the presence and extent of Leafy spurge on the site – large, dense populations may signify high invasive propagule availability (seeds and vegetative buds) for post-fire recolonization and low native plant propagules.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (5 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from wind-borne or residual seeds or from increased light availability.

Post-fire Monitoring and Management:
- Exclude grazers from burn area until native plant community has established to desirable levels as they are can transport Leafy spurge seeds in their gut.
- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Mulching is an option to limit light availability to seeds where pre-fire populations occurred. Ensure mulch is free of invasive plant propagules.
- Continued monitoring is necessary to ensure early detection and eradication of Leafy spurge (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally at least 85% cover of desirable species.

Marsh Plume Thistle

Photo credit: BC gov't

Photo credit: BC gov't

Photo credit: BC gov't

Scientific Name:
Cirsium palustre

Family:
Asteraceae (Aster)

Status:
Regional Noxious Weed (Bulkley-Nechako, Fraser-Fort George) (*BC Weed Control Regulation*)

Origin:
Europe

General Description:
Marsh plume thistle or Marsh thistle is an erect, biennial or short-lived perennial forb that grows up to 2.0m tall. Each plant has a single slender, winged stem with many spines that is usually unbranched except if cut or bent or in the upper portion which terminates in clusters of purple flowerheads. Stems have a purplish appearance. Most of the plant is covered in long sticky hairs. Rosette leaves are deeply lobed, long and spiny. Stem leaves are alternate, deeply lobed, spine-tipped, hairy on the underside and have prominent woody veins. Leaves close to the base of the plant are 15 to 30cm long but become shorter further up the stem. Purple flowerheads develop on short branches at the end of the stem in clusters of few to many. Marsh plume thistle produces a taproot with clusters of fibrous roots but no rhizomes.

Impacts:
Marsh plume thistle is capable of rapid expansion and negatively impacts native plant communities by displacing native vegetation. It can form dense spiny stands that are near impenetrable and has been implicated in the degradation of sedge meadows in BC.

Habitat:
Marsh plume thistle is common in disturbed habitats such as roadsides, early seral forests, overgrazed pastures and rangelands, and gardens. It is adapted to grow in moist environments and is typically found in wetlands, moist meadows, and coastal grasslands, though it may not tolerate long-term flooding or saturation. This species likely has low drought tolerance.

Shade Tolerance:
While Marsh plume thistle populations do best in open, bright sites, it is still considered somewhat shade tolerant. It is capable of germinating in low-light, low-temperature environments; however, the growth and reproduction of Marsh plume thistle may be reduced by shading.

Current BEC Range:
Boreal White and Black Spruce
Coastal Douglas-fir
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Ponderosa Pine
Sub-Boreal Spruce

Reproductive Strategy:
Sexual – Marsh plume thistle reproduces exclusively via seed production. It is monocarpic, meaning it dies once it flowers and produces seeds usually after 2 years. Flowers are self-compatible, though most are cross-pollinated by insects and seeds of self-pollinated plants generally have lower viability. A single Marsh plume thistle plant can produce upwards of 2,000 seeds. Seeds germinate under conditions of warm temperatures and full light after cold stratification. A feathery pappus attached to each seed allows for wind dispersal generally within 10m of the parent plant,

although strong winds can carry seeds for several kilometers. Seeds are also dispersed over long distances via water runoff and by human or animal activities.

Vegetative – Marsh plume thistle does not reproduce vegetatively, though it can undergo vegetative regeneration following damage.

Known Fire Response:

Marsh plume thistle plants are likely top-killed by fire, although re-sprouting from the root crown is likely after low- or moderate-severity fires. Post-fire conditions such as exposed soil, reduced competition and increased nutrient availability provide suitable establishment sites for Marsh plume thistle seedling emergence given an available seed source either from a remnant seedbank or off-site populations.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Marsh plume thistle on the site – large, dense populations may signify high post-fire regenerative ability or seed availability for post-fire establishment and low native propagules. External populations may supply a seed source to the burn site via wind-borne seeds.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (5 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- Mechanical treatment by cutting or mowing must be repeated monthly. Mechanically treat large patches by mowing before flowering to prevent seed-set and reduce or eliminate propagules for post-fire germination. Dig individuals, ensuring that the top of the taproot is removed to prevent re-sprouting from the crown. Ensure flowerheads are removed from site if mechanically treating after flowering to eliminate post-treatment seed-set and dispersal.
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from wind-borne or residual seeds.
- Mulching is an option to limit light availability to seeds where pre-fire populations occurred or where external populations are close by. Ensure mulch is free of invasive plant propagules.

Burn Plan Development/During Burn:

Post-fire Monitoring and Management:

- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Mechanically treat newly germinating or sprouting populations by hand-pulling prior to flowering and seed-set.
- Continued monitoring is necessary to ensure early detection and eradication of Marsh plume thistle (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally at least 85% cover of desirable species.

Meadow Salsify

Photo credit: Thomas Huntke

Photo credit: BC gov't

Photo credit: Andrea Moro

Scientific Name:
Tragopogon pratensis

Family:
Asteraceae (Aster)

Status:
Unregulated invasive weed

Origin:
Eurasia (and northern Africa?)

General Description:
Biennial or monocarpic (dies after flowering and seed production) perennial forb. Yellow, dandelion-like flowers. Hybridizes readily with other *Tragopogon* spp. (***Key features for differentiating diploid Tragopogon species are ligule colour, number and length of involucral bracts, size and shape of head and peduncle, achene length, leaf morphology, and leaf length.***) Leaves are curled at the apex and crisp at the margin, although the amount of leaf curling varies. A milky juice is exuded from the stem when broken. Unlike *T. dubius*, meadow salsify has 8 or fewer bracts that do not extend beyond the flower head. Mature seedhead is a large, conspicuous sphere comprised of seeds with long, slender beaks and an umbrella-like pappus for wind dispersal. Leaves are linear and grass-like, flowers consist of two distinct belts of ligulate florets (inner and outer). Rosettes are erect (allowing them to emerge through litter or vegetation and colonize areas where plant communities are already established). Only one flowerhead is produces per stalk but plants may produce several flowering stems ranging from 2-11. Rosette of grass-like leaves.

Impacts:
Meadow salsify is a concern for rangelands in BC. It competes with native species. Meadow salsify can dominate certain areas due to its extensive roots system and prolific reproduction from seed and can form dense stands in urban areas.

Habitat:
Meadow salsify favours slightly moist habitats, and flourishes in dry interior regions of BC. Meadow salsify grows on a variety of soil types ranging from sandy to clay loam. Does well on roadsides and waste places (disturbed areas).

Shade Tolerance:
Not observed in shaded areas.

Current BEC Range:
Bunchgrass
Boreal White and Black Spruce
Coastal Douglas-fir
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Montane Spruce
Ponderosa Pine
Sub-Boreal Pine – Spruce
Sub-Boreal Spruce

Reproductive Strategy:
Seeds have relatively large umbrella-like pappuses which promote long-distance dispersal. Seeds require warm temperatures for germination, most significantly between 15 and 25^{0}C. At 5^{0}C very few seeds will germinate but remain viable. Seeds lose viability after prolonged duration in anaerobic conditions. Flowering occurs mainly between June and July in the second or subsequent years of growth. Seeds germinate in the fall or in the spring contributing to greater viability of isolated populations under fluctuating conditions. Meadow salsify is pollinated by insects. A high proportion of seeds are viable. This species does not have a large or persistent seed bank. Seeds can germinate in darkness. Dormancy

of seeds increases with increased burial depth. Increased burial depth does not inhibit germination but does reduce emergence. Less than 3% of buried seeds remain viable after 13 months. Delayed flowering may result in greater seed production. This species does not reproduce vegetatively.

Known Fire Response:
From experiment, after 1 second of exposure to direct flames germination was reduced by >90%.

Species Specific BMPs for Prescribed Burns
For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:
- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Meadow salsify on the site – large, dense populations may signify high post-fire regenerative ability or seed availability for post-fire establishment and low native propagules. External populations may supply a seed source to the burn site via wind-borne seeds.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (2 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from wind-borne or residual seeds.
- Mow after bolting but before seed setting to reduce seed production.

Burn Plan Development/During Burn:
- If possible, burn after bolting but before seed setting to reduce seed production.
- Burning while seeds are still suspended in plant canopy may be more effective at reducing seed viability than exposing seeds to a surface burn.

Post-fire Monitoring and Management:
- Herbicides are most effective in seedling stage. Treat next growing season after fire to prevent seedlings from maturing and going to seed, ultimately reducing, or eliminating the seed bank.
- Intensive grazing in the early season can reduce weed density by 25 to 50% after 3 years.
- Avoid disturbing soil as buried seeds that may not have been affected by heat of fire will not germinate when buried but may germinate if exposed to the surface.

North Africa Grass

Photo credit: Matt Lavin

Photo credit: Paul Slichter

Photo credit: M. Hassler

Photo credit: Matt Lavin

Scientific Name:
Ventenata dubia

Family:
Poaceae

Status:
Provincial Noxious Weed (*BC Weed Control Regulation)*

Origin:
Mediterranean region of North Africa, southern Europe, and western Asia and to central Europe

General Description:
North Africa grass is a winter annual that typically grows from 15 to 46cm in height and has shallow roots from 2.5 to 5cm deep that easily pull out from soil. It has an open form with a few wiry spreading stems that appear erect to slightly droopy. North Africa grass leaves are rolled lengthwise or folded. The ligule is long (1-8mm) and membranous and can be seen by pulling the leaf blade away from stem. The inflorescence is an open, spreading to drooping, pyramid-shaped panicle up to 41cm long. It can be mistaken for cheatgrass as it has a similar appearance and habitat preference in some areas. Each spikelet contains 3 to 4 florets with bent, twisted, or straight awns up to 2.5cm long. As it develops, North Africa grass shows distinct colour changes. In early spring plants are bright green before nodes turn reddish- to purplish-black in late spring. Plants become distinctly shiny when flowering and turn silvery green before senescing, when they become tan in colour.

Impacts:
North Africa grass can replace and displace perennial bunchgrasses and other annual non-native grasses on disturbed sites. This species has little to no forage value, high silica content, and can deplete forage resources for wildlife and livestock. Severe infestations can result in the degradation and loss of valuable wildlife habitat. The shallow roots are poor at binding soil and contribute to soil erosion. This species is highly invasive in rangelands, pastures and hayfields, especially on sites with exposed soil. North Africa grass often increases fuel continuity, fire spread and fire frequency, exposing plant communities to novel fire regimes they are poorly adapted to. North Africa grass harbours barley cereal yellow dwarf virus that can lower the vigor and fecundity of crops and native bunchgrasses.

Habitat:
North Africa grass can typically be found on open, disturbed sites including roadsides, overgrazed pastures and rangelands, and dry grasslands. This species grows best in areas that are inundated by water in early spring but dry out by late spring. It establishes readily on bare soils after disturbances such as heavy grazing, fire, frost heaving, flooding and land clearing.

Shade Tolerance:
North Africa grass is tolerant of partial shade but is not prevalent under these conditions.

Current BEC Range:
Coastal Western Hemlock
Interior Cedar – Hemlock
Interior Douglas-fir
Ponderosa Pine

Reproductive Strategy:
Sexual – North Africa grass reproduces exclusively by seed. It flowers in spring and produces seed heads from May through August. Seeds shatter and plants senesce in July or August when awns bend and twist. Seeds of this species can absorb moisture from the air and

are capable of germinating in a wide range or temperatures. Most seeds (85%) germinate in the first year after dispersal and require warm stratification to germinate. Seeds germinate in the fall with moderate to high temperatures, go dormant over winter, and resume growth in early spring. Seeds decrease in viability (<1%) when buried under 2cm of soil, and few seeds (0.1%) remain viable for up to 2 years.

Known Fire Response:

Fire likely promotes and facilitates North Africa grass establishment and spread. While some North Africa grass seeds are likely destroyed during grassland fires, especially if they have not shattered at the time of burning, buried seeds are likely to survive due to the flashy and low-severity nature of these fires. It is likely that enough North Africa grass seeds survive after grassland fires to populate the next generation, especially since post-fire conditions such as increased bare soil and reduced competition favour North Africa grass establishment. Early-season fires may top-kill North Africa grass, though it may be difficult for fires to carry through the green foliage. North Africa grass often increases fuel continuity in ecosystems that historically had discontinuous fuel exposing ecosystems to unnatural fire behaviour and disturbance regimes. This species may negate the advantages of fuel treatments by increasing after the disturbances caused by the treatments.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of North Africa grass on the site – large, dense populations may signify high invasive propagule availability (i.e., seeds) for post-fire recolonization and low native plant propagules.
- Post-emergent stages typically occur in spring after snow melts (March to early May) and in fall after the first rains (September to November). Once seed heads emerge, mature and senesce (June to August), extra care must be taken to not disturb the site.
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from residual seeds.
- Ensure North Africa grass is kept out of fuel breaks of fuel treated areas as it will negate these practices by carrying a fire during a prescribed burn.
- Mulching with at least 3cm of mulch is a good option for areas where North Africa grass populations exist pre-burn to ensure that remnant seeds do not germinate.

Burn Plan Development/During Burn:

- If possible, burn in spring before seeds shatter to expose seed heads to high temperatures that may destroy seeds. Burning as primary means of control however, has not been found effective. Consider supplementing with additional fuel as fire does not carry well through North Africa grass during this time.

Post-fire Monitoring and Management:

- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Continued monitoring is necessary to ensure early detection and eradication of North Africa grass (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species or for the duration of seed viability from pre-burn populations (3 years), which is generally at least 85% cover of desirable species.

Orange Hawkweed

Photo credit: BC gov't

Photo credit: BC gov't

Photo credit: BC gov't

Scientific Name:
Hieracium aurantiacum

Family:
Asteraceae (Aster)

Status:
Regional Noxious Weed (Bulkley-Nechako, Cariboo, Central Kootenay, Columbia-Shuswap, East Kootenay, Thompson-Nicola) (BC Weed Control Regulation)

Origin:
Northern and central Europe

General Description:
Orange hawkweed is a perennial rhizomatous and/or stoloniferous herb that exudes a milky sap. Plants have a basal rosette of leaves covered in hair-like outgrowths called trichomes. Each rosette produces 10-30 flowering stems. Flowering stems may also arise from spreading stolon. Plants produce from 4-12 leafy stolons that can reach lengths of 10-30cm. Roots are shallow and fibrous, and rhizomes are short, resembling root crowns. Leaves are mostly basal with the leafless flowering stalk covered with stiff, black, glandular hairs. It has vibrant orange-red flowers.

Impacts:
Orange hawkweed may be allelopathic, supressing the growth of surrounding native vegetation. Once established, orange hawkweed populations are persistent and may occur at high density or in a monoculture. Orange hawkweed populations form dense mats that exclude other plants, including native plants and economically valuable forage species.

Habitat:
Orange hawkweed establishes on sites with a range of soil and climate conditions and does not appear to have specific elevation requirements. Orange hawkweed occurs in a variety of plant communities, including grasslands and other open areas, forests and wetlands.
Orange hawkweed readily establishes on disturbed areas, including roadsides, pastures, hay fields, abandoned farmland, mountain meadows, logged areasand forest clearings.

Shade Tolerance:
Orange hawkweed appears to be shade intolerant but occurs in open forests.

Current BEC Range:
Bunchgrass
Boreal Black and White Spruce
Coastal Douglas-fir
Coastal Mountain-heather Alpine
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Interior Mountain-heather Alpine
Mountain Hemlock
Montane Spruce
Ponderosa Pine
Sub-Boreal Pine – Spruce
Sub-Boreal Spruce
Spruce – Willow – Birch

Reproductive Strategy:
Orange hawkweed reproduces by seeds and spreads vegetatively via stolons and rhizomes. Most Orange hawkweed seeds are produced without fertilization. It occasionally produces seed through pollination via wind and visiting insects. Orange hawkweed produces many seeds – a single Orange hawkweed flower can produce 12-50 tiny black seeds. A single flowering stem can produce hundreds of seeds. Seeds mostly disperse over short distances (within 1m of parent), though long-distance dispersal may occur via minute barbs on seeds

allowing them to stick to hair, fur, feathers, clothing and vehicles. Seeds may also be transported by water. Although unverified, several sources report that Orange hawkweed seeds may survive for up to 7 years in soil seed bank. Seeds can germinate immediately after dropping from the parent plant. Fall-germinated seedlings usually do not survive. Once a population establishes (usually by seed initially) most Orange hawkweed spread is accomplished vegetatively. “orange hawkweed reproduces rapidly by seed, stolon, and rhizomes and forms dense mats.” Seedlings establish in the spring. Stolons elongate through the summer, forming daughter rosettes at their tips. Stolons die as roots anchor daughter rosettes, and the young plants become independent of the mother. New plants sprout each year from rhizomes.

Known Fire Response:

Orange hawkweed is likely top-killed by fire; below-ground rhizomes may survive. It is likely that rhizomes below the soil surface survive fire. Long-distance dispersal of seeds may enable it to establish from off-site sources (or from persistent soil seed bank) on favourable post-burn conditions including disturbance and high-light conditions.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Orange Hawkweed on the site – large, dense populations may signify high invasive propagule availability (i.e., seeds) for post-fire recolonization and low native plant propagules.

Post-fire Monitoring and Management:

- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Long-term (~10 years) annual monitoring may be necessary post-burn to limit orange hawkweed establishment in burned area, especially if nearby populations are known to exist.

Rush Skeletonweed

Photo credit: Washington gov't

Photo credit: BC gov't

Photo credit: Oregon State University

Scientific Name:
Chondrilla juncea L.

Family:
Asteraceae (Aster)

Status:
Provincial noxious weed (*BC Weed Control Regulation*)

Origin:
Central and Mediterranean Europe, north Africa, western and central Asia

General Description:
Rush skeletonweed is a perennial forb with a long, thin, deep taproot. Growing from rosettes, a single many-branched stem is filled with a milky latex, has a wiry appearance, and is covered in stiff, reddish-brown hairs at its base. This species can grow up to 1.3m in height. The barely visible narrow leaves give this plant a skeleton-like appearance, hence its name. Rosette leaves are hairless with pointed leaf lobes projecting backwards, such as on a barbed spear. Single yellow flowers or clusters of 2 to 5 flowers grow along and at the top of the stems.

Impacts:
Rush skeletonweed can form dense monocultures displacing desirable native vegetation. Infestations of this species can reduce livestock and wildlife forage. Rush skeletonweed's extensive deep root system makes the plant difficult to manage.

Habitat:
This species can grow in a wide range of climatic conditions, but it does best adapted to areas with warm summers, cool winters, and a predominance of spring and winter rainfall. It commonly grows on nutrient-poor, well-drained sandy to gravelly soils and is likely to establish in open and disturbed areas such as rangelands, open forests, roadsides, gravel pits and abandoned fields.

Shade Tolerance:
Both seedlings and mature plants have limited shade tolerance and are seldom found under trees.

Current BEC Range:
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Montane Spruce
Ponderosa Pine

Reproductive Strategy:
Sexual – Rush skeletonweed plants are apomictic meaning they can produce viable seed without fertilization that result in genetically identical plants. This species is a prolific seed producer, and a single plant can produce as many as 15,000 to 27,000 seeds. Seeds have high viability and little to no dormancy. They are typically only viable in the soil for 6 to 18 months and so do not create an extensive seedbank. Seeds will not germinate if buried in the soil deeper than 2.5cm. However, seeds do not require light to germinate and can do so over a range of temperatures. Germination and emergence of seedlings typically occurs in the fall and are sensitive to moisture availability. Seeds are wind-dispersed and can travel long distances via water or animal and human activities.

Vegetative – Localized spread of Rush skeletonweed occurs primarily though vegetative spread of adventitious root buds found on the vertical and lateral roots. This species can re-sprout from anywhere on its deep, extensive root system from as deep as 3ft in the soil. It is also able to spread via root fragmentation.

Biocontrol:
Effective biocontrol exists for Rush skeletonweed in some areas of BC.

Known Fire Response:
Because of its ability to re-sprout from anywhere on its root system above 3ft deep in the soil and from adventitious root buds, this species is unlikely to be killed by sever fires and may increase in density after a fire. The fate of Rush skeletonweed seeds due to fire is not well studied; however, prolific seed production from this plant appears to be less responsible for post-fire increases in density than does vegetative reproduction in established stands. Post-fire conditions promote establishment from wind-borne seeds of external populations when adequate moisture is available.

Species Specific BMPs for Prescribed Burns
For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:
- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Rush skeletonweed on the site – large, dense populations on-site may signify high re-sprouting ability post-fire. External populations may supply wind-borne seeds that establish new populations post-fire.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (2-3 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- Carefully monitor areas disturbed from pre-burn work before applying fire to ensure the increase of resources in these areas do not facilitate Rush skeletonweed establishment or spread.

Post-fire Monitoring and Management:
- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Continued monitoring is necessary to ensure early detection and eradication of Rusk skeletonweed (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally at least 85% cover of desirable species.

Scotch Broom

Photo credit: BC gov't

Photo credit: BC gov't

Photo credit: BC gov't

Scientific Name:
Cytisus scoparius

Family:
Fabaceae (Pea)

Status:
Forest and Range Practices Act, and *Community Charter*.

Origin:
Europe and northern Africa

General Description:
Scotch broom is an erect, long-lived, evergreen bushy shrub that grows 2 to 4m tall and has a taproot. It has stiff, woody, slender branches with green to brownish-green stems that are hairy when young and hairless when mature. The stems are also prominently 5-angled. Scotch broom's upper leaves are simple and unstalked, while its lower leaves are stalked and comprised of 3 oval leaflets. It has bright-yellow, pea-like flowers that sometimes have red markings in the middle. Its flat, brownish to black seed pods have fine hairs on the margins.

Impacts:
Because of the rapid development of both its roots and foliage, Scotch broom is capable of forming dense, practically impenetrable stands and can persist and dominate new habitats. Scotch broom can interfere with the establishment and spread of many rare and endemic species, such as those found in Garry oak ecosystems, and can interfere with the re-establishment of conifer forests after logging. In Scotch broom infestations, the ratio of woody to green material increases as stands age, often leading to novel fuel characteristics that can increase fire hazard and potentially alter fire behaviour and regimes.

Habitat:
Scotch broom is typically found in disturbed areas such as roadsides, right-of-ways, clearcuts, overgrazed pastures and rangeland, riparian areas, and gravel bars and can also occur on sandy substrates such as dunes and beaches. It invades rapidly following logging, land clearing and burning. Scotch broom is well adapted to grow in open, high sunlit environments.

Shade Tolerance:
Scotch broom is largely shade intolerant and will not grow in heavily shaded places. However, this species is sometimes able to grow and compete under partial tree canopy.

Current BEC Range:
Coastal Douglas-fir
Coastal Mountain-heather Alpine
Coastal Western Hemlock
Interior Cedar – Hemlock
Interior Douglas-fir
Mountain Hemlock
Montane Spruce
Sub-Boreal Spruce

Reproductive Strategy:
Sexual – Scotch broom reproduces via abundant seed production once plants reach an age of 2 to 3 years and a height of 0.6 to 1m. While flowers have both male and female reproductive organs, they typically do not self-pollinate. Less than 50% of Scotch broom flowers develop into fruit. Mature plants can produce anywhere from several hundred to 7,000 seed pods with an average of 5 to 8 seeds per pod (but can be as high as 22 seeds per pod). Scotch broom seeds have high viability (often 100%) and the seeds contain a hard coat that delays germination for months or years, until the seeds are scarified. This enables the seeds to survive in the soil for long periods, possibly as

long as 30 years, creating an extensive seedbank. As seed pods mature and dry, the two halves split open and wrap in alternate directions while seeds are ballistically dispersed from pods. Long distance dispersal is often facilitated via human and animal activities.

Vegetative – while Scotch broom does not reproduce vegetatively, it is sometimes able to sprout from the root crown after damage, particularly with sufficient moisture.

Known Fire Response:

Scotch broom is often top-killed from fires, and complete mortality can occur during high-severity fires. Scotch broom can sprout from the root crown following fire, though this ability varies with season, severity of damage, site conditions and burn frequency. Scotch broom seeds are well adapted to post-fire germination, with temperatures of 65˚C for 2 minutes significantly increasing seed germination. However, temperatures at or above 150˚C for 2 minutes destroys seeds in the top 2cm of soil. Increased seed germination after a fire can significantly reduce the Scotch broom seedbank.

Species Specific BMPS for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site survey or proposed burn area and surrounding area (100m) to determine the presence and extent of Scotch broom on the site – large, dense populations will signify high invasive propagule availability (seeds) for post-fire recolonization and low native plant propagules.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (30 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- Masticate large infestations prior to seeding to reduce seedbank in post-fire environment and increase fuel load to expose seeds to lethal temperatures (150˚C for 2 minutes or more).
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from seed banks or nearby seed sources.

Burn Plan Development/During Fire:

- If management objectives can still be achieved, apply an additional prescribed burn within 2 to 3 years of the initial prescribed burn to destroy newly germinated plants before they are reproductively mature.
- If possible, burn during the hottest and driest time of year to ensure soil temperatures reach lethal temperatures for seed mortality.
- If pre-burn treatments do not occur, avoid burning in spring since fire often cannot burn under dense Scotch broom stands during this time.

Post-fire Monitoring and Management:

- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Continued monitoring is necessary to ensure early detection and eradication of Scotch broom (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally at least 85% cover of desirable species.

Spotted Knapweed

Photo credit: Matt Lavin

Photo credit: Power County, Idaho

Photo credit: Linda Wilson

Scientific Name:
Centaurea stoebe

Family:
Asteraceae (Aster)

Status:
Provincial Noxious Weed (*BC Weed Control Regulation)*

Origin:
Eastern Europe

General Description:
Spotted knapweed is a biennial to short-lived perennial forb with branched stems growing to 1.5m in height. Plants have a deep, stout taproot and basal rosette with leaves growing up to 20cm long and 5cm wide. Leaves are alternate, deeply cut, hairy and very bitter to taste. Flowers are purple and occasionally white. Bracts on the flower head have a black-tipped fringe giving the flower head a "spotted" appearance.

Impacts:
Spotted knapweed can outcompete native grasses, forbs and tree seedlings for resources, reducing their associated communities and biodiversity. Spotted knapweed's allelopathic properties and age class hierarchy allow it to dominate available niches and form monotypic stands. Soil erosion and runoff can increase because of large Spotted knapweed infestations leading to sedimentation of watercourses. This species has been reported to reduce available forage for livestock and wildlife, although some animals graze on it.

Habitat:
Spotted knapweed occupies a variety of habitat types and plant communities, but readily establishes on dry, disturbed sites, especially when overstorey species are removed. This species is typically found growing on roadsides, grasslands, shrublands and open forests, and is generally found on south facing aspects.

Shade Tolerance:
Spotted knapweed seeds can germinate under full canopy, but mature plants are uncommon in shaded areas and are typically found under open canopy.

Current BEC Range:
Boreal Altai-heather Alpine
Bunchgrass
Boreal White and Black Spruce
Coastal Douglas-fir
Coastal Mountain-heather Alpine
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Interior Mountain-heather Alpine
Mountain Hemlock
Montane Spruce
Ponderosa Pine
Sub-Boreal Pine – Spruce
Sub-Boreal Spruce

Reproductive Strategy:
Sexual – Spotted knapweed primarily reproduces through seed production. Spotted knapweed is a prolific seed producer and a single plant can produce anywhere from 65–2,000 seeds. This species has high seed viability, with approximately 90% viability of seeds upon dispersal. Seeds can remain dormant in the soil for up to 8 years. Seed fertilization requires cross-pollination in this species. Seeds can be wind dispersed and long-distance dispersal is facilitated by animal and human activities. Seeds require red light to germinate and survival of seedlings is poor when conditions are dry post-germination.

Vegetative – Spotted knapweed can extend underground lateral shoots

that form rosettes adjacent to the parent plant. A single root crown can produce multiple new rosettes.

Known Fire Response:

Spotted knapweed seeds are heat-tolerant and likely to survive low-severity fires, although high-severity fires may kill some seeds. Areas of bare soil and increased sunlight on the soil surface caused by fire is likely to promote the establishment and spread of spotted knapweed post-fire. The sturdy taproot is also likely to survive low-severity fires and re-sprouting from the root crown can occur post-fire. Spotted knapweed can suppress burns as fire does not usually carry well through stands of this species, especially in the absence of other fine fuels.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Spotted knapweed on the site – large, dense populations may signify high invasive propagule availability (seeds and vegetative buds) for post-fire recolonization and low native plant propagules.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (8 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- If prescribing thinning pre-burn, monitor the area closely between treatments to ensure increased light availability is not resulting in new invasions or growth of existing populations.
- Mulching is an option to limit light availability to seeds where pre-fire populations occurred. Ensure mulch is free of invasive plant propagules.

Burn Plan Development/During Fire:

- Prescribe late-season head fire burns to infestations with fuel loads of 300g m^{-2} or more to increase heat dosage to seeds, or
- Consider piling slash on top of spotted knapweed patches. Fuel load or back burn to expose seeds to higher temperatures for longer durations of time (from studies, 200˚C for 120+ seconds or 400˚C for 30+ seconds).
- Fuel load for higher-severity fires to kill seeds and root crowns (however, consider how high-severity fires affect the recovery of natural ecosystem and desirable vegetation).

Post-fire Monitoring and Management:

- Exclude grazers from burn area until native plant community has established to desirable levels as they are often a vector for seed introduction into new areas.
- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Hand-pull small populations followed by seeding for small populations.
- Continued monitoring is necessary to ensure early detection and eradication of spotted knapweed (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally at least 85% cover of desirable species.

Gap Analysis

- More research is needed to determine the response of Spotted knapweed to burn season and fire severity.
- Fuel loads and burn prescriptions are based on lab results. More field studies are needed to determine seed responses to burns in variable environmental conditions.

St. John's-Wort

Photo credit: BC Gov't

Photo credit: BC Gov't

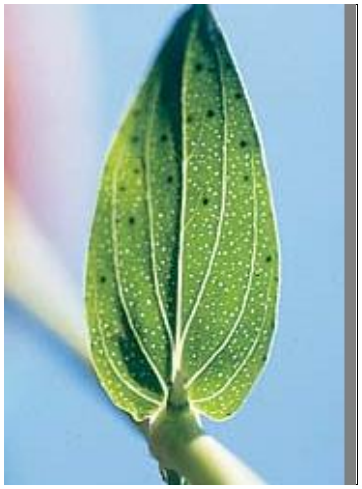


Photo credit: BC Gov't

Scientific Name:
Hypericum perforatum L.

Family:
Clusiaceae

Status:
Forest and Range Practices Act, and *Oil and Gas Activities Act*.

Origin:
Europe, western Asia, and northern Africa

General Description:
St. John's-wort is an erect, perennial forb growing from underground rhizomes and deep, extensive roots. It can reach heights of 0.3 to 1m. On a single plant, one to several stems arise from a woody root crown. Stems of this species are woody at the base, have many leaves and are many-branched mainly in the upper portion of the plant. Transparent dots are visible over the surface of bright-green, 1-3cm long oblong leaves when held to the light. Flowers are 2cm in diameter, numerous and bright yellow with 5 petals. Plants turn a rusty colour when mature.

Impacts:
St. John's-wort establishment often results in dense infestations of grazed and disturbed landscapes causing displacement of native plant species and a reduction of forage for livestock and wildlife. This species contains a toxin that causes skin irritation and blistering in light-coloured livestock when exposed to the sun after consumption.

Habitat:
St. John's-wort occurs in a range of habitats and plant communities including forest, woodland, rangeland, grassland communities and riparian areas. It is commonly associated with disturbances such as caused by roads, logging, grazing and fire.

Shade Tolerance:
St. John's-wort requires abundant light for best development and is rarely observed within undisturbed, dense forests, dense brush fields or under the shade of trees in open forests.

Current BEC Range:
Bunchgrass
Coastal Douglas-fir
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Mountain Hemlock
Montane Spruce
Ponderosa Pine
Sub-Boreal Spruce

Reproductive Strategy:
Sexual – St. John's-wort can reproduce via seed production as a result of self- and cross-pollination. This species is a prolific seed producer as a single plant can produce anywhere from 15,000 to 34,000 seeds on average. Seeds can remain viable in the soil for 10 years creating an extensive seed bank and can germinate in the soil at depths up to 2.5cm. Seeds can also remain viable while immersed in water for up to 5 years. Seed dispersal is facilitated over short distances via gravity and to a lesser extent by wind and can disperse over long distances in water and by sticky capsules on the seeds sticking to humans and animals.

Vegetative – St. John's-wort has rhizomes that develop over-wintering, soil-surface buds up to 0.9m from the parent plant that facilitate its spread. Vegetative growth begins early in the spring, giving this species a competitive advantage over late emerging plants, and is stimulated by grazing,

fire and defoliation. Vegetative re-sprouting can occur from root crowns after damage as well as from root fragments.

Biocontrol: There are effective biocontrol agents existing on St. John's Wort in some areas of BC.

Known Fire Response:

This species is likely top killed by fire; however, the deep, extensive root system is unlikely to be killed even by severe fires and fire often stimulates vegetative propagation in this species. Roots of this species are offered additional protection from heat by suberized polyderm cells. Increased germination of seeds has been reported when exposed for short periods (5-60 minutes) of exposure to temperatures of 100^{o}C and 127^{o}C, suggesting fire stimulates seedling establishment. Indeed, flushes of St. John's-wort seedlings are often observed following fires.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of St. John's-wort on the site – large, dense populations may signify high invasive propagule availability (seeds and vegetative buds) for post-fire recolonization and low native plant propagules.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (10 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- If prescribing thinning pre-burn, monitor the area closely between treatments to ensure increased light availability does not result in new invasions or growth of existing populations. The increase in light availability is likely to stimulate germination in this species.
- Prevent livestock grazing in proposed burn areas as sticky seeds from external populations can stick to fur and spread to site.
- Mulching is an option to limit light availability to seeds where pre-fire populations occurred. Ensure mulch is free of invasive plant propagules.

Burn Plan Development/During Fire:

Post-fire Monitoring and Management:

- Exclude grazers from burn area until native plant community has established to desirable levels as sticky St. John's-wort seeds readily stick to livestock and other animals.
- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Continued monitoring is necessary to ensure early detection and eradication of St. John's-wort (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally at least 85% cover of desirable species.

Sulphur Cinquefoil

Photo credit: BC Gov't

Photo credit: BC Gov't

Photo credit: BC Gov't

Scientific Name:
Potentilla recta

Family:
Rosaceae (Rose)

Status:
Regional Noxious Weed (Colombia-Shuswap, North Okanagan, Okanagan-Similkameen, Thompson-Nicola) (*BC Weed Control Regulation)*

Origin:
Eastern Mediterranean region of Eurasia

General Description:
Sulphur cinquefoil is an erect, long-lived (up to 20 years) tap-rooted perennial forb with hairy stems growing from 0.3 to 0.8m tall. It may have one or many stems per plant. Sulphur cinquefoil leaves are divided into 5 to 7 hairy leaflets in palmate fashion with toothed edges. Leaflets are 3 to 6cm long and less than 1cm wide with green undersides. Flowers are pale yellow and have 5 heart-shaped petals around a bright yellow center.

Sulphur cinquefoil is often confused with other native cinquefoils including Graceful cinquefoil (*Potentilla gracilis*), which is shorter and has white woolly hair on the undersurface of the leaves.

Impacts:
Sulphur cinquefoil displaces native plant species and their associated communities. It forms monotypic stands thereby reducing biodiversity. This species can impact economies as it reduces available forage due to its unpleasant taste and by reducing grass production.

Habitat:
This species occupies a variety of habitat types and plant communities including grasslands, dry open forests, shrubby areas, and disturbed sites such as roadsides, pastures and rangelands. It grows in a wide variety of soil types and climates but does best in semi-arid regions.

Shade Tolerance:
Sulphur cinquefoil will grow under open forest canopies, but it is intolerant of complete shade.

Current BEC Range:
Bunchgrass
Coastal Douglas-fir
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Mountain Hemlock
Montane Spruce
Ponderosa Pine
Sub-Boreal Pine – Spruce
Sub-Boreal Spruce

Reproductive Strategy
Sexual – Sulphur cinquefoil primarily reproduces by seed production. A single plant can produce over 1,600 seeds per year. Seeds mature quickly and can remain viable in the soil for more than 4 years, creating a large seed bank. Seeds disperse passively to the ground and are not airborne. Long-distance dispersal is typically a result of animal or human activities. Seeds typically require soil disturbance to germinate and will not germinate in darkness.

Vegetative – perennating buds can re-sprout from the caudex at the top of the rootstock after damage (e.g., by fire). Annual re-sprouting from the main root results in several closely spaced individuals over time circling the old, decaying root. This species is not rhizomatous.

Known Fire Response:

Sulphur cinquefoil seeds are likely to survive low-severity fires if buried. This species typically grows in habitats with low-severity fires, so seed survival is likely. Post-fire conditions (decreased competition, increased light availability, increased nutrients) are favourable for Sulphur cinquefoil seed germination and establishment.

Perennating buds in the caudex are likely to survive fire if not exposed to lethal temperatures and quickly re-sprout after a fire. The woody taproot is unlikely to be killed during a fire. Ultimately, response of this species to fire is dependent on several factors including fire severity, plant phenological stage at the time of burning, and the depth of burial of perennating tissue and seeds. A fall burn could cause high mortality of young seedlings.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Sulphur cinquefoil on the site – large, dense populations may signify high invasive propagule availability (seeds and vegetative buds) for post-fire recolonization and low native plant propagules.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (4 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- If prescribing thinning pre-burn, monitor the area closely between treatments to ensure increased light availability is not resulting in new invasions or growth of existing populations.
- Mulching is an option to limit light availability to seeds where pre-fire populations occurred. Ensure mulch is free of invasive plant propagules.

Burn Plan Development/During Fire:

- Burning in the spring is likely to kill new populations of recently germinating plants. If possible, burn in spring if pre-burn work (e.g., thinning) has resulted in newly germinating populations and if spring burns will still result in management objectives.
- Where established populations exist, backburn or pile burn on infestation sites to expose the seeds and vegetative tissue to lethal and damaging temperatures.

Post-fire Monitoring and Management:

- Exclude grazers from burn area until native plant community has established to desirable levels as they are often a vector for seed introduction into new areas.
- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Continued monitoring is necessary to ensure early detection and eradication of sulphur cinquefoil (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally at least 85% cover of desirable species.

Tall Yellow Invasive Hawkweed species

Photo credit: Richard Old


Photo credit: Nicole Kimmel


Photo credit: Flora of Quebec


Spotted Hawkweed leaves.
Photo credit: Prov. BC

There are several "Tall Yellow" hawkweed species growing in BC. Since they can be difficult to tell apart and as the following species generally all behave similarly, this information has been combined.

Scientific Names:
Meadow (Pilosella caespitose)
Kingdevil (Pilosella floribunda)
Yellowdevil (Pilosella glomerate)
Tall (Pilosella piloselloides)
Queendevil (Pilosella praealta)
Smooth (Hieracium laevigatum)
Common (Hieracium lachenalia)
European (Hieracium sabaudum)
Polar (Hieracium atratum)
Spotted (Hieracium maculatum)
Wall (Hieracium murorum)

Family:
Asteracea (Aster)

Status:
Oil and Gas Activities Act

Origin:
Northern, central, and eastern Europe

General Description:
Fibrous-rooted, perennial forb with or without a rhizome or stolon; exudes a milky sap when damaged; leaves, stems and stolons are conspicuously hairy. When present, stolons are long and leafy. Plants generally have a basal rosette and 10-30 flower stems that are 25-91cm in height. A stem produces 5-30 yellow flowers arranged in a flat-topped cluster. Spotted hawkweed has distinctly spotted leaves. ***Refer to Hawkweed ID key for further descriptions and identification.**

Impacts:
Tall yellow hawkweed species ***may be*** allelopathic – Meadow hawkweed pollen could potentially limit the sexual reproduction of other plants by inhibiting pollination, seed germination, and/or seedling growth (**Murphy, 2001**). Tall yellow hawkweed species have the potential to alter native plant communities. Individual plants may quickly develop into large, dense patches that displace other vegetation. In fields and pastures, Tall yellow hawkweed species may reduce forage quality. May also be problematic in lawns and gardens.

Habitat:
Tall yellow hawkweed species occur in a wide variety of plant communities ranging from old fields to forests. Sites most vulnerable to invasion are disturbed areas including roadsides, pastures, hay fields, abandoned farmland, mountain meadows, logged areas and forest clearings. Tall yellow hawkweed species may also establish in wetlands and riparian areas. Tall yellow hawkweed species prefer soils that are well-drained, coarse-textured, and moderately low in organic matter.

Shade Tolerance:
Tall yellow hawkweed species are not completely shade intolerant, but shade likely limits their establishment and growth.

Current BEC Range:
Boreal White and Black Spruce
Coastal Douglas-fir
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Montane Spruce
Ponderosa Pine
Sub-Boreal Pine – Spruce
Sub-Boreal Spruce

Reproductive Strategy:
Tall yellow hawkweed species reproduce by seeds and vegetatively by stolons, rhizomes and adventitious root buds if present. Seed production is primarily asexual through apomixis

(the production of seed without pollen), although occasional sexual reproduction, outcrossing and hybridization is believed to occur. Seeds germinate in both spring and fall, but seedlings typically have a higher survival rate in the spring. Stolons elongate throughout the summer and give rise to new rosettes. Plants commonly flower by late June to July. Seeds mature and disperse shortly after flowering. A single Tall yellow hawkweed species flower head produces between 12-50 seeds. Increased light availability may result in increased production of flowering shoots. Seeds are dispersed by wind, animals and humans. Tall yellow hawkweed species do not seem to form a persistent seed bank, and seeds may not be viable in the soil for long periods of time and may germinate as soon as they are released from the plant. Removal (via disturbance or otherwise) of litter or ground cover and/or increased moisture may increase seed germination. Increased temperature and light may also increase seed germination. Seeds may not germinate in soil at depths greater than 2cm.

Some Tall yellow hawkweed species spread vegetatively via stolons and rhizomes that originate from axillary buds at the base of rosette leaves. Some species also sprout from adventitious root buds located on fibrous roots producing satellite plants.

Known Fire Response:

Tall yellow hawkweed species plants and stolons are likely top killed by fire. Belowground rhizomes and adventitious root buds may survive. Tall yellow hawkweed species exhibit some characteristics that make them likely to survive and/or establish after fire. Belowground rhizomes and adventitious root buds are likely to survive, and these and stolons reportedly sprout after physical disturbance suggesting that post-fire sprouting is possible. Seeds have potential for long-distance dispersal, though seeds do not seem to persist in the seed bank. High-light conditions may favour Tall yellow hawkweed species' sexual reproduction and vegetative regeneration. All Tall yellow hawkweed species may be favoured by disturbance.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Tall yellow hawkweed species on the site – large, dense populations may signify high post-fire regenerative ability or seed availability for post-fire establishment and low native propagules. External populations may supply a seed source to the burn site via wind-borne seeds.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (2 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from wind-borne or residual seeds. Follow general recommendations regarding weed prevention.

Post-fire Monitoring and Management:

- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).

Toadflax,Dalmatian

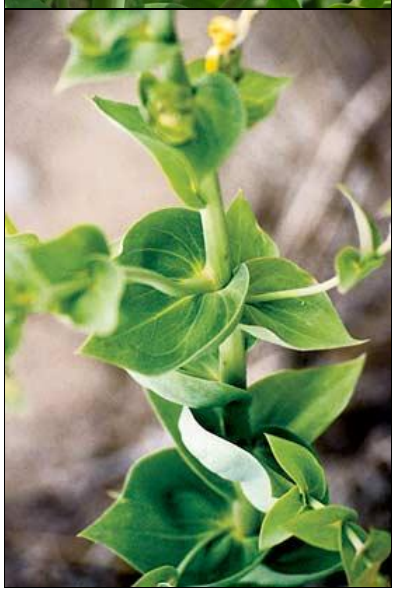


Photo credits: BC gov't

Scientific Name:
Linaria genistifolia subsp. *dalmatica*

Family:
Scrophulariaceae (Figwort)

Status:
Provincial Noxious Weed (*BC Weed Control Regulation*)

Origin:
Mediterranean region (from Yugoslavia to Iran)

General Description:
Dalmatian toadflax is a deep-rooted, herbaceous perennial forb growing to 1.2m tall. Taproots of this plant can reach depths of up to 3m, and lateral roots can extend from the parent plant to 3.6m. Tough stems are somewhat woody at the base and grow in clusters of 1 to 25 stems from the root crown. Upper portions of the stem are typically many-branched. Waxy, pale green, heart-shaped leaves with pointed tips clasp the stems. Bright yellow, snapdragon-like flowers grow in axils of the upper leaves and have orange spots on the lower lip and spurs that are about as long as the rest of the flower.

Impacts:
Dalmatian toadflax is an aggressive competitor that displaces native plant communities and associated wildlife, reduce forage in pastures, rangelands and overwintering habitat, and increase soil erosion and surface runoff.

Habitat:
Due to its high genetic variability, Dalmatian toadflax can grow in a wide variety of habitat conditions. It is typically found in disturbed areas such as cultivated fields, roadsides and fence lines, overgrazed pastures and rangelands, and clearcuts. It prefers well-drained and relatively coarse-textured soils.

Shade Tolerance:
Dalmatian toadflax tolerates moderate amounts of shade.

Current BEC Range:
Bunchgrass
Boreal White and Black Spruce
Coastal Douglas-fir
Coastal Mountain-heather Alpine
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Montane Spruce
Ponderosa Pine
Sub-Boreal Pine – Spruce
Sub-Boreal Spruce

Reproductive Strategy:
Sexual – Dalmatian toadflax reproduces sexually by seed. Flowers must be cross-pollinated for viable seed fertilization. This species is a prolific seed producer, and a single plant with 10 stems can produce up to 500,000 seeds under favourable conditions. Seeds can remain viable for up to 10 years. Seeds germinate in the top 2-3cm of soil and on the soil surface, and germination can be induced by wet and cold stratification and increased light. Most seeds are distributed within 0.5m of the parent plant. Seeds can be dispersed over greater distances by wind, human activities and within the digestive tracts of browsing animals.

Vegetative – Dalmatian toadflax can spread vegetatively and form colonies via adventitious buds that form on taproots and lateral roots as well as via root fragments. Vegetative buds on taproots can be found as deep as 1.8m in the soil, and in the upper 5-30cm of soil on the lateral roots.

Biocontrol:
Effective biocontrol exists for Dalmatian toadflax throughout BC.

Known Fire Response:
Dalmatian toadflax plants are likely to survive even severe fires because of their deep and extensive perennial sprouting root systems. Plants that are top killed during fires are likely to re-establish from vegetative root buds following fire. Germination of soil-stored seeds or seeds dispersed from off-site sources can also establish Dalmatian toadflax plants post-fire where reduced competition for resources enhances establishment success. Seed production and per plant biomass of Dalmatian toadflax are likely to increase after fire, and it is likely that Dalmatian toadflax populations are increased or unaffected by fire.

Species Specific BMPs for Prescribed Burns
For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:
- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Dalmatian toadflax on the site – large, dense populations will signify high invasive propagule availability (seeds and vegetative buds) for post-fire recolonization and low native plant propagules.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (10 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from seed banks, nearby seed sources, or from root fragments or adventitious buds. Treat any newly established populations before setting seed.

Burn Plan Development/During Burn:
- Follow general recommendations regarding invasive plant prevention (Section 2).

Post-fire Monitoring and Management:
- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Continued monitoring is necessary to ensure early detection and eradication of Dalmatian toadflax (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally at least 85% cover of desirable species.

Toadflax, Yellow (Common)

Photo credit: BC gov't

Photo credit: BC gov't

Photo credit: BC gov't

Scientific Name:
Linaria vulgaris

Family:
Scrophulariaceae (Figwort)

Status:
Provincial Noxious Weed (*BC Weed Control Regulation)*

Origin:
Steppes of southeastern Europe and southwestern Asia

General Description:
Yellow toadflax is a short-lived (4 years), deep-rooted perennial forb growing from 0.3 to 0.9m tall. Taproots can reach depths of 1m into the soil and lateral roots can be several meters long and contain adventitious root buds. Stems of Yellow toadflax are tough, somewhat woody at the base, and are simple to branched. Stems grow from the crown in clusters of 1 to 25. Leaves are narrow, pointed at both ends, and stalkless. Yellow toadflax flowers are bright-yellow and "snapdragon-like" with an orange spot on the lower lip and a spur that is about as long as the rest of the flower. Flowers are similar but smaller than those of Dalmatian toadflax. Flowers first emerge in clusters at the end of the stems and become more widely spaced along the stems as the season progresses.

Impacts:
Due to its competitive nature, Yellow toadflax is capable of displacing plant communities and their associated animal life, resulting in reduced biodiversity and ecosystem function. This species can reduce forage availability for domestic animals and wildlife. Yellow toadflax infestations can also result in increased soil erosion and surface runoff. This species can become prolific in agricultural fields, especially where reduced-tillage farming methods are used.

Habitat:
Yellow toadflax is commonly found in disturbed areas such as cultivated fields, roadsides and fence lines, waste areas, forest clearcuts, overgrazed pasture and rangelands, and in plant communities that are typically open and disturbed. Yellow toadflax prefers well-drained, relatively coarse-textured soils but is capable of growing in heavier soils.

Shade Tolerance:
Yellow toadflax tends to be more common in open areas with direct sunlight. It is less abundant and prolific in shaded areas.

Current BEC Range:
Bunchgrass
Boreal White and Black Spruce
Coastal Douglas-fir
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Mountain Hemlock
Montane Spruce
Ponderosa Pine
Sub-Boreal Pine – Spruce
Sub-Boreal Spruce

Reproductive Strategy:
Sexual – Yellow toadflax reproduces sexually via seed production. This requires cross-pollination for viable seed fertilization and typically displays low seed set and low seed viability. On average, seeds produced on a single Yellow toadflax stem vary from 165 to 5,584 seeds. Seeds typically fall within 0.5m of the parent plant, but intermediate dispersal by wind can occur. Long-distance dispersal of seeds is facilitated by water as well as anthropogenic and animal activities. Seeds display a strong

dormancy (up to 8 years) that is broken by wet stratification. Light-induced germination occurs in the top 2 to 3cm of soil and on the soil surface.

Vegetative – Yellow toadflax reproduces vegetatively via adventitious root buds on its lateral roots. Root buds are typically found 2 to 5cm below the soil surface but can also form deeper on the taproot. Vegetative reproduction is also facilitated by root fragments as short as 1cm.

Biocontrol: There are a number of biocontrol agents existing on Yellow toadflax throughout BC.

Known Fire Response:

Yellow toadflax plants are likely to survive even severe fires because of their deep and extensive perennial sprouting root systems. Plants that are top killed during fires are likely to re-establish from vegetative root buds following fire, although severe ground fires may damage lateral root buds. Germination of soil stored seeds or seeds dispersed from off-site sources can also establish Yellow toadflax plants post-fire where reduced competition for resources enhances establishment success. Burning may promote vegetative reproduction of Yellow toadflax, and this species is likely to increase or be unaffected by fire.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Yellow toadflax on the site – large, dense populations will signify high invasive propagule availability (seeds and vegetative buds) for post-fire recolonization and low native plant propagules.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (8 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.
- Monitor disturbed areas before burning if pre-burn operations result in disturbance to ensure that new populations do not establish from seed banks, nearby seed sources, or from root fragments or adventitious buds.

Post-fire Monitoring and Management:

- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species (see Section 3.0 above for more requirements on seeding).
- Continued monitoring is necessary to ensure early detection and eradication of Yellow toadflax (and other priority invasive plants) until native vegetation has reached adequate levels to limit resource availability for invasive species, generally at least 85% cover of desirable species.

Gap Analysis

- It is unclear what the effects of fire are on Yellow toadflax seeds.
- It is unclear how historic fire regimes might affect Yellow toadflax populations.
- It is unclear how the presence of Yellow toadflax in native ecosystems might affect fire regimes.

Teasel, Fuller's

Photo credit: BC gov't

Photo credit: BC gov't

Photo credit: Washington State Noxious Weed Control Board

Scientific Name:
Dipsacus fullonum

Family:
Dipsacaceae

Status:
Unregulated invasive weed

Origin:
Europe, temperate Asia, and northern Africa

General Description:
Spiny, robust perennial that can grow 2-3m tall. Stems are erect, hollow, and support erect branches. Fuller's teasel flowers occur in terminal, stiff, egg-shaped heads that are up to 10cm long. Inflorescences contain 250-1,300 flowers which bloom for only 1 day. Flowering begins in the middle of the inflorescence and then progresses up and down. Often, there are few flowers blooming at the same time. Flower heads are subtended (extend under the flower to support or enfold it) by linear bracts that are about 4 times as long as they are wide. Leaves are entire with toothed or wavy margins and flowers are typically lavender in colour. The cups formed by clasping leaves may be up to 13cm deep. Fuller's teasel has a stout taproot up to 0.6m deep and 2.5cm in diameter at the crown.

Impacts:
Fuller's teasel is an aggressive competitor in disturbed sites including those heavily grazed by livestock and wildlife. Fuller's teasel can develop large monocultures displacing native vegetation and possibly restricting wildlife movement, negatively impact riparian area integrity, and occupy habitats important to sensitive or threatened plant species.

Habitat:
Fuller's teasel occupies a variety of habitats and soil types including riparian areas, meadows, grasslands, savannas, forest openings and disturbed sites. Habitats most commonly occupied are open and sunny with limited tree or shrub cover; however, it prefers moist habitats. Fuller's teasel is frequent on roadsides and ditches and in pastures, old fields, meadows, riparian areas, savannas, and forest edges.

Shade Tolerance:
Fuller's teasel can tolerate partial shade and is common in canopy openings.

Current BEC Range:
Coastal Douglas-fir
Coastal Western Hemlock
Interior Cedar – Hemlock
Interior Douglas-fir
Ponderosa Pine
Sub-Boreal Spruce

Reproductive Strategy:
Fuller's teasel reproduces by seed and plants die after flowering. Plants may sprout following damage during the rosette or flowering stage. This species typically flowers after 2 or more years of growth. Plants grow as a rosette before bolting and flowering. Flowering typically occurs from July to October. Seeds mature and disperse from September to late November. Seeds germinate in the spring or fall. Most Fuller's teasel seeds germinate in late summer or fall and overwinter as rosettes. A small portion of seeds may remain dormant for a year and germinate the following spring. Flowers are perfect (have both male and female reproductive organs) with most fertilization occurring from cross-pollination by insects. Self-fertilization results in a low number of viable seeds. Individual Fuller's teasel plants produce several flowers and may produce over 3,000 seeds. Most seeds fall within 1.5m of the parent plant. Water and human activities (e.g., collected for use in dried-flower decorations) are the most likely methods of long-

distance teasel seed dispersal. The Fuller's teasel seed bank is relatively short-lived, generally up to 5 years. Seeds may germinate immediately (do not require stratification), but dormancy may be induced by freezing temperatures. Seeds germinate equally well in dark or light conditions and immature seeds cut from the stem may still germinate. Warm temperatures, regardless of light conditions, may produce high seed germination. Soil disturbances may cause flushes of seed germination, while litter and established vegetation may inhibit germination but foster seedling growth and survival. The probability of successful Fuller's teasel seedling establishment is several times greater in open sites left by dead parent plants than in surrounding vegetation.

Known Fire Response:

It is likely that low-severity fires only topkill Fuller's teasel plants. Since meristematic tissue occurs just below the soil surface, high-severity fires that produce high belowground temperatures may kill Fuller's teasel plants. Buried seeds may survive low-severity fires. Seed germination would likely be successful on burned sites. Seedlings, though, may require some protection from desiccation in order to survive (possibly provided by sprouting vegetation). Aboveground Fuller's teasel vegetation has low flammability, and if present in the pre-fire vegetation, it is likely to be present in the post-fire vegetation. Fuller's teasel would likely persist in periodically burned habitats. Seed germination levels could be high on open, burned areas and given some protection by sprouting vegetation, teasel seedling establishment could be high. Fire may expose teasel rosettes, potentially increasing effectiveness of other treatments. Burning may be difficult in teasel habitats as fire does not spread well in dense stands of teasel rosettes or mature plants, and in moist habitats where teasel is common, fire spread and temperatures lethal to plant tissue are rare.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Fuller's teasel on the site – large, dense populations may signify high invasive propagule availability (seeds and vegetative buds) for post-fire recolonization and low native plant propagules.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (4 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.

Burn Plan Development/During Burn:

-- Burning areas where teasel was cut before mature seed production should limit seed production and dispersal (cut stems should be burned to prevent seed maturation post-cut).

- Cut teasel plants just before they flower and plan burning before the plants re-sprout and flower again. Repeat annual burnings for 2 or more years may control this species since it requires 2 or more years to complete its life cycle.
- Long, fire-free intervals would likely limit teasel establishment, which is best in canopy gaps and in early- to mid-seral habitats.

Post-fire Monitoring and Maintenance:

- Revegetate areas that are susceptible to invasion (e.g., where previous populations existed, where there are nearby external populations, where native propagule availability is low) with competitive native or desirable and short-lived agronomic species(see Section 3.0 above for more requirements on seeding).
- Continue monitoring and treating newly germinated teasel plants before flowering for up to 5 years post-fire to eliminate seed bank.
- Burned sites in the vicinity of established teasel populations should be monitored for seedling establishment, and appropriate control measures should be taken.

Whiplash and Mouse-ear Hawkweeds

Mouse-eared hawkweed. Photo credit: BC gov't

Mouse-eared hawkweed. Photo credit: BC gov't

Whiplash hawkweed. Photo credit: BC gov't

Scientific Name:
Whiplash *(Pilosella flagellare)*
Mouse-eared *(Pilosella officinarum)*

Family:
Asteraceae (Aster)

Status:
Whiplash: Unregulated invasive weed
Mouse-eared: Provincial Early Detection Rapid Response

Origin:
Central Europe

Whiplash and Mouse-eared hawkweeds have a similar growth habit that is distinctive from the tall yellow hawkweeds. Since they can be difficult to tell apart and generally behave similarly, this information has been combined.

General Description:
Fibrous-rooted, perennial herb growing from a stout rhizome. Hawkweeds exudes a milky sap when broken. Plants have a basal rosette and flowering stems that reach less than 30cm in height. Mouse-eared hawkweed has 1 yellow flower at the end of the stem. Whiplash hawkweed has 2 to 6 flowers on branched stems that are 6-20cm long. Whiplash hawkweed flowers often have a reddish strip or tinge on the underside. Both species have stolons. ****Refer to ID guide for further identification:** https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/invasive-species/publications/key_to_identification_of_invasive_and_native_hawkweeds_in_the_pacific_northwest.pdf

Impacts:
Whiplash and Mouse-eared hawkweeds form mats which displace native plant species and their associated communities. This species can impact economies by reducing available forage due to its unpleasant taste and by reducing grass production.

Habitat:
Whiplash and Mouse-eared hawkweeds occur in a variety of plant communities within its North American distribution, including grasslands and other open plant communities, shrublands, woodlands or savannahs, and forests. These hawkweeds can also establish in wetlands, lakeshores, and coastal areas, and will establish on sites with a range of soil and climatic conditions but does not appear to have specific elevation requirements. Whiplash and Mouse-eared hawkweeds occur primarily in disturbed areas, including fields, pastures, meadows, roadsides, gravel pits and along railroads. Whiplash and Mouse-eared hawkweeds also establish in dry woods, sandy and rocky openings, even, wet ground,and open woodlands. Whiplash and Mouse-eared hawkweeds prefer moist soil, though it may establish in areas where soils are dry and experience high summer temperatures.

Shade Tolerance:
Low light levels may keep Whiplash and Mouse-eared hawkweeds in a vegetative state and limit flowering.

Current BEC Range:
Boreal White and Black Spruce
Coastal Douglas-fir
Coastal Mountain-heather Alpine
Coastal Western Hemlock
Engelmann Spruce – Subalpine Fir
Interior Cedar – Hemlock
Interior Douglas-fir
Mountain Hemlock
Montane Spruce
Ponderosa Pine
Sub-Boreal Pine – Spruce
Sub-Boreal Spruce

Reproductive Strategy:
Plants reproduce by seed or vegetatively by rhizomes and adventitious root buds. Seed production is apomictic (the production of seeds without pollen). Vegetative spread is suggested to be the more common means of regeneration than seed production. Most vegetative spread is from adventitious root buds with rhizomatous spread being less important. Survival of tall hawkweed plants of vegetative

origin appears to be high. Whiplash and Mouse-eared hawkweeds may produce many seeds (**up to 200 per plant**. Seeds are wind dispersed. Although not confirmed, it is likely that Whiplash and Mouse-eared hawkweeds have a short-lived seed bank. Stratification is not required for seed germination. Seeds can germinate immediately upon exposure to unlimited water and temperatures. Moisture likely favours establishment, growth and survival.

Known Fire Response:

Whiplash and Mouse-eared hawkweeds are likely top-killed by fire. Belowground rhizomes and root buds may enable Whiplash and Mouse-eared hawkweeds to survive as they exhibit some characteristics that make plants likely to survive and/or establish after fire: rhizomes/root buds may survive, seeds have potential for long-distance dispersal onto burned site, may establish via soil-stored seeds. Disturbances associated with fire (e.g., bulldozing fire lines) may also encourage Whiplash and Mouse-eared hawkweed establishment. Prescribed fire is likely not an effective method for controlling Whiplash and Mouse-eared hawkweeds.

Species Specific BMPs for Prescribed Burns

For all phases, follow general recommendations regarding invasive plant prevention and spread. (Appendix 1)

Planning Phase and Site Assessment:

- Perform initial site surveys of proposed burn area and surrounding area (100m) to determine the presence and extent of Whiplash and Mouse-eared hawkweeds on the site – large, dense populations may signify high invasive propagule availability (seeds and vegetative buds) for post-fire recolonization and low native plant propagules.
- Check the Invasive Species Database to determine the history of this species on the site – if it does not currently exist on the site but was previously recorded there within the lifespan of the seeds (4 years), it is possible a seed bank exists that could germinate post-fire. Contingent management plans should be incorporated into the prescribed burn plan for post-fire management.

Post-fire Monitoring and Management:

- Monitor burn units near Whiplash and Mouse-eared hawkweed populations since likelihood of wind-borne seed establishment is possible.
- Monitor burn units with existing pre-fire populations of Whiplash and Mouse-eared hawkweeds for sprouting.
- Closely monitor fire guards created via bulldozing pre- and post-fire as these can encourage establishment of Whiplash and Mouse-eared hawkweeds, especially if nearby populations are known.

Yellow Starthistle

WARNING: THIS SPECIES IS NOT YET KNOWN TO BE FOUND IN BC!

IF FOUND, DO NOT DISTURB AND IMMEDIATELY REPORT TO THE FLNRORD INVASIVE PLANT PROGRAM AT INVASIVE.PLANT@GOV.BC.CA or VIA THE "REPORT INVASIVES" MOBILE APP.

Photo credit: Peter M. Dziuk

Photo credit: Coastal Invasive Species Committee

Photo credit: CABI

Scientific Name:
Centaurea solstitialis

Family:
Asteracea (Aster)

Status:
Provincial Noxious Weed (*BC Weed Control Regulation)*

Origin:
Southern Europe and western Eurasia

General Description:
Yellow starthistle is a winter annual or, rarely, a biennial or short-lived perennial forb that grows from 0.6 to 1m tall. It has a long taproot that grows to depths of 1m or more in the soil. Deeply lobed rosettes form close to the ground and produce stiff, hairy, many-branched winged stems. Waxy stem leaves are long near the ground (5-15cm) and become progressively smaller up the stem (1-3cm at the top). Upper leaves become covered with cobwebby hairs late in the season. Bright yellow flowers are borne on the ends of branches and armed with sharp thorns up to 2cm long.

Impacts:
Yellow starthistle is highly competitive and can establish dense populations that displace native plants and reduce wildlife habitat and forage. Dense stands can also limit recreational access to areas. Dense stands of Yellow starthistle reduce sunlight penetration to the soil surface inhibiting germination development of many native plants. Large populations deplete soil moisture reserves and alter water cycles in plant communities. Yellow starthistle is toxic to horses and causes the neurological "chewing disease" when eaten.

Habitat:
Yellow starthistle is best adapted to open grasslands with annual average precipitation between 250-1,500mm and elevations below 1,500m. It is uncommon in deserts and moist coastal areas. At the northern edge of its range, Yellow starthistle is limited to growing on south-facing slopes. This species is commonly found in disturbed areas such as roadsides, abandoned fields and pastures, waste places, recreational areas, and disturbed grasslands and woodlands.

Shade Tolerance:
Yellow starthistle is shade intolerant. This species depends on light on the soil surface for winter rosette and taproot development. Yellow starthistle rosettes are particularly vulnerable to shading.

Current BEC Range:
This species is not currently known in BC. but close to its borders in Washington and Idaho.

Reproductive Strategy:
Sexual – Yellow starthistle reproduces sexually by abundant seed production. Though individual plants have both male and female reproductive organs, they are generally self-incompatible and are pollinator dependent for cross fertilization. Depending on soil moisture and competition for resources, a single Yellow starthistle plant can produce 1 to 1,000 flowerheads with 30 to 80

seeds per flowerhead. A single plant is therefore capable of producing up to 80,000 seeds in one year. Over 90% of seeds are germinable one week after dispersal, and seeds can remain viable in the soil for up to 10 years. Seeds usually germinate in late fall or early winter, though spring germination does occur. Seeds contain a small, feathery plume and are wind dispersed over short distances. Barbs on the plume's pappuses readily adhere to clothing and hair allowing for long-distance dispersal from human and animal activities.

Vegetative – this species does not undergo vegetative reproduction.

Known Fire Response:

Yellow starthistle plants are likely top killed by fires; however, some plants may re-sprout after low severity fires. Fires are often not severe enough to destroy Yellow starthistle seeds and if present, seeds are likely to germinate and establish after a fire. Post-fire conditions such as increased sunlight at the soil surface, increased areas of bare soil, and reduced competition with other species are favourable for the establishment of Yellow starthistle. Fire regime characteristics may be altered by dense infestations of Yellow starthistle due to changes in fuel characteristics.

Species Specific BMPs for Prescribed Burns

YELLOW STAR THISTLE IS NOT YET KNOWN TO BE IN BC.

DO NOT CONDUCT ANY DISTURBANCE OR INTRODUCE FIRE INTO AN AREA WITH YELLOW STAR THISTLE FOR ANY REASON. CONTACT THE INVASIVE PLANT PROGRAM FOR MORE INFORMATION IF FOUND at invasive.plant@gov.bc.ca.

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