Conservation, Restoration and Stewardship of Low Elevation Brushland (Gb), Grassland (Gg) and Dry Forest Ecosystems in the West Kootenay Region

<u>Background Information Document</u>

v.7

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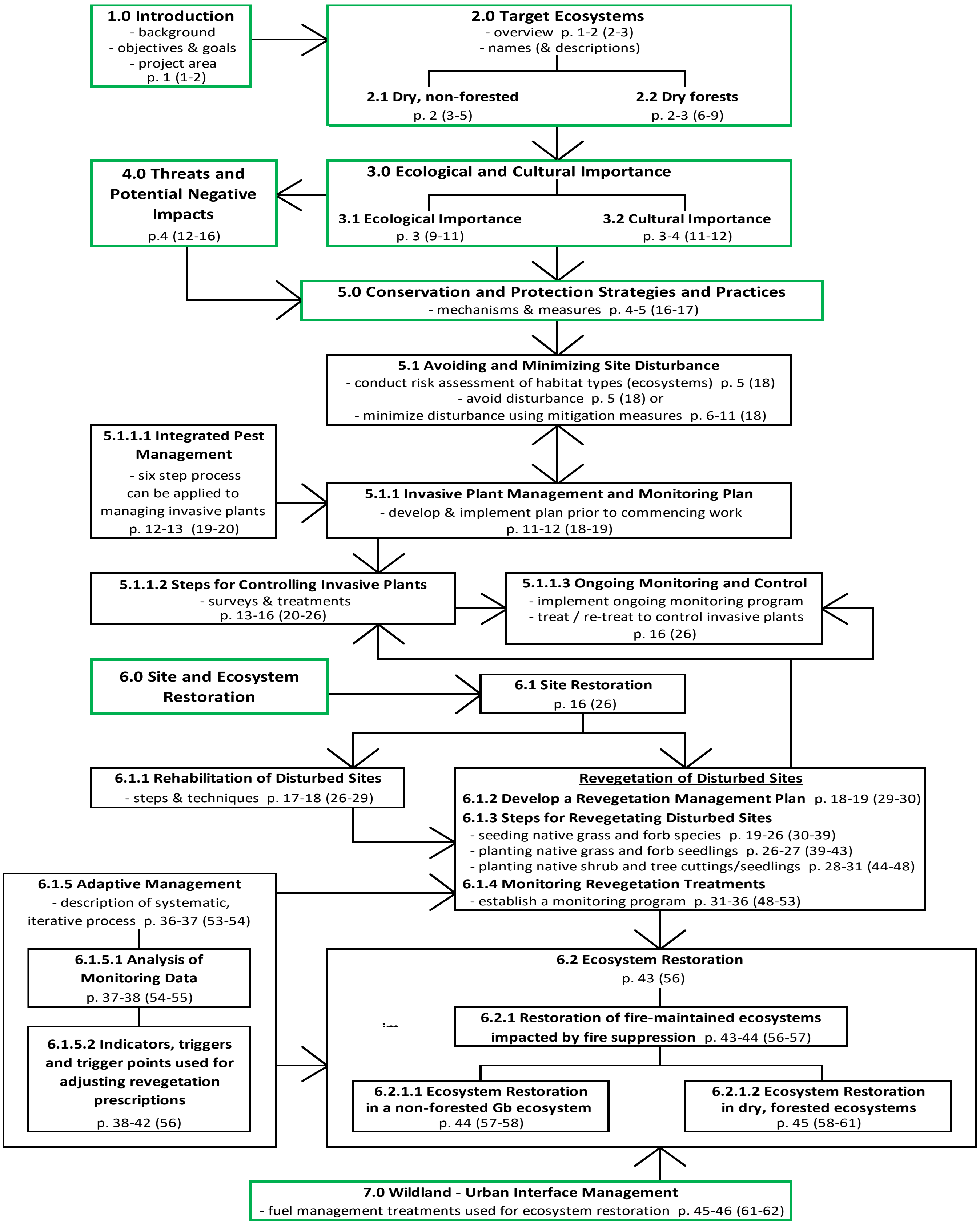


[1] first page numbers refer to the field manual (e.g., p. 1) and numbers in brackets are for the background information document (e.g., p. (1-2))

1.0 INTRODUCTION

Non-forested brushland (Gb) and grassland (Gg) ecological communities that occur on dry sites at low elevations in the West Kootenay Region have high ecological values but are uncommon across the landscape. The grassland community that occurs in our area has been designated at-risk (red-listed) by the B.C. Conservation Data Centre (CDC) since 2018. Two of the three brushland ecosystems in the region have also recently been ranked as red-listed (B.C. CDC, 2023) due to their ecological importance, scattered distribution, high sensitivity to disturbance and low resilience. In October 2021, the FWCP section of the Ministry of Forests organized a field tour of brushland (Gb) sites in the ICHxw biogeoclimatic subzone located south of Trail to share knowledge about the key conservation and management issues for the ecosystems. The tour visited examples of the three different Gb ecosystems (Gb03, Gb05, Gb06) described within the ecosystem field guide for the south-central Columbia Mountains (MacKillop and Ehman, 2016) and the key issues were discussed at the different sites.

One of the recommendations that came out of the field tour was to develop a set of best management practices that could be used by industry and other stakeholders when conducting work in brushlands and other sensitive ecosystems on dry sites at low elevations. Dry forest ecosystems also provide important habitats for plants and animals and are sensitive to disturbance. They are included with brushlands and grasslands as target ecosystems for which the best management practices will apply. It was suggested that the best practices be summarized in a field manual supported by a document with more detailed background information.

This background information document describes the project objective, goals and project area and provides information related to guiding work activities in low elevation Gb, Gg and dry forest ecosystems. It was developed to supplement and support the field manual summarizing the best management practices. The background document provides additional information on the following topics:

- Target ecosystems in the West Kootenay Region
- Ecological and cultural importance of target ecosystems
- Threats and potential negative impacts to these ecosystems
- Conservation and protection strategies and practices
- Site and Ecosystem Restoration

Prior to the Gb brushland field tour, the Lower Columbia Land Managers Conservation Action Forum was held in 2018 to identify priority needs and actions that would contribute to maintaining species at risk and their habitats and ecosystems at risk in the Lower Columbia Valley over the next five years. The forum included a workshop and field tour where participants representing a diversity of land management organizations discussed needs and constraints to promoting improved management and conservation actions and implementation of best management practices to protect species and ecosystems at risk. The forum incorporated a Conservation Neighbourhood Approach to framing conservation and stewardship objectives in terms of ecological benefits to local landscapes. The Lower Columbia River Valley Conservation Neighbourhood encompasses the area from Trail south to the U.S. border including the Pend d'Oreille Valley.

In preparation for the forum, participants received a comprehensive list of recommended management and conservation actions to reduce impacts to at-risk species and ecosystems due to nine land management activities. The recommended actions for each activity are included in Table 1 of the forum summary report (Kootenay Conservation Program, 2018). The nine activities were grouped into four land management activity themes and small groups of participants discussed the recommended actions with respect to each of the themes. The discussions resulted in identifying six priority actions to overcome barriers to implementing management and conservation actions within the local landscape area.

The recommended actions for each land management activity and the six priority actions included in the summary report are all applicable to conserving the target ecosystems identified in this document and the field manual. Appendix A in the summary report also identifies a number of land management organizations, scientists and conservationists that have a stake in protecting and reducing impacts to the target ecosystems and associated species at-risk.

1.1 Project Objective

To review and summarize best management practices for conserving and protecting target ecosystems (low elevation, dry, non-forested and forested habitats) during development, maintenance and restoration activities.

1.2 Project Goals

The project includes two main goals as follows:
1) To produce a document of background information describing the target ecosystems, their ecological importance, potential threats and associated negative impacts to the ecosystems, strategies and best management practices for conserving and protecting the habitats, and methods for rehabilitating/restoring impacted sites.
2) To develop a concise field manual for guiding the practical implementation of the best management practices when planning and carrying out development, maintenance and/or restoration activities within the target ecosystems. The manual will summarize best practices for avoiding/minimizing disturbance on sensitive sites, site and ecosystem restoration of disturbed/impacted sites, and monitoring to evaluate the effectiveness and success of rehabilitation/restoration treatments.

1.3 Project Area

The project area covers the south and central parts of the West Kootenay Region including the Boundary area.

2.0 TARGET ECOSYSTEMS IN THE WEST KOOTENAY REGION

The target ecosystems are fire-maintained (NDT4[2]) ecosystems that include both non-forested brushlands and grasslands and dry forested ecosystems. They typically occur on dry, warm-aspect slopes with shallow and/or coarse-textured soils, but also occur on coarse-textured glaciofluvial terraces in the Lower Columbia Valley. In the West Kootenay Region, these ecosystems mainly occur at low elevations within the Interior Cedar-Hemlock (ICH) biogeoclimatic zone and the following subzones, variants and phases: the very dry warm ICH subzone **(ICHxw)**, the warm phase of the very dry warm ICH subzone **(ICHxwa)**, and the West Kootenay variant of the dry warm ICH subzone **(ICHdw1)**. The brushlands and grasslands are also scattered and uncommon on the driest, warmest sites at mid elevations in three

[2] NDT 4 = Natural Disturbance Type 4

variants of the moist warm ICH subzone (ICHmw) including the Slocan (ICHmw2), the Ymir (ICHmw4), and the Granby (ICHmw5) variants, and in the dry mild ICH subzone (ICHdm) located to the east of south Kootenay Lake and the Creston Valley. A dry forested ecosystem in the ICHdm subzone is also included as one of the target ecosystems.

Grasslands and Gb05 brushlands are more common in the drier Bunchgrass (BG), Ponderosa Pine (PP) and Interior Douglas Fir (IDF) zones in the Okanagan and Boundary areas while Gb03 brushlands may be more common in the IDF subzones in the Boundary. Grassland and Gb03 ecosystems also occur in the drier ICH units (ICHxm1, ICHdw4) in the Okanagan and Shuswap areas (MacKillop et al, 2021).

The target ecosystems are briefly described below and are described in more detail in the provincial land management handbook 70 – *A Field Guide to Ecosystem Classification and Identification for Southeast British Columbia: The South-Central Columbia Mountains* (MacKillop and Ehman, 2016).

2.1 Dry non-forested ecosystems

Non-forested ecosystems have <10% tree cover. The target ecosystems are associated with sites that are too dry for forest establishment in the ICH zone and include brushlands (Gb) and grasslands (Gg) of the Grassland Group of ecosystems.

<u>*Grasslands*</u> are very uncommon within the ICH zone in the West Kootenays and only one site association (ecosystem) is present. The ***Gg11 Idaho fescue – Bluebunch wheatgrass – Junegrass*** grassland is often limited to small openings where it occurs on exposed, moderately steep to steep, warm-aspect slopes, usually with shallow soils. It is more common in the drier IDF and PP zones in the Boundary and Okanagan areas, but also occurs in the ICH. The grassland is ranked as a red-listed ecological community (B.C. Conservation Data Centre (CDC), 2023). The sites are dominated by bunchgrasses (e.g. bluebunch wheatgrass, Idaho fescue, slender wheatgrass) with moderate to minor amounts of junegrass, poverty oatgrass, silky lupine, selaginellas, yarrow, parsnip-flowered buckwheat and often arrow-leaved balsamroot. The ecosystems may be disturbed by cheatgrass, other annual brome grasses, and invasive and other weedy forb species. Examples of small grassland areas in the ICHdw1 unit are shown in photos 1 and 2.


Photos 1 and 2: Small areas of grassland on warm aspect slopes with shallow soils located near Tye in the Darkwoods Conservation Property

Brushlands also occur on dry, warm-aspect slopes but the sites typically have rockier and shallower soils than grassland sites. Brushland ecosystems are more common in the West Kootenays than grasslands and there are three site associations described. The Gb03 and Gb06 brushlands were recently ranked as at-risk (red-listed) ecological communities by the B.C. CDC (2023) as the ecosystems (a) support a high diversity of plants and animals including numerous at-risk species, (b) are uncommon, and (c) are highly threatened by development activities. The Gb05 brushland community is also ecologically important, very uncommon in the region, and highly sensitive to disturbance. It was not ranked at the same time as the Gb03 and Gb06 brushland ecosystems due to time constraints and insufficient mapping data (Deb MacKillop, pers. comm., Oct 20, 2023). The ranking process will be undertaken by the CDC at a later date when time and more mapping data are available.

The ***Gb03 Mallow nine-bark – Oceanspray – Bluebunch wheatgrass*** brushland occurs on steep, warm slopes with shallow, usually rocky, coarse-textured soils, occasionally with exposed bedrock. The ecosystem occurs throughout the ICH subzones and variants but is more common in the ICHxwa, xw, and dw1 units. Douglas-fir (Fd) and Ponderosa pine (Py) trees may be present on the sites, but they have < 10% cover. The shrub community is typically characterized by mallow ninebark, oceanspray, saskatoon, common snowberry, and Oregon-grape, often with wild cherries, common juniper and mock-orange. The herb layer usually has bluebunch wheatgrass, often with pinegrass, fescues, and junegrass, and a diversity of forb species including yarrow, small-flowered blue-eyed Mary, silky lupine, desert-parsleys, lance-leaved stonecrop, dryland sedges, Scouler's hawkweed, death-camas, selaginella, and the non-native species thyme-leaved sandwort. Haircap mosses may be common in the moss-lichen layer. The sites are often disturbed by the invasive species spotted knapweed, St. John's-wort, cheatgrass, and others. Examples of Gb03 brushland communities are shown in photos 3 and 4.


Photos 3 and 4: Areas of Gb03 brushlands along the T/L corridor between Waneta and the Selkirk Substation above the Seven Mile Dam Road in the Pend d'Oreille Valley

The ***Gb05 Sumac – Bluebunch wheatgrass*** brushland occasionally occurs in the ICHxwa biogeoclimatic unit on very dry, warm, sandy and/or rocky slopes. The ecosystem is more common on steep, warm-aspect sites with coarse soils in the very dry BG, PP and IDF subzones in the south Okanagan and in the very dry IDF unit in the Boundary area. The Gb05 is characterized by smooth sumac in the shrub layer and usually bluebunch wheatgrass in the herb layer. Saskatoon, common snowberry, tall Oregon-grape and sometimes poison ivy can also be common in the shrub layer. Other native herb species can include Scribner's witchgrass, needle-and-thread grass, needle grass, other native grasses, parsnip-flowered buckwheat, arrow-leaved balsamroot, selaginella, yarrow, and spreading dogbane. The soils are very sensitive to disturbance by invasive plant species and cheatgrass, other annual brome grasses, St.

John's-wort, hare's-foot clover, and hairy vetch may be common. Photos 5 and 6 show a Gb05 ecological community in the Pend d'Oreille Valley.


Photos 5 and 6: Gb05 brushland on a steep, warm-aspect slope above the Pend d'Oreille Reservoir. The site is dominated by smooth sumac, Scribner's witchgrass and parsnip-flowered buckwheat and highly disturbed by cheatgrass, St. John's-wort, hare's-foot clover and other non-native species.

The ***Gb06 Snowbrush – Poverty oatgrass*** brushland is very limited in southeast B.C. and in adjacent areas in the USA. In B.C., it is restricted to the ICHxwa unit in the area south of Trail where it occurs on very coarse-textured glaciofluvial terraces and scarp slopes above the Columbia River. Snowbrush is usually the dominant shrub in association with Oregon-grape, saskatoon, common snowberry and choke cherry. Poverty oatgrass is typically the most common species in the herb layer. Other common species include kinnikinnick, junegrass, spreading dogbane, stiff needlegrass, porcupine grass, hair bentgrass, Scribner's witchgrass and the non-native species sheep sorrel. Common matte lichen and haircap mosses may be common in the moss-lichen layer. Scattered trees including Fd, Py, and white pine (Pw) may be present at low densities (< 10% cover). Invasive species such as spotted knapweed, St. John's-wort, Dalmatian toadflax and cheatgrass, and other non-native grasses (e.g. redtop) can also occur on the sites. Examples of Gb06 brushlands are shown in photos 7 and 8.


Photos 7: (left) A small area of Gb06 brushland on an upper glaciofluvial terrace in the Fort Shepherd Conservancy area; Photo 8: (right) An area of Gb06 on a sandy, gravelly glaciofluvial scarp slope above Casino Creek just north of the Fort Shepherd Conservancy.

2.2 Dry forest ecosystems

Dry forested ecosystems include very dry and dry forests that occur on steep, warm-aspect, mid to upper slopes and crests with shallow and/or coarse soils. The forests often have open canopies (10% to 25% tree cover). Slightly dry forests in the very dry ICHxw and xwa units are also considered target ecosystems and occur on moderate, warm-aspect slopes with shallow to deep, medium- to coarse-textured soils. They tend to have more closed canopies with > 25% tree cover.

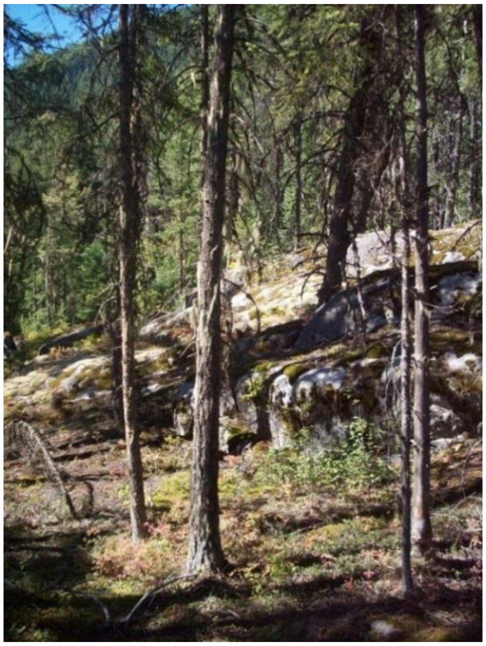
Very dry forests are classified as the 102 site series in the Biogeoclimatic Ecosystem Classification (BEC) system (MacKillop and Ehman, 2016). The 102 represents the driest forested site series; drier sites are non-forested brushlands (Gb), grasslands (Gg), rock outcrops or talus with < 10% tree cover. The 102 forest ecosystems usually occur on steep, warm-aspect slopes with very shallow soils and prominent exposed bedrock or blocky talus. The very dry (102) forests that are included as target ecosystems in the project area include the following site series (ecosystems):

ICHxw, xwa / 102 FdPy – Oceanspray – Bluebunch wheatgrass
ICHdw1 / 102 FdPy – Pinegrass – Rock-moss
ICHdm / 102 Fd – Snowberry – Tall Oregon-grape

The very dry forests at low elevations (<1350 m) In the ICHxw, xwa and dw1 biogeoclimatic units have open stands dominated by Fd and Py. In the ***ICHxw, xwa / 102*** forests, shrub cover is moderate and common species include mallow ninebark, saskatoon, Oregon-grape, common snowberry, and birch-leaved spirea often with oceanspray and mock-orange. Bluebunch wheatgrass is typically the dominant species in the herb layer. Other characteristic herb species include round-leaved alumroot, rock ferns (parsley fern, woodsia ferns, fragile fern), fescues, pinegrass, yarrow, stonecrops and selaginella. Haircap mosses, rock-mosses and clad and pelt lichens are usually common in the moss-lichen layer.

In the ***ICHdw1 / 102*** site series, the most common species in the shrub layers are falsebox, Douglas maple and birch-leaved spirea. Other common species are saskatoon, oceanspray, baldhip rose and often ninebark and mock-orange. Pinegrass is the most common species in the herb layer and occurs with kinnikinnick, rock ferns, round-leaved alumroot, fescues, and strawberry. Selaginella, stonecrops and other plants associated with rock outcrops may also occur in minor amounts. The moss-lichen layer includes red-stemmed feathermoss, rock-mosses and often clad lichens and haircap mosses. This ecosystem correlates to the historic ICHdw1/02 Fd – tall Oregon-grape – parsley fern site series that is ranked as a red-listed ecological community (B.C. CDC, 2009). Photos 9 and 10 show examples of very dry 102 forests in the ICHdw1 variant.

The ***ICHdm / 102*** forests occur at mid elevations (1000-1650 m) on steep, warm-aspect slopes with either shallow soil and prominent exposed bedrock **(*102a*)** or shallow and/or coarse-textured soils without rock outcrops **(*102b*)**. The very dry forests are dominated by Fd with occasional scattered western larch (Lw) and lodgepole pine (Pl). Shrub cover is moderate to high with the most common species being common snowberry, saskatoon, Oregon-grape, roses and often falsebox. Birch-leaved spirea and black huckleberry are also common on some sites. In the herb layer, pinegrass and often bluebunch wheatgrass are the dominant species and occur with minor amounts of round-leaved alumroot, yarrow and often rock ferns. Mosses and lichens are uncommon.




Photos 9: (left) A very dry 102 forest ecosystem located in the Darkwoods Conservation Property on the east side of the Creston Valley; Photo 10: (right) A very dry (102) open forest on shallow soils at Lyons Bluff above the West Arm near Nelson

Dry forests are classified as the 103 site series in MacKillop and Ehman (2016). They typically occur on steep, warm, mid to upper slopes with coarse and/or shallow soils, but they can also occur on very coarse-textured glaciofluvial terraces. Unlike the 102 forest ecosystems, the sites do not have prominent exposed bedrock. Early seral stages of the dry forests dominated by shrub and herb species can be difficult to distinguish from the non-forested Gb03 brushlands that occur on similar sites. The seral forest ecosystems can be identified based on the presence of stumps and/or regen of conifers or broadleaf tree species (trembling aspen, paper birch). The dry (103) forests frequently occur in a mosaic with very dry 102 forests and non-forested Gb03 brushlands, rock outcrops or talus ecosystems. The 103 site series included as target ecosystems are as follows:

> ***ICHxw, xwa / 103 FdPy – Oregon-grape – Pinegrass***
> ***ICHdw1 / 103 Fd(Py) – Douglas maple – Pinegrass***

The dry forests are characterized by open stands of Fd and Py with moderate to high shrub cover in the understory. Lw, Pl, paper birch (Ep) and trembling aspen (At) can also occur in the tree layers. In the ***ICHxw, xwa / 103*** forests, common shrubs include common snowberry, Oregon-grape, saskatoon, redstem ceanothus, birch-leaved spirea, roses (baldhip, prairie), and often mallow ninebark and oceanspray. Pinegrass and often bluebunch wheatgrass are the dominant species in the typically diverse herb layer. Other common species can include yarrow, Scouler's hawkweed, junegrass, pussytoes, dryland sedges, strawberries, nodding onion, kinnikinnick, fescues, paintbrushes and desert-parsleys. Moss and lichen cover is generally low. Photos 11 and 12 show an ICHxw/103 dry forest ecosystem on Deer Park Mountain northwest of the Deer Park community.


Photos 11 and 12: A dry open 103 forest in the ICHxw subzone located on Deer Park Mountain

In ***ICHdw1 / 103*** forests, the well-developed shrub layer includes falsebox, Douglas maple, birch-leaved spirea, Oregon-grape, common snowberry, baldhip rose, saskatoon, often oceanspray, and sometimes mallow ninebark at lower elevations. (photos 13 and 14). Pinegrass is usually the dominant species in the herb layer occurring with low amounts of strawberry, white hawkweed and often kinnikinnick, yarrow and fescues. Moss and lichen cover is generally sparse.


Photos 13 and 14: A dry, open 103 forest in the ICHdw1 located above Kootenay Lake just north of Tye in the Darkwoods Conservation Property. The understory is dominated by mallow ninebark and pinegrass indicating that the low elevation site is transitional to the ICHxw unit.

A *slightly dry forest* ecosystem that occurs in the ICHxw and xwa is also considered a target ecosystem. It is classified as the ***ICHxw, xwa / 104 Fd(Py) – Douglas maple – Pinegrass*** site series. The target 104 forest occurs on moderate to steep, warm-aspect slopes with medium- to coarse-textured soils. In the drier climates of the ICHxw and xwa, the 104 site series is similar to the dry 103 forest ecosystem in the slightly moister ICHdw1 variant and has the same name. Fd is typically dominant in the tree layer and can occur with Py, Pl, Lw, Ep and At. The shrubby understory is usually dominated by mallow ninebark, oceanspray, Douglas maple, common snowberry, Oregon-grape and baldhip rose with lower amounts of saskatoon and birch-leaved spirea. Unlike the ICHdw1 / 103 forests, the ecosystem typically has mallow ninebark, more oceanspray and lacks falsebox. Pinegrass is common in the herb layer and occurs with strawberry species, kinnikinnick, pussytoes, dryland sedges, fescues, white hawkweed, heart-leaved arnica, showy aster and rough-fruited fairybells. Low covers of twinflower, prince's pine and wild sarsaparilla can also occur on slightly moister sites. Moss and lichen cover is usually low. Photos 15 and 16 show an example of a slightly dry 104 forest ecosystem in the ICHxwa unit.

Photos 15, 16: An ICHxwa/104 ecosystem on a moderate, warm-aspect slope located along the Broadwater Road near Deer Park. The Fd(Py) stand has moderate cover of tall Oregon-grape and common snowberry in the shrub layer, and pinegrass, blue wildrye, white hawkweed, pathfinder and the non-native orchard grass are the most common species in the herb layer.

3.0 ECOLOGICAL AND CULTURAL IMPORTANCE OF TARGET ECOSYSTEMS

3.1 Ecological Importance

<u>Provide habitat for a high diversity of plant and animal species</u>
Non-forested brushlands and grasslands provide structural diversity in landscapes that are largely dominated by forests. They often occur in complexes with dry open forests and rock outcrops, and together the ecosystems provide habitat for a large variety of plants and animals. The Gb03 brushlands and dry open forest ecosystems in particular can support very high plant species diversity. For the *West Kootenays Intact Ecosystems Project 2008* (McKenzie and Hill, 2008), six relatively intact (undisturbed) Gb03 and dry 103 forest sites were surveyed in the ICHxw, xwa and dw1. An ICHxw / Gb03 brushland community sampled at Kitchener Face east of Creston supported at least 104 native species. At another site in the ICHxw at Fox Tree Hill south of Creston, 109 native species were identified in an area of Gb03 transitional to a dry 103 forest. At the other four sites, between 62 and 73 native plant species were identified in each of the Gb03 and dry 103 forest habitats. These diverse plant communities support a number of mammals, birds, reptiles and insects. Gb06 brushland ecosystems on glaciofluvial terraces also support a high diversity of ground-nesting bees (V. Huff, pers. comm.).

<u>Provide important habitat for ungulates</u>
Brushland, grassland and dry forest ecosystems provide foraging areas for **mule deer**, **white-tailed deer**, **Rocky Mountain elk** and **bighorn sheep**, which is a blue-listed species. Palatable shrubs, including saskatoon, redstem ceanothus and cherry species in brushlands and dry forests as well as Douglas maple and willows in the slightly moister ICHdw1/103 and ICHxw, xwa/104 forests, are browsed by deer and elk. Smooth sumac in the Gb05 brushland is also browsed. In grasslands, brushlands and the drier forest

ecosystems, bunchgrasses (mainly bluebunch wheatgrass and Idaho fescue) and to a lesser extent junegrass are grazed by elk and bighorn sheep. The dry forests with insolation on steep warm-aspect slopes, lower snow depth, high forage availability and tree cover also provide key winter ranges for the ungulates.

Support a number of at-risk species

At the federal level, at-risk species are designated as extirpated, endangered, threatened or special concern by the Committee On the Status Of Endangered Species In Canada (COSEWIC, 2022). In B.C., at-risk species are red-listed if they are ranked as extirpated, endangered or threatened or blue-listed if they have a status of special concern indicating that they are vulnerable to becoming threatened, endangered or extirpated in the province. An explanation of the BC List Status is available at https://www.env.gov.bc.ca/atrisk/help/list.htm .

At-risk wildlife species

Brushlands, grasslands and dry forests provide habitat for a number of at-risk wildlife species. The at-risk species that depend on habitat features within low-(mid) elevation, dry non-forested and forested ecosystems in the West Kootenays are noted in the Wildlife Habitat sections for the ICHxw, ICHdw1 (and ICHdm) biogeoclimatic units in MacKillop and Ehman (2016). Several at-risk reptiles are found in the target ecosystems. At lower elevations (ICHxw, xwa, dw1), the blue-listed **North American (western yellow-bellied) racer** occurs in both brushland (Gb) and grassland (Gg11) habitats and the blue-listed **western skink** utilizes the Gg11, Gb03 and dry (102, 103) forest ecosystems. The **northern rubber boa**, designated as a species of special concern by COSEWIC, uses dry, rocky Gb03 and 102 forest habitats in the ICHxw, dw and dm subzones. The ecosystems also support at-risk birds and a listed bat species. The red-listed **yellow-breasted chat** nests in open habitats with dense shrubs layers and frequently uses Gb03 brushlands and shrub-dominated, early seral stages of dry 103 forests in the ICHxw and xwa. The **common nighthawk**, ranked as a species of special concern by COSEWIC, nests in open areas within dry (102, 103) forests as well as in brushlands and grasslands. The blue-listed **Lewis's woodpecker** is a frequent user of low elevation, dry open forests where large snags are available for nesting. The **flammulated owl** is another blue-listed species that uses wildlife trees in similar habitats in the ICHdw1 variant. Dry open forests in both the ICHxw and dw subzones provide habitat for the blue-listed **fringed myotis**, another wildlife tree-dependent species. There are also a number of at-risk insects that occur in the target ecosystems. Species summaries, conservation status reports, and species descriptions and distribution maps on the E-Fauna BC website are available at B.C. CDC, 2022.

At-risk plant species

A search of the B.C. Conservation Data Centre (CDC) database was conducted to identify at-risk plants that can occur in the target ecosystems (B.C. CDC, 2022). The dry grassland, brushlands and open forests are known to provide habitat for at least four at-risk species. The blue-listed **Pursh's wallflower** (*Erysimum capitatum* var. *purshii*) occurs in Gb03 brushlands in the vicinity of Waneta. **Common clarkia** (*Clarkia rhomboidea*) is a blue-listed species known only from the Trail and Pend d'Oreille River Valley areas. It occurs in the ICHxw in dry open (102, 103) forests and potentially in Gb03 brushlands. **Least bladdery milk-vetch** (*Astragalus microcystis*) is another blue-listed species that has been found in dry open forests and on dry, grassy slopes in the ICHdw1. The species has been documented in the Pass Creek area and in the Pend d'Oreille. The red-listed species **Nelson needlegrass** (*Achnatherum nelsonii* ssp. *nelsonii*) has been observed in Beaver Creek Park south of Trail growing in a dry open FdPy forest on a sandy terrace along the

Columbia River. The species could also occur in Gb06 brushlands and dry 103 forests on coarse textured glaciofluvial terraces, and in Gb03 and dry (102, 103) open forests on dry rocky slopes.

3.2 Cultural Importance

The Grassland ecosystems are viewed by the syilx People as a diverse, sensitive collaboration of life that provided, by example, the lessons to sustainably co-exist and flourish. The knowledge systems of the syilx Okanagan are inextricably tied to the land, and these dry ecosystems provided culturally and ecologically important space and time for the transfer of knowledge, teachings, laws, protocols and societal delegations. Representing more than simply a source of sustenance, these spaces housed many story markers that would be revisited in spring by the emerging People, instilling and reinforcing role and responsibility to the land as guided by the captikʷɬ (traditional oral stories) that were shared and reflected on throughout winter months (skʷkʷlal E. Tonasket, pers. comm., Jan 5, 2026).

sp’iƛ̓əm (bitterroot) and siyaʔ (saskatoon berry) are two dry ecosystem-based, culturally significant species that play key roles in the syilx Okanagan Creation story as two of the four Food Chiefs as told in How Food Was Given (Okanagan Nation Alliance 2026). The flowering of sp’iƛ̓əm (bitterroot) in the early spring marks the time for new growth and new life as the sun makes its way back north bringing the warmth with it. sp’iƛ̓əm represents the roots and teaches vital lessons in respect, reciprocity, compassion, and relationships. It is also a symbol of the feminine and links women to the grasslands. Subsequently, the time of siyaʔ (saskatoon) provided space for youth to endure rights-of-passage, learn leadership, and their role amongst their community. siyaʔ represents all things growing on the land and relates to the youth, innovation, and creativity. Additionally, plants such as the thorny cactuses teach people to step carefully and guide mindful steps through a sensitive place that provides food and medicine plants, setting the stage for training grounds that instill first lessons in people. These open lands were viewed as a less rugged environment providing an ideal learning space for elders to transfer knowledge to children and adolescence.

Reciprocity and respect were practiced through sustainability and included seed propagation, cycling through the land to avoid over-staying in one place, and working with “good fire” to revitalize the land. Land was not considered to be managed for but a space to participate alongside all living things – our relatives (skʷkʷlal E. Tonasket, pers. comm., Jan 5, 2026).

These areas also provided gathering spaces for social events such as the Round Dance- an opportunity for youth to be introduced and meet relatives or neighboring nation members, later called the "Grass Dance", which today serves as modern entertainment and competition. Today, land-based ceremony and gatherings by knowledge holders bridge knowledge systems to adapt to and address the current conditions of the land, akin to data collection of western science (skʷkʷlal E. Tonasket, pers. comm., Jan 5, 2026). This connection provides critical opportunity for knowledge systems to adapt to new and emerging changes to these ecosystems such as invasive species introduction and encroachment, changes in wildlife and plant populations, extirpation of species, impacts from fire suppression, development, and the impacts of cattle ranching.

These diverse and plentiful ecosystems were valued hunting grounds and harvesting sites for food, medicine and materials for traditional technological uses. While all plants were valued, the following provides examples of culturally important species common in the dry target ecosystems: bitterroot, saskatoon, arrowleaf balsamroot, (skʷkʷlal E. Tonasket, pers. comm., Jan 5, 2026), Douglas-fir, choke cherry, ceanothus, Oregon-grape, rose, juniper, smooth sumac, kinnikinnick, yarrow, strawberry, desert-parsley, yellow glacier lily, nodding onion, and death camas (Sinixt Culture 2022; Keefer and McCoy 1999).

In these fire-adapted landscapes, cultural burns were used by First Nations to manage plants for food, medicine and technological use, as well as to benefit wildlife, habitat and to rebalance fire-dependent ecosystems (Science World 2021; The Narwhal 2021). Tied closely to the roles and responsibility of the People as caretakers of the land, the controlled, low-intensity burns maintained biodiversity and ecosystem health, promoted the growth of fire-adapted food and medicine plants, and rejuvenated shrubs and grasses important as food sources for ungulates. Cultural burning also contributed to community safety by maintaining open lines of sight and reducing the risk of high-intensity fires.

4.0 THREATS AND POTENTIAL NEGATIVE IMPACTS TO TARGET ECOSYSTEMS

The association of Gb ecosystems with low elevations and the prevalence of human settlement and development in these valley bottom habitats puts these ecosystems at significant risk of disturbance and degradation due to human activities. Primary threats (both current and past) include direct habitat loss, the introduction and spread of invasive species, fire suppression, recreation (motorized and non-motorized) and historic air / soil pollution in the Columbia Valley.

Direct habitat loss has occurred by physical removal or replacement of this ecosystem type via various mechanisms and has resulted in a reduction of the total area of Gb ecosystems in the region. One important aspect of direct habitat loss with respect to Gb ecosystems is that development of human infrastructure is disproportionally high in valley bottom areas where this habitat type occurs, so impacts to Gb habitats are high relative to their limited distribution on the landscape. Hydroelectric development and the associated flooding of valley bottoms is a major activity that has resulted in a shift in the distribution and abundance of Gb ecosystems. Other activities such as transportation corridor development (roads, railways, airstrips) and the development of industrial sites have physically replaced Gb ecosystems with human infrastructures, resulting in significant contributions to habitat loss. Examples of direct habitat loss from transportation corridor and industrial development can been seen throughout the lower Columbia Valley where highways, rail lines, airports, industrial complexes and communities occupy areas that were once Gb ecosystems (**Figure 1**).

The introduction and spread of invasive species through improper management of soil disturbance has contributed to degradation of the target ecosystems in many areas throughout the region. These ecosystems have low ecological resiliency and are easily colonized by invasive species due to their dry nature, high light availability due to a lack of significant forest canopy, and shallow soils with thin surface organic layers that are easily disturbed. The Pend d'Oreille Valley is a local example of an area where invasive plants have become established in Gb, Gg and dry open forest habitat types on a significant scale and are a major threat to native species. Knapweed (*Centaurea* spp.), sulphur cinquefoil (*Potentilla recta*), St. John's wort (*Hypericum perforatum*), non-native hawkweeds (*Hieracium* spp.), and cheatgrass (*Bromus tectorum*) are examples of invasive species that have become established throughout the area and are having negative effects on native plant communities.

Figure 1. Examples of direct habitat lost in the lower Columbia Valley. Gb06 ecosystems on the east side of the river have been replaced by an airstrip, gravel pit, industrial site and railyard. Intact Gb habitats can be seen on the west side of the river in the center of the image.

Photos 16 and 17 show areas of brushland (Gb03) and grassland (Gg11) near Waneta that are highly degraded due to invasive plant infestations. The fact that species such as spotted knapweed are using chemical allelopathy to compete with native species further increases the scale of impact because ecological processes are being affected. The main negative effects of invasive plant infestations to Gb, Gg and dry forest ecosystems are decreases in native species diversity and decreases in native species abundance resulting in loss of ecosystem integrity and function on degraded sites. This is a serious concern because these ecosystems are biodiversity hotspots with high species diversity and are considered uncommon to rare ecosystems in the region. Impacts of invasive species establishment in these ecosystems could have irreversible negative impacts to the diverse plant communities and the many other vertebrate and invertebrate species associated with them.

Photos 16: (left) A spur road built through Gb03 habitat is heavily infested with patches of sulphur cinquefoil and spotted knapweed. Photo 17: (right) An area of Gg11 grassland is heavily infested by cheatgrass with meadow brome and patches of sulphur cinquefoil to the detriment of bluebunch wheatgrass and other native species. The sensitive target ecosystems located along the T/L ROW between Waneta and Selkirk Substation are highly degraded by the weed infestations.

The open nature of the dry habitat types is transitioning to more closed conditions as the natural wildfire cycle is being disrupted through fire suppression. Fire suppression is known to change the course of succession in fire- maintained ecosystems and radically alter habitat availability for a large number of red and blue-listed species (Tiedmann et al. 2000 in Holt, 2001). Coniferous regeneration spreading into open shrubland and grassland areas, as well as forest ingrowth into open forest types, is causing extensive changes to these ecosystems. These processes negatively affect the target ecosystems by: (1) increasing shade, which alters species composition and distribution; (2) affecting phenological adaptations to high fire frequency, including limiting species with serotinous seeds; (3) removing the opportunity for vegetative growth fluxes of key shrubs and grasses after fires; and (4) reducing the availability and palatability of browse and decreasing habitat suitability on ungulate winter ranges (Mackillop and Ehman 2016). The total area of habitat lost due to fire suppression in dry, low elevation ecosystems is difficult to determine but is likely significant in the region. A comparison of current and historic aerial photographs in the Creston Valley conducted as a part of the West Kootenay Intact Ecosystems Project (McKenzie and Hill, 2008) provides a good example of dramatic changes to habitat structure due to forest ingrowth and conifer encroachment (**Figure 2**).

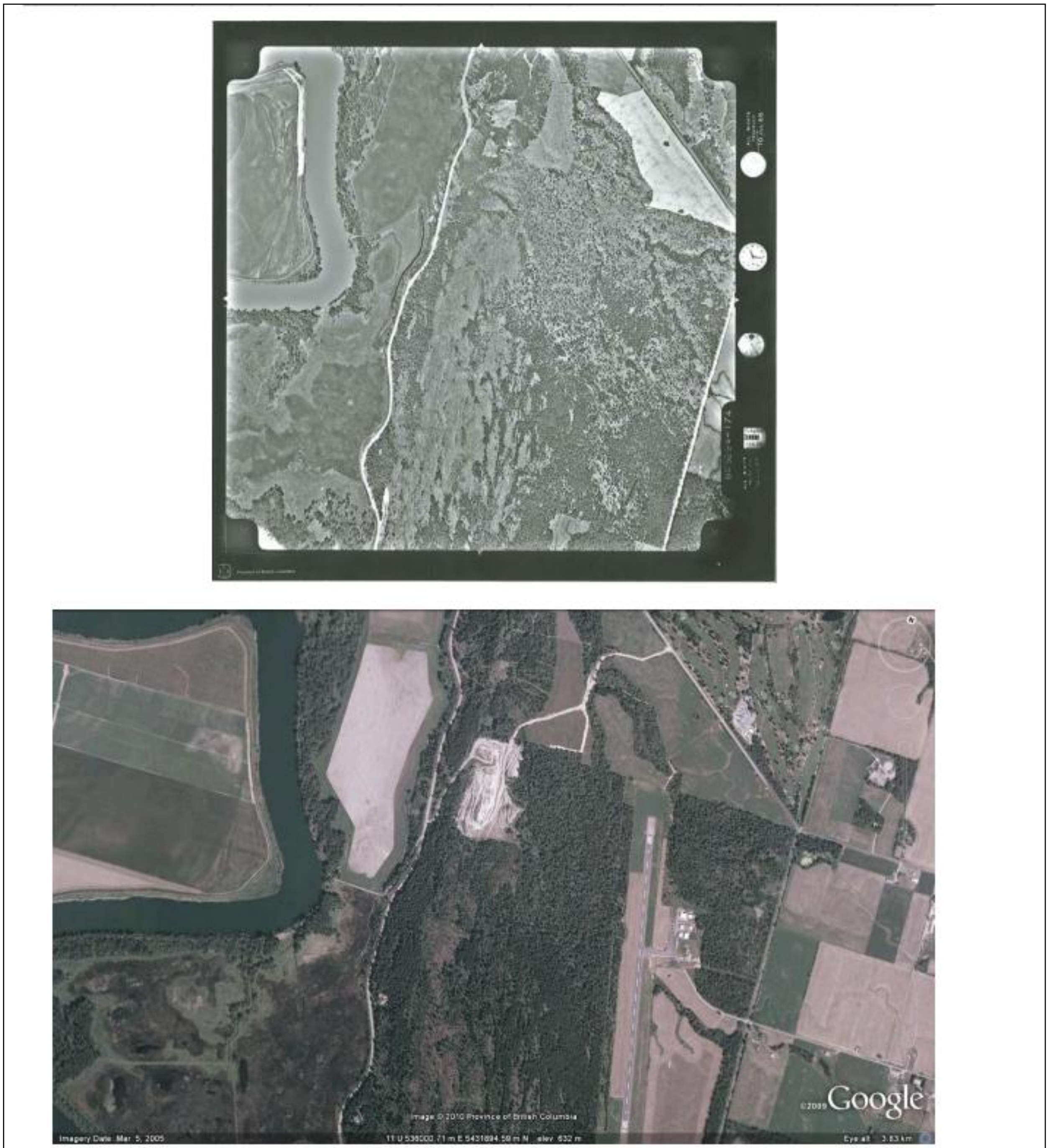


Figure 2. A comparison of historic (1968) and 2006 imagery in the vicinity of Fox Tree Hill near Creston shows significant forest ingrowth on the lower 2006 photo resulting in loss of Gb, Gg and open forest habitat types due to fire suppression.

Both motorized and non-motorized recreation contribute to soil disturbance by exposing bare mineral soil which can lead to the establishment and spread of invasive species. Motorized recreation in areas like Fort Shepherd and the Pend d’Oreille Valley has caused extensive physical damage to Gb habitats through off-road riding and is a threat to the integrity of these ecosystems.

Sulphur dioxide (SO_2) and heavy metal outputs from the Trail smelter have affected plant community composition and ecological processes in the lower Columbia Valley area near Trail causing changes in Gb, Gg and forest ecosystem structure and function. The long term impacts of SO_2 and heavy metals on soils and vegetation in the fume kill area have not been quantified though, mainly due to a lack of data regarding plant community composition prior to the emissions.

5.0 CONSERVATION AND PROTECTION STRATEGIES AND PRACTICES

Conservation and protection of at-risk target ecosystems (Gb brushlands, Gg11 grassland, ICHdw1/102 very dry forest) involves various mechanisms including: inventorying and mapping the distribution of the at-risk ecosystems, provincially ranking the ecosystems as vulnerable or threatened (blue or red-listed) through the B.C. Conservation Data Centre (CDC), legally protecting intact representative areas of the red- and blue-listed ecosystems within designated parks or reserves (and preventing recreational and human use activities in the protected areas that negatively impact these ecosystems), avoiding / minimizing disturbance in all target ecosystems (i.e. transmission line maintenance, recreational activities), regulating development in the vicinity of target ecosystems, monitoring and control of invasive plants on relatively intact sites within the sensitive ecosystems, and restoring degraded sites where feasible. Gb brushlands are currently being ranked by the CDC while the Gg11 grassland and ICHdw1/102 forest are already designated as at-risk (red-listed) ecosystems.

With respect to conserving and protecting Gb brushlands, provincial mapping of the ecosystems in the southern West Kootenay area is now complete and the ranking process through the CDC is underway. This will help provide more detail regarding the locations of the ecosystems of interest and guidance for activities taking place within or adjacent to them. As it has yet to be determined whether or not the ranking will result in red or blue listing of the Gb ecosystems, implications for conservation are unknown at this point.

Due to the extensive impact of invasive species to Gb ecosystems in the region (McKenzie and Hill, 2008), locating remnants of these uncommon and diverse habitats and providing protection via land acquisitions or ecological reserves is an important step for meeting long term conservation goals. A review of data from the West Kootenay Intact Ecosystem Project (McKenzie and Hill, 2008 and 2010) could help determine priority sites. Other Gb ecosystems that were not visited as a part of this project should be evaluated for levels of degradation from invasive plants, and sites with low levels or no impacts from invasive plants should be added to the candidate list for protection.

Identifying risks of activities associated with soil disturbance or physical alteration of habitat within the target ecosystems is a key step to mitigating direct or nearby negative impacts. Mapping of at-risk and other sensitive target ecosystems, avoiding or minimizing disturbance, and appropriate rehabilitation and restoration of disturbed soils are essential steps to help avoid long-term degradation. **Figure 3** shows new road construction within meters of the Gb03 polygon at Kitchener face. If the soil disturbance in this image has not been properly managed and invasive species have become established here, then the integrity of this very diverse native plant community (104 native plant species identified in 2 ecosystem plots) is at risk.

New development activities should not be proposed within the at-risk Gg11 grassland, Gb brushlands, and ICHdw1/102 forest ecosystems. Where construction or maintenance activities are planned within other target ecosystems, proper planning is essential to identify appropriate practices. Avoiding unnecessary disturbance to sensitive sites with shallow soils and thin organic layers should be the primary objective. When disturbance is unavoidable, exposed mineral soil should be immediately revegetated with appropriate native seed mixes.

Figure 3. New road construction within meters of the Gb03 polygon at Kitchener Face. The associated soil disturbance poses serious risks to native plant communities if invasive plants have become established in disturbed areas since construction began in 2020.

There are few locations in the southern West Kootenay where invasive plants have yet to impact Gb ecosystems (McKenzie and Hill, 2008). The sites that remain relatively weed free are remnants of these uncommon habitat types and should be managed to prevent impacts from invasive species in the future. The most effective conservation actions for these areas are to have ongoing monitoring and invasive plant control strategies in place and to regulate development activities that cause soil disturbance in the vicinity of these at-risk ecosystems.

Ecosystem restoration can be a valuable conservation tool for restoring dry open habitats to help maintain representative areas of the target ecosystems. In the absence of invasive plants, prescribed fire can be used to restore and maintain the habitat structures that were once prevalent in pre-fire exclusion times. The habitats were generally more open with productive understories, both in the Gb brushlands and dry low-elevation forest types. Slashing prescriptions can also be developed to emulate fire effects under scenarios where fire is not an option due to the presence of invasive plants or other constraints. Both treatment types increase the resiliency of the target ecosystems by managing fuels in a controlled manner, resulting in less severe impacts to habitat structure in the event of a wildfire. This is accomplished by managing surface and ladder fuels and disrupting horizontal and vertical fuel continuity. There are many areas where ecosystem restoration is occurring in the region as well as many other candidate sites that would benefit from this action.

5.1 Avoiding and Minimizing Site Disturbance in Target Ecosystems

Avoiding Site Disturbance

The overall objective of developing and implementing best management practices is to protect existing values by preventing or mitigating negative impacts during work activities. The highest priority and best practice when working in areas with target ecosystems is to avoid the sensitive habitats if at all possible. Preventing disturbance to vegetation, soils, habitats and associated wildlife in the ecosystems is more desirable than having to revegetate sites and restore habitats and wildlife populations that have been negatively impacted.

In an area where work activities are being planned, it is recommended to conduct an initial risk assessment of the ecosystems in the area. Using air photo interpretation supported by ground inspections if feasible, stratify the area into **habitat types** based on site and vegetation features. Field survey methods used to describe site and vegetation characteristics and classify ecosystems (BEC site associations/site series) and structural stages are provided in the Field Manual for Describing Terrestrial Ecosystems 2nd Edition (B.C. Ministry of Forests and Range and B.C. Ministry of Environment, 2010). A habitat type can include one or more ecosystems. After classifying each habitat type according to ecosystem(s) and structural stage, rate them as to their level of risk to degradation or loss based on sensitivity to disturbance and existing impacts, and then develop a risk assessment map that shows the distribution of the habitat types with associated levels of risk. The habitats that have high sensitivity to disturbance (at-risk ecosystems, other target ecosystems on dry, shallow soil sites), and therefore are at high risk of being degraded by work activities, should be avoided where possible. During planning of activities, avoid locating roads, corridors, equipment storage sites and parking/turn-around areas in sensitive target ecosystems if alternative areas are available. Alternatives include ecosystems with slightly dry (submesic) to average moisture (mesic) site conditions that are typically more common on the landscape, less sensitive to disturbance and invasive plant infestations, and recover more quickly after disturbance.

Minimizing Site Disturbance

If avoiding target ecosystems is not possible, then apply mitigation measures to minimize impacts to any cultural sites, wildlife and associated habitats including species at risk (SAR) habitats and identified wildlife habitat features (WHFs) (BC Min. of Env. and Climate Change Strategy, 2018), vegetation, and soils. By minimizing site disturbance, future costs of rehabilitating degraded sites, controlling the spread of invasive plants, and restoring wildlife habitats will be reduced.

A number of mitigation measures that can be used to minimize site disturbance in the sensitive target ecosystems are described in the Field Manual.

5.1.1 Invasive Plant Management and Monitoring Plan

The target ecosystems are very sensitive to disturbance by invasive plants and have low resiliency to recover after being degraded by invasive species. Prior to accessing an area to carry out work activities, develop and implement an **Invasive Plant Management and Monitoring Plan**. The objectives of a plan are to: 1) assess pre-disturbance (baseline) levels of invasive plants at sites, 2) control the establishment and spread of invasive plant species in the work area, 3) evaluate the effectiveness of invasive plant control treatments, and 4) continue to assess changes in composition, abundance, density and distribution of invasive species in the work area and apply treatments as required throughout an ongoing monitoring and control program.

The plan can include education on preventing the introduction and spread of invasive plants, scheduling of initial and periodic invasive plant surveys, site-specific prescriptions, various control actions (mechanical, chemical, cultural and biocontrol treatments), an effectiveness monitoring program, and adaptive management based on monitoring results. When developing the plan, it is recommended to (a) review any invasive plant management plans that already exist for the area and (b) consult with local land management resource specialists and the Central Kootenay Invasive Species Society (CKISS) https://ckiss.ca/ as they can provide guidance on best management practices and the development of integrated invasive plant management programs. CKISS can also assist with plant I.D., surveying and inventory, control treatments, and developing ongoing monitoring and treatment plans. The Invasive Species Council of BC (ISCBC) https://bcinvasives.ca/ also provides education, information and publications on responsible practices to stop the spread of invasive plants in B.C. Another useful resource for invasive plant management planning is the Invasive Alien Plant Program (IAPP) Reference Guide Part 1 (B.C. Ministry of Forests and Range - Range Branch 2010)[3]. The guide covers prevention, planning of management programs, inventory, treatments and monitoring methods.

Other useful websites to consult when developing the plan are as follows:

- B.C. Government Integrated Pest Management Program: https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/plant-health/integrated-pest-management
- B.C. Government Invasive Plants website https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species/management/plants
- https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species
- B.C. Government InvasivesBC (formerly Invasive Alien Plant Program (IAPP)) https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species/invasivesbc

An important component of invasive plant management in B.C. is early detection and eradication. Rapid response to the early detection of new invasive plant species is a key management strategy. Prevention, eradication, containment, and strategic control are all essential for the management of spreading and established invasive plants. The Central Kootenay Invasive Species Society (CKISS) manages invasive plant species using a prioritized approach. The current CKSS Invasive Plant Priority List as well as definitions for the five priority categories and the management approach for each category are available on the CKISS website at https://ckiss.ca/species/invasive-plant-priority-lists/ .

5.1.1.1 Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is a decision-making process that can be used to manage pests in an effective, economical and environmentally-sound way. Techniques used in Integrated Pest Management programs range from preventative and cultural measures to the use of biological, physical, behavioral and chemical controls. In IPM, one or several measures can be coordinated into a management program to control one target species or an entire pest complex of species. The Integrated Pest Management concept evolved in response to problems caused by over-reliance on chemical pesticides. There are six components to Integrated Pest Management (B.C. Government website, 2022).

[3] https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/invasive-species/iapp-resources/iapp_reference_guide_part_i.pdf

1. Planning and managing agricultural production systems to prevent insects, plant diseases and invasive plants from becoming pests
2. Identifying pests, their natural enemies and damage
3. Monitoring populations of pests and beneficial organisms, pest damage, and environmental conditions
4. Making control decisions based on potential damage, cost of control methods, value of production, and impact on other pests, beneficial organisms and the environment
5. Using strategies that may include a combination of behavioural, biological, chemical, cultural and mechanical methods to reduce pest populations to acceptable levels
6. Evaluating the effects and efficacy of management decisions

Integrated Pest Management can be applied to managing invasive plants within a project area. The six components as modified for invasive plant management programs are listed in the Field Manual.

5.1.1.2 Steps for Controlling Invasive Plants

1. Conduct a survey to determine if invasive plants are already present in the proposed work area, on roads accessing the area, and on specific sites in the work zone. Invasive, nuisance and other non-designated alien plant species that commonly occur in the target ecosystems are listed in **Table 1**.

Table 1: Noxious, Invasive, Nuisance and Other Non-designated Alien (Exotic) Plant Species commonly found in the dry target ecosystems and their B.C. Provincial Weed Designations

Alien (Exotic) Plant Species		B.C. Weed Designation [a]	Tracked under InvasivesBC [b]
Common Name	**Scientific Name**		
Trees/Shrubs			
black locust	*Robina pseudacacia*	Minor Upland Invasive	
Herbs			
black medic	*Medicago lupulina*		
brome, Japanese	*Bromus japonicus*		
brome, meadow	*Bromus commutatus*		
brome, soft	*Bromus hordeaceus*		
burdock, common	*Arctium minus*	Regional Noxious	*
cheatgrass	*Bromus tectorum*	Invasive	*
hare's foot clover	*Trifolium arvense*		
hawkweed, meadow	*Hieracium pilosella*	Nuisance	*
hawkweed, orange (orange-red king devil)	*Hieracium aurantiacum*	Regional Noxious	*
hawkweed, yellow	*Hieracium caespitosum*	Nuisance	*
hawkweed, yellowdevil	*Hieracium glomeratum*	Nuisance	
hoary alyssum	*Berteroa incana*	Regional Noxious (Kootenay-Boundary)	*
hoarycress, heart-podded	*Lepidium (Cardaria) draba*	Regional Noxious	
hound’s-tongue, common	*Cynoglossum officinale*	Provincial Noxious	*

Table 1: Noxious, Invasive, Nuisance and Other Non-designated Alien (Exotic) Plant Species commonly found in the dry target ecosystems and their B.C. Provincial Weed Designations

Alien (Exotic) Plant Species		B.C. Weed Designation [a]	Tracked under InvasivesBC [b]
Common Name	**Scientific Name**		
knapweed, diffuse	*Centaurea diffusa*	Provincial Noxious	*
knapweed, spotted	*Centaurea stoebe ssp. australis*	Provincial Noxious	*
mullein, great	*Verbascum thapsus*	Nuisance	*
North Africa grass (ventenata)	*Ventenata dubia*	Provincial Noxious	*
oxeye daisy	*Leucantheum vulgare*	Regional Noxious	*
plantain, common	*Plantago major*	Nuisance	*
plantain, ribwort	*Plantago lanceolata*	Nuisance	
salsify, yellow (western goatsbeard)	*Tragopogon dubius*	Invasive	*
sheep sorrel	*Rumex acetosella*	Nuisance	*
St. John's-wort, common	*Hypericum perforatum ssp. perforatum*	Invasive	*
stork's bill, common	*Erodium cicutarium*	Weed	
sulphur cinquefoil	*Potentilla recta*	Regional Noxious	*
tansy, common	*Tanacetum vulgare*	Regional Noxious (Central Kootenay)	*
thistle, bull	*Cirsium vulgare*	Invasive	*
thistle, Canada	*Cirsium arvense*	Noxious - Provincial	*
thistle, plumeless	*Carduus acanthoides ssp. acanthoides*	Regional Noxious (Central Kootenay)	
toadflax, Dalmatian	*Linaria dalmatica ssp. dalmatica*	Provincial Noxious	*
toadflax, yellow/common (butter-and-eggs)	*Linaria vulgaris*	Provincial Noxious	*
vetch, hairy	*Vicia villosa var. villosa*		

[a] B.C. Weed Designation taken from BC Inter-Ministry Invasive Species Working Group and Invasive Species Council of BC (ISCBC) (2021), E-Flora BC (2012) and Perzoff (2008)
[b] B.C. Government website (2023) InvasivesBC and E-Flora BC (2012)

2. Identify and map invasive plant species occurrences and concentrated patches in the project area

   - Areas of infestation within the project area can include habitat type units[4] (if mapped) when infestations are widespread, concentrated patches, and point occurrences. Delineate larger invasive plant patches as polygons and small infestations as waypoints using a handheld GPS unit and identify the polygons and point occurrences on a map.

[4] Habitat types are described under "Avoiding site disturbance" at the start of section 5.1

- Conduct the invasive plant survey in accordance with the BC Government's InvasivesBC application[5] and upload data to the InvasivesBC database[6]. For each area of infestation, collect information on site location, site features, size (m^2), and density and distribution pattern for each invasive plant species and other non-native species of concern within the area. Density and distribution codes are included with the InvasivesBC Terrestrial Observation Field Form[7]. The abundance (% cover) of each invasive and other non-native species could also be estimated and recorded. Take photos and record photo comments to document addition information about infestations at selected sites.

3. Treat invasive plants along access roads, ROWs and on other disturbed sites prior to commencing work activities.

4. Eradicate new and/or small infestations and control the spread of larger invasive plant patches using mechanical, chemical, cultural and biological treatment methods based on an integrated pest management approach.

- Mechanical treatments include hand-pulling, digging up, or weed whacking plants before seed set. Hand-pulling and digging are useful for treating small infestations that have a limited number of plants while weed whacking is useful for controlling invasive plants within larger areas.

- Chemical treatments using herbicides is a viable option for controlling larger infestations of noxious and invasive plant species. If persistent herbicides are used, then chemical treatments are also effective at killing seeds thereby reducing the seed banks of invasive species on treated sites.

  - Determining whether or not to use herbicides and which herbicide treatments to use depends on a number of factors including target species, sensitive habitats or native species present, site characteristics, time of year, and site objectives. CKISS can provide the following information to guide decision making about herbicide use (E. Bates, pers. comm., April 25, 2022)
    - How to use an integrated management approach, with herbicides as one part of a larger toolkit to manage invasive plants. CKISS's Operational Framework provides a good explanation of this approach.
    - An explanation on how herbicide use works within the BC and Canadian regulatory environment and where to find the information needed. The Invasive Plant Pest Management Plan (PMP) for the Southern Interior of B.C. PMP for Southern Interior lists the most commonly used herbicides for invasive plants that are permitted for use on Crown lands in our region.
    - A list of experienced herbicide contractors who are licensed for noxious weed applications and who should always be doing the work to ensure that best practices are

[5] InvasivesBC – formerly Invasive Alien Plant Program (IAPP) https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species/invasivesbc
[6] https://invasivesbc.gov.bc.ca/Landing (review "Getting Access to InvasivesBC" in the above link to access the database)
[7] https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/invasive-species/invasivesbc-resources/terrobserv_paper_field_form.pdf

followed and the best chemicals are chosen for the target species and site considerations.
  - How to carefully document any invasive plant surveys or treatments in accordance with provincial protocols and enter data into the provincial database in order to inform regional and provincial management decisions and planning.

- The timing of any herbicide treatments should take into consideration wildlife use, pollinator windows, and cattle grazing in the vicinity of areas proposed for spraying of toxic chemicals. Also, any herbicide treatments on private land would require the approval of the landowner.
- Avoid spraying herbicides around creeks and in riparian areas. Concentrated weed patches that occur beside streams, creeks or seepage areas cannot be treated using herbicide sprays as there is a minimum 10 m pesticide-free zone adjacent to watercourses and wet sites plus a 30 m buffer to prevent herbicide spray from drifting into the pesticide-free zone. Small infestations of invasive weeds located close to creeks and wet areas could be controlled by hand-pulling or digging followed by re-seeding with native species where soil disturbance caused by invasive plant removal is significant. Biological control agents can also be used to treat infestations of some invasive plant species in sensitive riparian areas.

- Cultural treatments – One of the most important cultural treatments to control invasive plants is to plant competing native vegetation to limit the establishment of non-native species (see section 6.1.2 Develop a Revegetation Management Plan). Fertilization and/or irrigation could also be used to favour the growth of the native vegetation. Other invasive plant control practices include proper grazing management, mechanical mowing on selective sites, and prescribed fire.

- Biological Control treatments – Biological control (biocontrol) is another option available for managing invasive plant species that are well established and too widely distributed to be effectively controlled by herbicide treatments. This treatment method has been partially successful in controlling spotted knapweed and St. John's-wort in some parts of BC.

  - A number of biological control agents have been released in the province for controlling **spotted knapweed**, but no single agent has been totally successful on a range of sites. There are two species and two genera that have shown promise in controlling the weed and that are easily collected and redistributed. The moth *Agapeta zoegana* and the large weevil *Cyphocleonus achates* have larvae that feed on the roots of the plants while the larvae and adults of *Larinus* weevils and larvae of *Urophora* flies feed on the seed heads (Biological Control Agents and Host Plants, B.C. Government website, 2022). The moth and the seed-feeding weevils and flies spread by flying and have already spread to all accessible areas in the south West Kootenays. *Cyphocleonus achates* spreads by walking so further distribution of the species can be assisted through collection and release. (C. MacRae, pers. comm., July 23, 2012).

  - Two species of *Chyrsolina* beetles have been used to control **St. John's-wort** in BC. The metallic-coloured beetles have been successful in the past at controlling St. John's-wort in some areas of the Kootenays but have not been very effective as a biocontrol in the Pend d'Oreille Valley (C. MacRae, pers. comm., July 23, 2012). In recent years, St. John's wort has been increasing in abundance in the province (perhaps due to a decline in beetles) and there have been renewed efforts to redistribute the beetles in mixed populations (B.C. Ministry of Forests, 2022).

- There are also biological control agents being used in B.C. to manage **diffuse knapweed, Dalmatian toadflax, yellow toadflax, Canada thistle, plumeless thistle** and **bull thistle**. Studies also continue on another potential biocontrol agent for Dalmatian and yellow toadflax (Biological Control, B.C. Government website, 2022).

- Currently, there are no biological controls available for sulphur cinquefoil, invasive yellow hawkweeds, oxeye daisy, common tansy or hoary cresses. However, all the species except for sulphur cinquefoil are target species that are currently undergoing screening for potential biocontrol agents. Research is continuing on the gall wasp *Aulacidea plosellae* found on **hawkweeds** in Europe, and studies continue on the impact of the agent on the invasive species in B.C. In tests so far, the gall wasp appears to very host specific on the invasive hawkweeds. Studies are also currently being conducted on three biocontrol agents for **oxeye daisy** and to date, two of them look promising. Tests on the root-mining tortricid moth *Dichrorampha aeratana* indicate that the agent appears to be host specific and effective at decreasing the below ground biomass and number of flowers of oxeye daisy plants. Research and testing also continues on the root galling tephritid fly *Oxyna nebulosa*. The fly has been found to decrease flower heads and reduce the height and above-ground biomass of attacked plants. As of 2020, both species were being tested for host-specificity and petitions were being initiated to get approval to release. For **common tansy**, three insects are being tested and to date, two of the species including the stem-mining weevil *Microplontus millefollii* and the shoot and flower-head mining moth *Platyptilia ochrodactyla* are showing a narrow host range. The weevil also caused reduced growth in a preliminary impact experiment. There are two species, including the gall-forming weevil *Ceutorhynchus cardariae* and the seed-feeding weevil *C. turbatus*, that are currently being tested as biocontrol agents for **hoary cresses**. For the gall-forming weevil, supplementary testing for a few non-target plant species has been completed and a release petition was submitted for review in 2020. Host range testing continues for the seed-feeding weevil (Biological Control, B.C. Government website, 2022).

- Further information on biological controls for invasive plants, biocontrol agents and host plants, and target invasive species undergoing screening for biocontrol is available under **Biological Control** on the **Invasive Plants** page of the B.C. Government website (2022). The website provides updated information about ongoing biocontrol research and testing results that could influence future invasive plant management in the target ecosystems. The Central Kootenay Invasive Species Society (CKISS) can also provide information about biological control of invasive plant species.

- Cheatgrass and other annual brome grasses (meadow brome, soft brome and Japanese brome) are often found on dry, open sites and can form dense infestations that negatively impact native plant communities. Sites that become dominated by the introduced annual grasses tend to have a reduction in the numbers and genetic diversity of native plants and animals, reduced biomass production, unpredictable and unreliable forage production, changes in the frequency, intensity and timing of wildfires, increased soil erosion after fires, changes in soil nutrient cycling, and reduced soil moisture availability for native plants. At present, the options available for managing large infestations of cheatgrass and/or other annual brome grasses are complex and challenging. Converting disturbed habitats back to native plant communities would require substantial invasive plant control and revegetation measures.

- **Cheatgrass** is designated as an invasive grass in B.C. and is widely distributed in dry, open habitats. Once established, it is very persistent, and eradication of large infestations is very difficult. Cheatgrass-infested areas are also susceptible to the establishment and proliferation of other invasive plants and non-native annual grasses. Suppression of cheatgrass requires an integrated management approach including physical, biological, chemical and cultural control methods including revegetation of treated sites with desirable native species. The cheatgrass plants and seedbank in infested areas must be depleted to get effective control and that can be a complicated and costly undertaking. Currently, there are no biological controls being used to manage cheatgrass although some research is being done on using fungi and bacteria as biocontrol agents for the species. More information on the methods used to control cheatgrass infestations are described under Management Considerations for *Bromus tectorum* on the Fire Effects Information System (FEIS) website (USDA, 2022). The best management practice for controlling cheatgrass is to identify and eradicate small patches before they expand into large dense infestations.

- Meadow brome, soft brome and Japanese brome are not designated as invasive plants in B.C. **Meadow brome** is considered a noxious invasive plant in some U.S. states. Suppressing large populations of the annual grass would require a similar management approach as for cheatgrass and identification and immediate removal of small patches is also recommended. **Soft brome** is a common non-native grass of dry to mesic, disturbed areas, fields, meadows and open forests. Herbicide spraying shortly after flowering and spring grazing with fall fire are treatments that have been successful in reducing soft brome (USDA, 2022). **Japanese brome** is usually regarded as a noxious invasive plant on rangelands and prairies in the U.S. because it competes with native species for water and nutrients. The species can be reduced through the use of herbicides (USDA, 2022).

- Contact CKISS re: treatment methods and chemical herbicides that can be used to control small infestations of cheatgrass and other annual brome species.

- **North Africa grass** or ventenata is another non-native annual grass that can be confused with cheatgrass. It is a relatively new species in B.C. with a limited extent (including the West Kootenay Region) and is designated as a provincially noxious invasive plant. The species grows in fine-textured soils that are shallow and rocky, and is found in open, disturbed habitats below 1800 m including fields, rangelands, roadsides, railway ROWs, dry forests and riparian corridors. It can invade disturbed grasslands and other open, dry ecosystems where it readily outcompetes most perennial native grass species (B.C. Gov., 2021; Okanagan Invasive Species Online, 2022).

  Seeds of North Africa grass are dispersed by contaminated grass seed mixtures and hay, machinery, vehicles, animals and humans, and viable seeds persist in the soil for at least 3 years. Prevention is the most effective way to limit the spread of the species. Some recommendations to prevent the introduction of the grass are included in Okanagan Invasive Species Online (2022). Treatments of infested areas should be conducted for a minimum of 3 years and include:

  - hand-pulling of small patches, and bagging, removing and disposing of all plants, plant parts and seeds

- mowing prior to seed set and before soils dry out (may require mowing twice a year)
- chemical control

Additional information on specific locations of North Africa grass in the West Kootenays and treatments to control and contain the species is available from CKISS.

5. Use invasive plant control treatments (mechanical, chemical and biocontrol) and cultural management practices in combinations and in the appropriate sequences to reduce the negative impacts of invasive species on native plants and to promote the development of desired plant communities.

6. Continue to stay informed about ongoing invasive plant management research and new treatment options that could be used to control non-native species and restore sites within the target ecosystems in the future.

5.1.1.3 Ongoing Monitoring and Control of Invasive Plants

Set up an ongoing monitoring program to assess the effectiveness of control treatments. Treated areas will likely continue to be re-infested with invasive plants due to the pre-existing seed banks in the soil and/or by seeds spreading from surrounding areas. Steps to take in an ongoing monitoring and control program include the following:

- Assess the status of invasive species (densities and distributions) on recently treated sites and re-apply treatments if necessary.
- Revegetate treated sites with native plants to compete with invasive species (see section 6.1.3 Steps for Revegetation Disturbed Sites).
- Periodically monitor (annually at a minimum) for persistent and new infestations. Re-treat/treat sites and maintain/establish native vegetation as required in subsequent years.
- During maintenance activities along roads and ROWs, continue to adhere to the invasive plant management and monitoring plan.

Ongoing monitoring of treatments, invasive species control, and revegetation of treated sites is highly recommended. The Central Kootenay Invasive Species Society (CKISS) can assist with ongoing monitoring and treatment planning.

6.0 SITE AND ECOSYSTEM RESTORATION

6.1 Site Restoration

When disturbance to sensitive ecosystems cannot be avoided or minimized during work activities, sites with higher levels of disturbance will require rehabilitation and revegetation; two important steps that facilitate site restoration over time.

6.1.1 Rehabilitation of Disturbed Sites

Site rehabilitation is a broad subject and detailed coverage of many of the related topics is beyond the scope of this document and the field manual. The potential steps involved with rehabilitating disturbed sites are described in the following section. Additional information on rehabilitation techniques is provided in the Tools and Techniques section of the Soil Rehabilitation Guidebook (B.C. Ministry of Forests, 1997).

- *Recontour and restore drainage patterns on highly disturbed sites*
  If sites have been highly disturbed by activities such as road building/upgrades/deactivation and excavating (e.g. T/L pole placement, laying pipeline), recontour the areas to re-establish and stabilize natural slopes and restore naturally-occurring drainage patterns. Drainage alterations such as increased surface water flow, interrupted below-ground flow, and restricted drainage result in the diversion of water on slopes that can lead to erosion and slope failure. Ensure that the above- and below-ground drainage patterns are restored and continue to be maintained at reclaimed sites. Measures that could be implemented to restore drainage patterns and prevent erosion prior to revegetating an area are included under “Water” in the Tools and techniques section of the Soil Rehabilitation Guidebook (B.C. Ministry of Forests, 1997).

- *Retention of Topsoil*
  As was briefly discussed previously under “Soils” in the section “Avoiding and Minimizing Site Disturbance in Target Ecosystems”, topsoil could be removed and stored during excavation at a site and redistributed after completing the work to increase the chances of successfully re-establishing vegetation. The topsoil could be stored in piles along the perimeter of the work site and then spread over the disturbed area to a recommended depth of 10-15 cm in preparation for seeding. If topsoil is to be stored for more than 6 months, it is recommended to seed it with native grasses to protect the soil from erosion and to maintain the existing microorganisms and other soil constituents. Guidelines and other points to consider to ensure successful handling of topsoil are included under “Soil” in the Tools and techniques section of the Soil Rehabilitation Guidebook (B.C. Ministry of Forests, 1997).

- *Soil Tillage*
  In rehabilitation work, tillage is used primarily to decompact the soil and re-establish soil porosity allowing plant roots to penetrate deeper into the soil. Decompaction can improve the productivity of a compacted soil by loosening the structure of the upper soil horizons, improving aeration and drainage, and increasing rooting depth. Tillage can be used to decompact extensive areas in a homogenous manner and/or to create favourable microsites for the re-establishment of native vegetation.

  One example of using tillage to both decompact an area and create microsites for enhancing native plant re-establishment is where an excavator is used to roughen up the site and loosen the soils by creating depressions and mounds. Rough and loose site conditions are better than smooth and compact when it comes to re-establishing vegetation. The rough (uneven) ground surfaces and loose soil conditions provide more suitable microsites and better substrates for the germination of native seeds from seed banks and surrounding vegetation and for the survival of seedlings. A “rough and loose” treatment was applied to sites on Teck land located along the access road to the Fort Shepherd Conservancy as an initial step to rehabilitate an area previously disturbed by vehicles and soil compaction. The rough and loose conditions are also more favorable for the establishment of native seed mixes and/or planted nursery stock that could be used to revegetate disturbed areas.

  Important topics to consider when using tillage to prepare sites for revegetation include determining tillage depth, maintaining soil structure after tillage, suitable soil moisture conditions for tillage, and equipment options. More details on these topics are provided under the heading "Tillage" in the Tools and techniques section of the Soil Rehabilitation Guidebook (B.C. Ministry of Forests, 1997).

- *Soil amendments, fertilizers and mulches*[8]

  If a disturbed site had little or no topsoil, or if the topsoil was not retained due to very rocky site conditions or other reasons, the productivity of mineral soils can be improved by adding organic material and nutrients. **Soil amendments** are materials that can be mixed into the soil to restore soil organic matter, long-term nutrient status, and soil structure. Organic materials that could be used as soil amendments include logging residues, topsoil and forest floor material salvaged from nearby construction sites, manure, compost, hay, and straw. As soil amendments are bulky and expensive to transport, local availability is a key factor in determining their suitability for use. It's also important to ensure that any amendments added to soils are not contaminated with non-native plant seeds.

  Chemical **fertilizers** provide an efficient means of improving the short-term nutrient status of soils and are used primarily to enhance the early establishment and growth of vegetation, which will restore soil structure and organic matter content. Repeat applications may be required until the internal nutrient cycle of the site is re-established and can meet the needs of the vegetation. To help determine fertilizer requirements for grasses and forbs on revegetated sites, soil tests can be obtained from commercial laboratories. Important things to consider when applying fertilizer to a site include fertilizer formulations (proportions of N, P, K), application rates, application methods (broadcast spreading, hydroseeding or mixed with soil amendments), timing of application, and reapplication.

  Native grasses respond best to slow-release synthetic or organic fertilizers (e.g. Biosol[9] or an equivalent), and these are preferred for fertilizing soils in cases where native species are seeded. A delayed release bulk fertilizer developed by Reforestation Technologies International (RTi) also works well with seeded grasses, forbs and shrubs[10]. If a fast-release fertilizer is to be used, its formula should be based upon analysis of the existing soil being seeded (Mathews, 2017).

  Transplant fertilizer paks (teabags) can also be used to fertilize tree or shrub seedlings at the time of planting[11]. The biodegradable packets include formulations of N, P, K and other nutrients specially developed for specific plants and sites. The packets can be placed into the planting holes next to the seedling roots to provide a balanced supply of nutrients that is readily available to the plants. The slow-release fertilizer aids in the establishment of fine roots and foliage and helps the seedlings quickly transition from the nursery to the site. The teabags provide nutrients for at least two growing seasons and result in increased survival, more vigorous growth, greater resistance to drought and early frosts, and quicker recovery from animal browsing. Hydration paks are fertilizer paks that also contain moisture-retaining

[8] Information summarized from B.C. Ministry of Forests. 1997. Soil Rehabilitation Guidebook – Tools and techniques. [Online] Available at: https://testwww.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/soilreha/rehab3.htm#soil2
[9] Biosol fact sheet [Online] Available at: https://www.biosol.com/japan/002/index.html
[10] https://www.reforest.com/delayed-release-22-7-11--minors
[11] https://www.reforest.com/teabag-fertilizer; https://www.reforest.com/canada-forestry-products

polymers to assist seedling establishment in times of moisture stress on dry sites. The polymers act as a sponge, absorbing moisture and releasing it back to the seedlings as soils dry out[12].

Fertilizers should only be added to the extent necessary. Native grasses, forbs and shrubs that are well adapted to dry, poor-nutrient soils of target ecosystems should require minimal or no fertilization.

Mulches are materials that can be spread over the soil surface after seeding (and fertilizing) or planting to reduce erosion and support plant establishment by conserving moisture and moderating soil temperatures. There are several types of mulches used in rehabilitation work, including relatively thick layers of organic material, thin layers of mulch primarily applied during hydroseeding, and manufactured mulch mats of various types.

Thick mulches are usually applied to a thickness of 5-10 cm and suitable materials include logging residues (e.g. chipped debris), forest floor material, straw or hay. They will prevent the growth of grass and many weedy species and are often used with planted shrubs and trees on drought-prone sites.

Thin mulches are used to aid in the germination and establishment of grasses and forbs on drought-prone sites, highly erodible soils, unconsolidated (sandy) surface soils, and slopes with southerly or westerly exposures. The most common mulching technique is to apply ground wood fibres mixed with a green dye using a hydraulic seeder with mechanical agitation. The mulch can be applied in combination with seed (and fertilizer) during hydroseeding or as a second pass (hydro-mulching) over the top of seeded areas to protect the seed from desiccation and movement by wind, water or gravity. Hydro-mulching is the recommended method of application so that the seed is in contact with the soil first and then covered by the mulch. A tackifier may also need to be applied to or with lighter mulches to prevent them from blowing or washing away. A thin straw mulch applied by hand or with a straw blower and held in place with a tackifier can also offer excellent soil protection.

Manufactured mulch mats include plastic and fibre matting or netting materials. They are efficient at trapping sediment and biomass and therefore are useful for erosion control, in building soil, improving surface soil conditions, and restoring soil organic matter. Some of the products can also aid in germination and vegetation establishment. Due to their high cost, use of manufactured mats is limited to small, specific areas (e.g. ditch lining) where erosion control is critical.

Additional information on soil amendments, fertilizers and mulches are included in the Tools and Techniques section of the Soil Rehabilitation Guidebook (B.C. Ministry of Forests, 1997).

6.1.2 Develop a Revegetation Management Plan

Some of the important objectives for revegetating sites include increasing slope stability and controlling surface erosion, deterring the establishment and/or spread of invasive and other non-native plant species, maintaining/enhancing biodiversity on the sites, and restoring and providing forage and/or habitat for wildlife including flowers for pollinators. Prior to revegetating any disturbed sites in the work

[12] https://www.reforest.com/hydrationpak16-8-5

area, identify and map all the various sites to be treated and develop a **Revegetation Management Plan** that includes determining rehabilitation objectives for the various sites, best approaches for revegetating sites based on objectives and goals, appropriate native species and seed mixes for use in the target ecosystems, seeding techniques, seeding rates, timing of seeding, species selection and planting densities for nursery stock, and methods for carrying out plant maintenance after planting. If intact ecosystems (reference sites) are available, they can be useful for providing guidance when developing the site revegetation goals. The plan would also include methods for establishing and documenting treatments (including any reseeding/replanting treatments), and steps for setting up a monitoring program.

When developing the plan, review any available results for past/ongoing revegetation trials and monitoring in target ecosystems to determine what treatments have worked or are currently working (e.g. Fortis BC seeded disturbed pole replacement sites along the 14L-17L transmission line corridor between Fort Shepherd and Trail in 2021 and planned to monitor the seeding treatments in 2022 and potentially in subsequent years).

6.1.3 Steps for Revegetating Disturbed Sites

Sites can be revegetated by spreading native seed and/or by planting native grasses and forbs, shrubs, and trees (in target forested ecosystems) as supplements or alternatives to seeding. Revegetate (a) sites previously disturbed and/or impacted by invasive plant infestations (treat invasive species first as part of the Invasive Plant Management and Monitoring Plan) and (b) any newly disturbed sites in the work area. Suggested methods for revegetating disturbed sites are as follows:

- <u>*Revegetate soils immediately after disturbance*</u>
  Revegetate disturbed soils with native plants as soon as possible after work activities are completed to quickly establish ground cover. The vegetation will stabilize the soils, reduce soil erosion and compete with non-native plant species in the area. Bare soils left untreated are very susceptible to colonization and infestations by invasive and other aggressive non-native plant species.

  Locally-sourced native plant materials (seeds, cuttings, nursery-grown seedlings) should be used to revegetate sites as local seeds and plants are best adapted to the environmental conditions in the geographic areas where they are collected. At this time, locally-sourced materials for revegetating and restoring disturbed areas are not available except for very limited amounts that have been collected and grown to seed or plant small experimental sites. To produce enough native plant materials from local sources to supply operational-level revegetation, restoration and enhancement projects in the future, it is necessary to develop a local source protection strategy to collect materials in a sustainable way, create seed banks for storing native seeds, and grow large quantities of the seeds and seedlings at nurseries. The strategy would include standards and guidelines for the conservation of focal plant communities and proper collection techniques to maintain healthy source populations. The activities that would be part of the strategy are listed under "Action # 1: Develop and protect native seed sources for focal plant species" in the South Selkirks-Lower Columbia Conservation Action Forum Summary Report (Kootenay Conservation Program, 2022).

- <u>*Revegetate disturbed soils initially by seeding native grass and forb species*</u>
  Broadcast spreading of grass and forb seeds is the often the quickest and most cost-effective way to revegetate disturbed soils. Using seeds of native species that are well adapted to the dry site conditions of the target ecosystems will likely increase revegetation success and contribute to the

biodiversity and wildlife habitat in the area. The native species that are suitable for revegetating target ecosystems are included in **Table 2**. Seeds of the native species that are commercially available are indicated with an “**X**” , and those that are not have a “*****”. The commercially-available seeds are not derived from local sources in the West Kootenays.

Table 2: Native Grass and Forb/Low Shrub Species Suitable for Revegetating Target Ecosystems in the ICHxw, xwa, dw1, and dm Biogeoclimatic Units

Species Name		Target Ecosystems						
Common	**Scientific**	**Grassland**	**Brushlands**			**Very Dry Forests**	**Dry Forests**	**Dry - Slightly Dry Forests**
		Gg11	**Gb03**	**Gb05**	**Gb06**	**ICHxw, xwa, dw1, dm /102**	**ICHxw, xwa /103**	**ICHdw1/103 ICHxw, xwa /104**
Grasses								
bluebunch wheatgrass	*Pseudoroegneria spicata*	X	X	X		X	X	
Idaho fescue, (rough fescue)	*Festuca idahoensis, (F. campestris)*	X	X			X	X	
junegrass	*Koeleria macrantha*	X	X		X	X	X	
Sandberg's bluegrass	*Poa secunda* ssp. *secunda*	X	X			X	X	
slender wheatgrass	*Elymus trachycaulus* ssp. *trachycaulus*	X	X			X	X	X
hair bentgrass	*Agrostis scabra*	X	X		X	X	X	X
stiff needlegrass	*Achnatherum occidentale ssp. pubescens*	*	*	*	*	*	*	
needle-and-thread grass	*Hesperostipa comata*			X				
Scribner's witchgrass	*Dichanthelium oligosanthes ssp. scribnerianum*			*	*			
porcupinegrass	*Hesperostipa spartea*				*		*	
poverty oatgrass	*Danthonia spicatum*	*	*		*	*	*	*
mountain brome	*Bromus carinatus* var. *marginatus*	*	*				*	*
pinegrass	*Calamagrostis rubescens*		*			*	*	*
western fescue	*Festuca occidentalis*							X
blue wildrye	*Elymus glauca*							X
Forbs/*Low shrubs								
arrowleaf balsamroot	*Balsamorhiza sagittata*	X	X	X		X	X	
brown-eyed Susan	*Gaillardia aristata*	X	X	X				
parsnip-flowered buckwheat	*Eriogonum heracleoides*	X	X	X		X		
selaginella	*Selaginella spp.*	*	*	*		*		
silky lupine	*Lupinus sericea*	X	X	X		X	X	X
golden-aster	*Heterotheca villosa*	*	*	*		*	*	
pink fairies	*Clarkia pulchella*	*	*			*	*	
nodding onion	*Allium cernuum*	*	*			*	*	

Table 2: Native Grass and Forb/Low Shrub Species Suitable for Revegetating Target Ecosystems in the ICHxw, xwa, dw1, and dm Biogeoclimatic Units

Species Name		**Target Ecosystems**						
Common	**Scientific**	**Grassland**	**Brushlands**			**Very Dry Forests**	**Dry Forests**	**Dry - Slightly Dry Forests**
		Gg11	**Gb03**	**Gb05**	**Gb06**	**ICHxw, xwa, dw1, dm /102**	**ICHxw, xwa /103**	**ICHdw1/103 ICHxw, xwa /104**
Forbs/*Low shrubs (continued)								
thread-leaved phacelia	*Phacelia linearis*	*	*	*		*	*	
nine-leaved desert-parsley	*Lomatium triternatum*	*	*			*	*	
fern-leaved desert-parsley	*Lomatium dissectum*	*	*			*	*	
yarrow	*Achillea millefolium*	**X**	**X**	**X**		**X**	**X**	**X**
paintbrush	*Castilleja* spp.	*	*			*	*	
Ross's sedge	*Carex rossii*	*	*	*		*	*	*
northwestern sedge	*Carex concinnoides*		*			*	*	*
spreading dogbane	*Apocynum androsaemifolium*			*	*		*	*
*shrubby penstemon	*Penstemon fruticosus*	**X**	**X**			**X**		
round-leaved alumroot	*Heuchera cylindrica*	*	*			*	*	
lanced-leaved stonecrop	*Sedum lanceolatum*	*	*			*	*	
showy daisy	*Erigeron speciosus*	*	*				*	*
*kinnikinnick	*Arctostaphylos uva-ursi*	*	*		*	*	*	*
showy pussytoes	*Antennaria pulcherrima ssp. pulcherrima*		*					
silverleaf phacelia	*Phacelia hastata*		*	*		*	*	
Scouler's hawkweed	*Hieracium scouleri*					*	*	*
wild strawberry	*Fragaria virginiana*						*	*
wood strawberry	*Fragaria vesca*						*	*
rosy pussytoes	*Antennaria rosea*						*	*
Howell's pussytoes, (field pussytoes)	*Antennaria howellii ssp. howellii, (A. neglecta)*						*	*
pussytoes	*Antennaria spp.*						*	*
white hawkweed	*Hieracium albiflorum*							*
showy aster	*Eurybia conspicua*							*
fireweed	*Chamaenerion angustifolium*							**X**
heart-leaved arnica	*Arnica cordifolia*							*
pearly everlasting	*Anaphalis margaritacea*							**X**
western Canada goldenrod	*Solidago lepida*							**X**

X = seed commercially available, * = seed not commercially available

yellow highlight = nursery stock available

Where it is important to quickly establish ground cover after disturbance and locally-sourced native plant seed is not available, the next best option is to use native seeds collected from non-local sources to revegetate sites. Although less well-adapted to germinating and growing on sites in a different geographical area, the native seeds and plants have evolved under similar edaphic and climatic conditions and are a better option than using seeds of non-native species. The non-native grass and forb species that are often used in reclamation seed mixes can take over sites to the exclusion of native species, reduce native plant diversity and habitat, and delay or prevent natural succession. They can also spread into other habitats where they may outcompete native species and degrade ecosystems. Therefore, seeding areas with native plant seeds derived from non-local sources is the recommended option until locally-sourced seeds can be sustainably collected and produced in sufficient quantities to supply the needs for revegetating, restoring and enhancing sites in the target ecosystems.

Based on native species suitability and commercially-available seed (Table 2), an interior native dryland seed mix was developed for revegetating sites in a number of the target ecosystems. The trial mix includes seeds of the native grass species bluebunch wheatgrass, Idaho fescue, junegrass, Sandberg’s bluegrass, slender wheatgrass and hair bentgrass and is available from Premier Pacific Seeds in Surrey, B.C. or DLF Pickseed Canada. The composition of the seed mix is shown in **Table 3**. Until locally-sourced native seeds are available, the interior native dryland mix (with additions of native forb seeds) could be used as an interim option to revegetate areas of disturbed soils in the Gg11 grassland, the Gb03 brushland, the very dry (102) forest site series, and the dry (ICHxw, xwa/103) forest ecosystems.

Table 3 Interior Native Dryland Seed Mix

Common Name	Scientific Name	% by Weight	Seeds/lb.	% by Seed Count
hair bentgrass (ticklegrass)	*Agrostis scabra*	2	4,000,000	22.3
slender wheatgrass	*Elymus trachycaulus*	43	145,000	17.4
junegrass	*Koeleria macrantha*	3	2,000,000	16.8
Sandberg's bluegrass	*Poa secunda*	6	925,000	15.5
bluebunch wheatgrass	*Pseudoroegneria spicata*	35	145,000	14.2
Idaho fescue	*Festuca idahoensis*	11	450,000	13.8
Totals		**100**	**358,100**	**100**

The interior native dryland seed mix could also be modified for use in the Gb05 brushland community by increasing the proportions of bluebunch wheatgrass, junegrass and Sandberg’s bluegrass seeds, adding seeds of needle-and-thread grass and native forbs, and eliminating seeds of Idaho fescue, slender wheatgrass and hair bentgrass that are uncommon in this ecosystem.

Seeds for some of the native grass species suitable for revegetating disturbed soils in the Gb06 ecosystem are also currently unavailable and would need to be collected from local areas and grown in commercial quantities at a nursery. Poverty oatgrass, stiff needlegrass, porcupinegrass and Scribner’s witchgrass are suitable for revegetating disturbed Gb06 sites. Seeds of those species could be combined with junegrass and hair bentgrass and some native forb seeds to create a custom Gb06 brushland native seed mix. Stiff needlegrass and poverty oatgrass seeds are also suitable for including in the interior native dryland mix used to revegetate sites in most of the other target ecosystems (see Table 2 above).

For revegetating disturbed sites in the dry to slightly dry forests of the ICHdw1/103 and ICHxw, xwa/104 ecosystems, a custom native seed mix could include slender wheatgrass, hair bentgrass, poverty oatgrass, western fescue, and blue wildrye as well as some appropriate native forbs.

Seeds of native forb species should be added to the native grass mixes to enhance species diversity and provide plants for pollinators when revegetating sites in the target ecosystems. Both grass and forb species are necessary to restore and maintain ecosystem integrity. Seeds (from non-local sources) for the native forbs arrowleaf balsamroot, brown-eyed Susan, parsnip-flowered buckwheat, silky lupine, yarrow and the low shrub species shrubby penstemon are also commercially available. Seeds of any or all of those species could be added to the interior native dryland mix for revegetating sites in the non-forested Gg11, Gb03 and Gb05 ecosystems.

For the target forested ecosystems, yarrow and silky lupine are suitable species to include in the custom native grass mixes for all sites. Seeds of arrowleaf balsamroot, parsnip-flowered buckwheat, and shrubby penstemon could also be added to the interior native dryland mix for very dry (102) forests, and arrowleaf balsamroot seeds could be added to the same mix for use in the dry (103) forests. For revegetating sites in the dry-slightly dry forest ecosystems, commercially-available seeds of fireweed, pearly everlasting and western Canada goldenrod could also be added to the custom native grass mix described above.

Native forb seed could be added to the interior native dryland mix by initially reducing the percentages of seeds for hair bentgrass and slender wheatgrass. If higher forb cover is desired on a treated site based on initial monitoring results (see Monitoring Seeding Treatments in section 6.1.4 below), then more forb seed could be added by reducing the percentages of junegrass and Sandberg's bluegrass seeds as well as further reducing the proportions of hair bentgrass and slender wheatgrass.

Cover crops provide quick ground cover to slow erosion and compete with weeds as the slower growing species in the seed mix become established. They also add organic matter to the soil, and cover crops that are native species can increase species diversity on revegetated sites. The native forbs golden-aster and pink fairies could be used as cover crops when revegetating grassland (Gg11), brushland (Gb03, Gb05) and dry (102, 103) forest sites (V. Huff, pers. comm., Oct 14, 2022) Seeds for those species are not commercially available, so they would have to be specially harvested from local areas and produced in larger quantities by growing the plants at a nursery. Fireweed is an early seral species that could serve as a cover crop when revegetating disturbed sites within dry to slightly dry forests of the ICHdw1/103 and ICHxw, xwa/104 ecosystems. It is also an important species for pollinators.

Native grass and forb seeds derived from sources located outside the West Kootenays are commercially available from Premier Pacific Seeds https://premierpacificseeds.ca/products/bc-native-species/ in Surrey, Sagebrush Nursery https://sagebrushnursery.com/seed-sales in Oliver, and DLF Pickseed Canada https://www.dlfpickseed.ca/native-seed/common-names-3 with western Canada offices in Dawson Creek and Edmonton, Alberta. When ordering seed from commercial suppliers, be sure to review Certificates of Seed Analysis prior to purchasing to identify any contamination by non-native plant seeds and ensure that the composition and quality of the seed mixes are appropriate. Suppliers do not provide the certificates unless requested by the buyer. Information about Certificates of Analysis can be found in the pamphlet published by B.C. Ministry of Transportation and Infrastructure (2023). Kinseed http://www.kinseed.ca/seeds/ located in Nelson sells small quantities of locally-sourced seed for some of the other native forb species listed in Table 2. Some of those species could also be included in native seed mixes used to revegetate small areas of disturbance within target ecosystems.

The suggested custom native seed mixes described above should be created using locally-sourced seeds as soon as sufficient quantities become available.

There are a number of other native graminoid (grass, sedge, rush) and forbs species not included in Table 2 that grow in the target ecosystems, some of which could also be considered for revegetating and restoring disturbed sites.

Seeding Techniques, Seeding Densities, and Timing of Seeding

- Seeding Techniques

  Sites can be seeded by using a seed drill, broadcast seeding (dry or wet), or hydroseeding.

  The **seed drill** is a device used to position seeds in the ground and cover them with soil. It is typically used in agriculture to sow seeds for crops but can also be used in reclamation and rehabilitation work. The drill is usually towed behind a tractor. It evenly distributes the seeds, plants them at the desired rate (density), and buries them at a specified depth. Covering the seeds ensures good seed to soil contact and improves germination rates resulting in fewer seeds being wasted and less time and effort used to establish grass and/or forb cover. Burying the seeds also protects them from being eaten by birds and animals. Drilling depths (~ 0.5 – 1.25 cm) are determined by the recommended depths for the species mix being seeded (Mathews, 2017). Drill seeding is the most efficient and economical way to sow seeds on larger reclamation or rehabilitation sites with gently sloping, smooth terrain, such as might occur at a mine reclamation site or along parts of a highway or pipeline corridor. The method would not be cost-effective for revegetating small areas and is not practical for seeding sites on steeper slopes and/or rough, uneven ground.

  The **dry broadcast seeding** method includes spreading dry seeds manually, or with motor-driven cyclone seeders, air blowers, and helicopters. Broadcast seeding by manual methods involves spreading seeds on the ground by hand or using a calibrated spreading device to achieve a more even seed distribution. Manual spreading devices include push (drop or cyclone) spreaders on wheels or hand-crank, rotary type “belly grinder” spreaders, some of which can be chest mounted. The push-type spreaders are suitable for seeding on smooth, even terrain while the hand-held seeders are better for applying seed on uneven ground. With a spreading device, it’s possible to seed a hectare in an hour (B.C. Min. of Forests, 1997). Hand seeding requires more physical effort and larger amounts of seed compared to the seed drill method due to lower germination rates. Germination is reduced as some of the seed on the surface can dry out from sun exposure, blow away, be washed away, and/or be eaten by insect, birds and small mammals. Although sowing larger amounts of seeds is more expensive, hand broadcast seeding is more practical and cost-effective for seeding smaller areas (up to a few hectares in size), including areas that are difficult to access. Raking seeded areas to lightly scarify the seeds and improve seed to soil contact can improve broadcast seeding results (Dobb and Burton, 2013).

Motor-driven cyclone seeders increase the speed of broadcast seeding compared to manual methods. They are usually mounted on the back of a vehicle or pulled behind. Air blowers use an air compressor to blow seed up to a distance of 10 m. They require vehicle transport, so are best suited for roadside seeding. A helicopter can be used to spread seed on gentle to moderate slopes using a spreader bucket slung from the machine. This method is useful for seeding areas that are not accessible by roads.

With respect to broadcast seed being lost to birds and animals, wild turkeys are a concern in the Fort Shepherd Conservation area south of Trail. The non-native species is abundant in the area and attracted to reclamation seed spread on the ground. The extent of seed loss due to the birds is currently unknown. One solution to deter wild turkeys from eating the native seed is to fence off seeded areas in such a way that the birds can't access the sites. For example, a small pollinator garden was recently established in the Fort Shepherd area and it was fenced off using orange, plastic-mesh fencing. The seeded site was protected by erecting the fence around a long, narrow rectangular-shaped area that the turkeys would not fly into. (V. Huff, pers. comm., Oct 14, 2021). Another potential option for protecting seeded areas is hydro-mulching, the process of covering seeds with a thin layer of mulch sprayed on the ground using hydroseeding equipment (see below). Insects, smaller bird species, rodents and other small mammals may also eat seeds spread using the dry broadcast seeding method.

The **wet broadcast seeding** method involves mixing grass and forb seeds with water and immediately spraying the water and seed on the area being treated. The advantages of this method over dry broadcast seeding are that seeds can be carried further by the water jet, larger areas can be seeded more quickly, better seed dispersal is possible, and seed germination is accelerated and enhanced. The method is useful for revegetating areas with limited access and is also highly effective at providing temporary erosion control on disturbed sites where immediate surface erosion control is required (B.C. Min. of Forests, 1997). It is not a substitute for hydroseeding as the method does not apply a tackifier to bond the seed to the soil. This method requires a source of water and is not suitable for use on steep slopes.

Hydroseeding (hydraulic seeding) spreads seeds in a slurry with a binding agent (tackifier) that binds the seeds to the ground. The slurry may or may not include mulch. This method of spreading seed has several advantages over the seed drill and broadcast seeding methods. In contrast to the other seeding methods, hydroseeding can be used to spread seeds on steep slopes as the binding agent tacks the seeds to the soil. The tackifier minimizes seed loss due to wind, water and wildlife and also provides some temporary erosion protection by holding surface soil particles in place. Mulch can be added to the mix to retain moisture, thereby reducing desiccation of the seeds and enhancing seed germination. Seeds can be evenly distributed on a site through the spraying of the slurry and fertilizers can also be added to the mix.

This seeding method can be ground-based or conducted using a helicopter. With ground-based hydroseeding, truck-mounted equipment (mixing tank with mechanical or hydraulic agitation and volume pump) is used to apply the slurry from roads. The mixture can be applied up to a distance of 100 m downhill when a fire hose is used for spraying. A spreader bucket slung from a helicopter can be used to hydroseed areas that are not accessible by roads.

The main disadvantage of hydroseeding is the cost. It is much more expensive than the seed drill method or broadcast seeding as there are the additional costs for the mulch, tackifier, special equipment and truck/helicopter use. The process also requires access to a water source for the slurry. Although seed germination is improved by adding mulch that retains moisture, if the mulch is applied with the seed, there can be poor seed-soil contact resulting in seedling mortality after germination. Therefore, when seed and mulch are applied together, higher seeding rates are recommended to meet target seedling densities (Tannis et al, 2016). As an alternative, mulch could be applied after seeding (hydro-mulching) to improve seed-soil contact, but that increases the cost of the operation.

Terrasol Environmental Inc. does hydroseeding work in the West Kootenays and has an office in Castlegar. The company completed a hydroseeding project along the 71 transmission line in the Pend d'Oreille Valley for Fortis BC a few years ago (A. Brooks, pers. comm., Oct 27, 2021). Interior Reforestation Co. Ltd based out of Cranbrook and Instant Green Hydroseeding out of Penticton also offer hydroseeding services in the West Kootenay area.

- Seeding Densities (Rates)

  Seeding rates for seed mixes depend on the species in the mixes, seeding method and the reclamation objectives for the site. Dry broadcast seeding densities appropriate for dry sites in the interior of B.C. area range from ~ 550 seed/m^2 (~50 seeds/ft^2) to ~1500 seeds/m^2 (~140 seeds/ft^2) based on information from several sources (N. Wall, pers. comm., 2022, Mathews, 2017, Tannis et al, 2016, B.C. Min. of Forests, 1997). The rates are usually determined for pure live seed (PLS)[13]. For bulk seed purchased at a commercial supplier, purity is usually > 90% and germination rates are often as high, although they can be lower depending on the age of the seed (N. Wall, pers. comm, April 28, 2022). Ranges for seeding rates are provided to accommodate for variations in site conditions. For example, the higher rates could be used on sites with poor soil or seedbed conditions or where more vegetation is desired to control erosion. Based on the assumption that a rate of 10 kg/ha corresponds to a seed density of ~350 - 450 PLS/m^2 for dryland seed mixes (N. Wall, pers. comm, 2022, Mathews, 2017), the following rates are suggested for the different seeding methods.

  Seed drill method – This is the most efficient way to sow seed and therefore it requires lower seeding rates compared to dry broadcast seeding. Several sources recommend seed density targets of 400 - 700 PLS/m^2 (~37 - 65 seeds/ft^2) for this method (Tannis et al, 2016, Mathews, 2017). Based on that information, recommended rates for drill seeding range from 12 kg/ha to provide a minimum of 400 seeds/m^2 to 20 kg/ha to achieve a target of at least 700 seeds/m^2.

  Broadcast seeding – The target seeding densities for **dry broadcast seeding** on dry sites suggested by Premier Pacific Seeds range from 800 seeds/m^2 (~75 seeds/ft^2) to 1100 seeds/m^2 (~100 seeds/ft^2) based on bulk seed (N. Wall, pers. comm., April 28, 2022). To achieve those minimum targets based on pure live seed (PLS), the seeding rates would need to be ~ 25 kg/ha to ~32 kg/ha. However, several sources recommend that broadcast seeding rates should be double that of drill seeding rates. (Mathews, 2017, Tannis et al, 2016). Following that

[13] % pure live seed (PLS) = germination rate (%) X purity (100%-% inert material) for each species

recommendation, the dry broadcast seeding rates for pure live seed could range from 25 kg/ha to provide a minimum of 800 seeds/m^2 (~75 seeds/ft^2) to 40 kg/ha, which would provide at least 1400 seeds/m^2 (~130 seeds/ft^2). The seed could initially be spread at the lower rate and increased to the higher density if necessary to achieve adequate vegetation cover on a site. For applying bulk seed, the rates used for PLS could be increased by 10-30% depending on the purity and germination rates of the seeds in the mix. In Appendix 2 of the Soil Rehabilitation Guidebook (B.C. Min. of Forests, 1997), the seeding rates for the **wet broadcast seeding** method were recommended to be 1.33 times higher than the dry seeding rates to compensate for some seed damage during mixing and application as well as some spillage during the operation. That corresponds to rates of 35 to 55 kg/ha.

Hydroseeding – Tannis et al (2016) recommends that the seeding rates for hydroseeding be 1.5 times the dry broadcast seeding rates which is equivalent to 3 times the drill seeding rates. Appendix 2 of the Soil Rehabilitation Guidebook (B.C. Ministry of Forests, 1997) recommends that hydroseeding rates be approximately 3 times higher than dry broadcast seeding rates, although the guidebook recommends lower dry seeding rates than other sources. Based on those guidelines, the rates could range from 40 kg/ha for a minimum density of 1400 seeds/m^2 (~130 seeds/ft^2) to 60 kg/ha to achieve a target of ~2100 seeds/m^2 (~200 seeds/ft^2). Seeding rates are higher for hydroseeding to compensate for spillage and increased seed damage due to mechanical agitation and application, as well as to ensure success of the expensive treatment. The higher rate (60 kg/ha) is appropriate for helicopter hydroseeding to also compensate for loss of seed due to wind drift. Additional information on hydroseeding and the other seeding methods is available in the Soil Rehabilitation Guidebook – Appendix 2.

- Timing of Seeding

  The best time for seeding is immediately after disturbance if climatic conditions are favourable. Other things to consider with respect to timing are soil moisture availability for germination and seedling establishment, and potential seed loss due to animals if broadcast seeding. For the dry target ecosystems, early spring (late March to May) is the best time for seeding as the seeds can germinate quickly and grow during the moist, cooler part of the growing season. Avoid seeding in periods of dry weather and drought conditions between mid-July and mid-September when seeds can dry out due to lack of moisture. Seeds could be sowed again in the late summer to early fall depending on the conditions. If there is enough moisture available to get a strong germination of seeds, the grasses and forbs could grow large enough to effectively overwinter. Seeds could also be sowed in the late fall, but some seeds would likely be lost over the winter. The seeding rates could be increased by 1.5 times to compensate for the overwinter loss (Tannis et al, 2016). Also, some seeds may require overwintering to break the built-in survival mechanism of dormancy and would germinate better in the spring after a fall sowing.

  The amount of seed lost to birds and other small animals at different broadcast seeding times would depend on the geographic location of the reclamation area, the target ecosystem and the wildlife species present in the area. Monitoring of seeding treatments may help to determine seed losses due to wildlife during spring, early fall or late fall seeding times. In the Fort Shepherd area, it is currently unknown how any seed loss due to wild turkeys corresponds to the timing of broadcast seeding. In 2021, Fortis BC conducted seeding treatments at transmission pole replacement sites along the 14L-17L transmission line corridor between Fort Shepherd and Trail and were planning to monitor the treatments in 2022 and potentially in subsequent years. The monitoring results may indicate if seeds were being eaten by the turkeys and if so, at which seeding time the loss of seeds was highest.

- Post-seeding Treatment
  A slurry of mulch and a binding agent (tackifier) could be applied to a site immediately after seeding. The thin layer of mulch sticks to the soil and can reduce erosion, minimize seed loss due to wind, water, and wildlife, and support germination and seedling establishment by conserving moisture and moderating soil temperatures. The treatment is similar to hydroseeding (see above under "Seeding Techniques") but without the seed.

  More information on revegetation techniques used for grass and forb seeding can be found in Appendix 2 of the Soil Rehabilitation Guidebook (B.C. Ministry of Forests, 1997.)

- Documentation of Seeding Treatments
  Information that could be recorded when initiating a seeding treatment is included in the Field Manual.

- *Revegetate disturbed sites using native grass and forb seedlings*
  Small areas of disturbance and/or areas that are difficult to revegetate using a seed mix can also be revegetated by planting grass and forb seedlings grown in a plant nursery. This treatment would be more expensive than applying a seed mix to sites, but seedlings can be planted at much lower densities than seeding rates, and planting nursery stock may result in better establishment and faster growth of the desired plants. Planting seedlings can also enhance the establishment of species that might not establish well from seed (e.g. bluebunch wheatgrass, silky lupine) and facilitate achieving a species composition on the revegetated site similar to that of the target ecosystem. A number of the grass and forb species suitable for revegetating disturbed sites in the target ecosystems are available as nursery stock. Those species are highlighted in yellow in **Table 2**. Most of the species are available at Nupqu Native Plant Nursery https://nupqu.com/native-plants-inventory/ on St. Mary's Reserve near Cranbrook. The nursery is also willing to grow other herbaceous species not on their inventory list. Native grasses and forbs are also available at Sagebrush Nursery https://sagebrushnursery.com/ in Oliver and Bron & Sons Nursery Co. https://www.bronandsons.com/info/native-plant-list-new.html in Grand Forks.

  The commercially-available seedlings are currently being grown from seeds sourced outside the West Kootenays. Planting these seedlings provides an interim treatment option until the native plant seedlings can be grown from locally-sourced seeds.

  - Native Grass/Forb Seedling Planting Densities
    Planting densities for native grass and forb seedlings depend on the target ecosystems, site conditions, and the native species being planted. Very dry and/or poor-nutrient sites will support fewer stems per unit area than sites with better moisture and/or nutrient availability. Spacing is also dependent on the size and growth habits of different species. Plants can also be planted at higher densities to compete with invasive plants in areas that are susceptible to infestations. One source recommends a planting density for native grasses of 10-15 plants/m^2 (~0.3-0.25 m spacing between plants) and a density of 5-9 plants/m^2 (~0.5-0.3 m spacing) for native forbs. (Smreciu et al, 2002). Another source suggests spacing native herbaceous plants 0.3-1 m (1-3 feet) apart (King County, Washington, 2022). A spacing of 1 m between plants corresponds to a density of 1 plant/m^2. Native grass and forb seedlings could also be planted in

denser patches or clusters (with reduced spacing between plants) to take advantage of favourable microsites and planted with lower densities (wider spacing) in areas between the microsites (see cluster planting under shrub planting densities (p. 45) below).

- Timing of Planting
  Native grass and forb seedlings have the best chance of surviving if transplanted when they are still dormant in the spring so that the root systems have time to grow and establish during the growing season. All transplants should be hardened-off (kept cold and relatively dry) prior to planting out at revegetation sites (Smreciu et al, 2002).

- Species Composition
  Ranges of abundance (% cover) values for grass and forb species that can occur in target ecosystems are shown in **Table 4**. The ranges can be used as guidelines for determining the appropriate composition (% covers and proportions) of native grass/forb species in treatment areas. They are based on information presented in the vegetation tables and descriptions for the target ecosystems included in the ecosystem field guide by MacKillop and Ehman (2016).

- Seedling care/maintenance
  Native grass/forb seedlings may require some care and maintenance before they become established. Soil nutrient levels could be improved on poor-nutrient sites to aid in plant establishment. A slow-release synthetic or organic bulk fertilizer applied to the site prior to planting works well to enhance the growth of native grasses and forbs (see Soil amendments, fertilizers and mulches in section 6.1.1).

  Repeat applications of fast-release chemical fertilizers could also be used to enhance growth rates, thereby improving soil structure through root growth and soil nutrient levels through organic litter accumulation. (Section 7.2 in B.C. Ministry of Forests, Lands and Natural Resource Operations, 2012).

  The native species planted should be well-adapted to growing on dry sites. However, in periods of drought, the plants may require supplemental watering during the first growing season, and for up to three growing seasons if drought conditions persist (Kipp and Calloway 2002 in B.C. MOFLNRO, 2012). Hydration paks can also be added during planting to provide moisture to seedlings during times of moisture stress. They are fertilizer paks that also contain moisture-retaining polymers that absorb moisture when available and release it back to the seedlings as needed (see section 6.1.1 as above).

  As a complement to supplemental watering and/or using hydration paks, mulch can be placed around new seedlings to assist with soil moisture retention. Mulching can also be a stand along treatment and provides the added benefits of invasive plant suppression, frost protection, moderation of soil temperature, and protection of the soil from erosion. Ensure that materials used for mulching are not contaminated with non-native plant seeds.

  Treat invasive plants on the site prior to planting. Monitor sites regularly and early in the growing season to detect any new occurrences of invasive plants and treat/retreat before any new infestations develop. Also, treat invasive plants in surrounding areas to prevent the spread of new seeds to the site. Manage for healthy native plant seedlings that can out-compete invasive plants (Dorner 2002 in B.C. MOFLNRO, 2012).

Table 4: Guidelines for Herb Community Species Composition (abundance (% cover) of native grass and forb/low shrub species) on Revegetated Sites within Target Ecosystems

Species Name		Target Ecosystems						
Common	Scientific	Grassland	Brushlands			Very Dry Forests	Dry Forests	Dry - Slightly Dry Forests
		Gg11	Gb03	Gb05	Gb06	ICHxw, xwa, dw1, dm / 102	ICHxw, xwa / 103	ICHdw1/103 ICHxw, xwa /104
Grasses		**Abundance (% Cover) Categories [a]**						
bluebunch wheatgrass	*Pseudoroegneria spicata*	xx - xxxx	xx - xxxx	x - xxxx	x	x – xxxx [b]	xx - xxxx	x - xx
California brome	*Bromus carinatus* var. *carinatus*	x - xx	x - xx				x - xx	x - xx
Idaho fescue, (rough fescue)	*Festuca idahoensis, (F. campestris)*	x - xxx	x - xxx			x – xxx [b]	x - xxx	
junegrass	*Koeleria macrantha*	x - xxx	x - xx	x	x - xx	x - xx	x - xxx	x
Sandberg's bluegrass	*Poa secunda ssp. secunda*	x - xx	x	x		x	x	
slender wheatgrass [c]	*Elymus trachycaulus ssp. trachycaulus*	x - xxxx	x - xxx			x - xxx	x	x - xxx
hair bentgrass	*Agrostis scabra*	x - xx	x		x - xx	x - xx	x	
stiff needlegrass	*Achnatherum occidentale ssp. pubescens*	x - xx	x - xxx	x - xx	x - xxx	x - xx	x - xx	x
needle-and-thread grass	*Hesperostipa comata*			x - xxxx				
Scribner's witchgrass [d]	*Dichanthelium oligosanthes ssp. scribnerianum*	x	x	x - xxxx	x - xx	x	x	
porcupinegrass [d]	*Hesperostipa spartea*				x - xx		x - xx	
poverty oatgrass	*Danthonia spicatum*	x - xxxx	x - xxxx	x	xxx - xxxx	x - xxx	x - xxx	x - xxx
pinegrass	*Calamagrostis rubescens*	x	x - xxx			x – xxxx [b]	xx - xxxx	xx- xxxx
western fescue	*Festuca occidentalis*					x	x	x - xx
blue wildrye	*Elymus glauca*						x	x -xxx
Forbs/*Low shrubs		**Abundance (% Cover) Categories [a]**						
arrow-leaved balsamroot	*Balsamorhiza sagittata*	x - xxxx	x - xx	x - xxx		x - xxx	x - xxx	
brown-eyed Susan	*Gaillardia aristata*	x - xx	x	x				
parsnip-flowered buckwheat	*Eriogonum heracleoides*	x - xx	x - xx	x - xxx		x	x	

Table 4: Guidelines for Herb Community Species Composition (abundance (% cover) of native grass and forb/low shrub species) on Revegetated Sites within Target Ecosystems

Species Name		Target Ecosystems						
Common	Scientific	Grassland	Brushlands			Very Dry Forests	Dry Forests	Dry - Slightly Dry Forests
		Gg11	Gb03	Gb05	Gb06	ICHxw, xwa, dw1, dm / 102	ICHxw, xwa / 103	ICHdw1/103 ICHxw, xwa /104
Forbs/*Low shrubs (continued)		**Abundance (% Cover) Categories [a]**						
selaginella	*Selaginella spp.*	x - xxxx	x - xxx	x - xxx		x - xxxx	x - xxx	x
silky lupine	*Lupinus sericea*	x - xxx	x - xx	x		x - xxx	x - xxx	x - xxx
western groundsel	*Senecio integerrimus* var. *exaltatus*	x - xx	x - xxx				x - xx	x - xx
golden-aster [e]	*Heterotheca villosa*	x	x	x		x	x	
pink fairies [e]	*Clarkia pulchella*	x	x			x	x	
nodding onion	*Allium cernuum*	x	x			x - xx	x - xx	
thread-leaved phacelia	*Phacelia linearis*	x - xx	x	x		x	x	
nine-leaved desert-parsley	*Lomatium triternatum*	x - xx	x - xx			x	x - xx	
fern-leaved desert-parsley	*Lomatium dissectum*	x - xx	x - xx			x	x - xx	
yarrow	*Achillea millefolium*	xx - xxx	x - xx	x		x - xx	x - xxx	x - xx
paintbrush	*Castilleja* spp.	x	x			x	x - xx	
silverleaf phacelia	*Phacelia hastata*		x	x		x	x	
showy daisy	*Erigeron speciosus*	x	x				x - xx	x
Ross's sedge	*Carex rossii*	x	x	x		x	x - xx	x - xx
northwestern sedge	*Carex concinnoides*		x			x	x - xx	x - xx
*kinnikinnick	*Arctostaphylos uva-ursi*	x - xxx	x - xxx		xx - xxxx	x - xxxx	x - xxxx	x - xxx
spreading dogbane	*Apocynum androsaemifolium*	x	x	x	x - xxx		x - xxx	x - xxx
*shrubby penstemon	*Penstemon fruticosus*	x	x			x		
round-leaved alumroot	*Heuchera cylindrica*	x - xx	x			x - xx	x	x
lanced-leaved stonecrop	*Sedum lanceolatum*	x - xx	x -xx			x - xx	x - xx	
wild strawberry	*Fragaria virginiana*	x - xx	x			x	x - xx	x - xx
wood strawberry	*Fragaria vesca*	x - xx	x			x - xx	x - xx	x - xxx

Table 4: Guidelines for Herb Community Species Composition (abundance (% cover) of native grass and forb/low shrub species) on Revegetated Sites within Target Ecosystems

Species Name		Target Ecosystems						
Common	Scientific	Grassland	Brushlands			Very Dry Forests	Dry Forests	Dry - Slightly Dry Forests
		Gg11	Gb03	Gb05	Gb06	ICHxw, xwa, dw1, dm / 102	ICHxw, xwa / 103	ICHdw1/103 ICHxw, xwa /104
Forbs/*Low shrubs (continued)		**Abundance (% Cover) Categories [a]**						
Scouler's hawkweed	*Hieracium scouleri*	x	x			x - xx	x - xxx	x - xxx
showy pussytoes	*Antennaria pulcherrima ssp. pulcherrima*	x	x - xx			x		
rosy pussytoes	*Antennaria rosea*					x	x - xx	x - xx
Howell's pussytoes, (field pussytoes)	*Antennaria howellii ssp. howellii, (A. neglecta)*	x				x	x - xx	x - xx
racemose pussytoes	*Antennaria racemosa*						x - xx	x - xxx
white hawkweed	*Hieracium albiflorum*					x	x	x - xxx
showy aster	*Eurybia conspicua*						x	x - xxx
fireweed [f]	*Chamaenerion angustifolium*							x - xx
heart-leaved arnica	*Arnica cordifolia*					x	x	x - xxx
pearly everlasting [f]	*Anaphalis margaritacea*							x
western Canada goldenrod [f]	*Solidago lepida*							x

[a] Modified after MacKillop and Ehman (2016**); abundance (% cover) categories: X = <1%, XX = 1-3%, XXX = 3-10%, XXXX = > 10%**

[b] bluebunch wheatgrass and Idaho fescue are more common than pinegrass in the ICHxw, xwa/102, pinegrass is more common in the ICHdw1/102, and both bluebunch wheatgrass and pinegrass are common in the ICHdm/102

[c] slender wheatgrass is more common in target ecosystems within the ICHdw1

[d] Scribner's witchgrass and porcupinegrass are mainly restricted to target ecosystems in the ICHxwa although porcupinegrass can also occur in the ICHxw

[e] golden-aster and pink fairies could have higher covers in target ecosystems if they are intended to serve as cover crops

[f] fireweed, pearling everlasting and western Canada goldenrod could have higher covers in the dry - slightly dry forest ecosystems if they are intended to serve as cover crops

- *Revegetate disturbed sites using native shrub and/or tree seedlings*
  On some disturbed brushland and dry open forest sites, it may be desirable to enhance the establishment of native shrubs, either as a stand-alone treatment or in conjunction with establishing native grass and forb cover. Although shrubs would likely recolonize the disturbed sites naturally over time, planting appropriate species would accelerate the re-establishment of shrub cover and advance succession and the restoration of wildlife habitat. Shrub thickets provide a food source and protective cover for ungulates and other wildlife species and also tend to exclude invasive plants. Although planting cuttings and/or nursery-grown shrubs to revegetate a site is considerably more expensive than spreading native seeds, accelerating the establishment of native shrubs may be more cost effective for controlling invasive plants in the long term and worth the initial higher treatment costs. Planting shrubs could also be used as a treatment to restore degraded sites where it is difficult to establish a ground cover of grasses and forbs. Providing structural deterrents to recreational disturbance is another reason for planting shrubs on some restoration sites.

  A number of native shrub species are suitable for revegetating dry to slightly dry sites associated with the target ecosystems. Shrub species that typically grow to a maximum height of 2 m may be preferred for growing along transmission line corridors. Low-growing shrubs suitable for revegetating sites in the target ecosystems include mallow ninebark, snowberry, Oregon-grape, birch-leaved spirea, baldhip rose, prairie rose, and common juniper. Snowbrush is another species that typically doesn't grow higher than 2 m tall and is a characteristic shrub in the Gb06 brushlands. The low-growing species falsebox could also be used to restore dry forest ecosystem sites in the ICHdw1 and dm biogeoclimatic units.

  If height is not an issue, other shrubs species recommended for revegetating sites in dry target ecosystems are saskatoon, ocean spray, mock orange, redstem ceanothus and chokecherry. Saskatoon, red-stemmed ceanothus and chokecherry are also important browse species. Smooth sumac is suitable for use in the Gb05 ecosystem and is browsed by ungulates as well. All of the above mentioned species are less than 5 m tall, and mock orange, redstem ceanothus and sumac grow to a maximum height of 3 m. Douglas maple, Scouler's willow and Bebb's willow are suitable for revegetating sites in the dry to slightly dry forest ecosystems (ICHdw1/103, ICHxw, xwa/104) and also provide browse for ungulates.

  Flammability is another characteristic to consider when selecting suitable shrub species for revegetation and determining planting densities (see p. 45 below). For example, snowbrush burns "quite hot" as the foliage contains volatile oils, so the shrubs could contribute to the fire hazard on a site (Anderson, 2001).

  Shrub species that are appropriate for revegetating disturbed sites in the different target ecosystems are listed in **Table 5**. Recommended species are indicated with an 'X' and other suitable species that may be desirable to plant based on the shrubs present on similar undisturbed sites in surrounding areas are marked with an '*'. Most of the native shrubs are available as seedlings at Nupqu Native Plant Nursery https://nupqu.com/native-plants-inventory/ (near Cranbrook) and many of them are also available at Sagebrush Nursery https://sagebrushnursery.com/stock/7 (Oliver) and Bron & Sons Nursery Co. https://www.bronandsons.com/info/native-plant-list-new.html (Grand Forks). Bitter cherry and baldhip rose are currently not available at any of the three nurseries. At this time, shrub nursery stock is grown from seeds sourced outside the West Kootenays and cuttings for suitable shrub species are also currently not available locally. Seeds and/or cuttings from local sources should be used for revegetation treatments as soon as the material becomes available.

Table 5: Native Shrub Species Suitable for Revegetating Disturbed Sites within the Target Ecosystems

Species Name		Target Ecosystems								
Common	Scientific	Brushlands			Very Dry Forests			Dry Forests	Dry - Slightly Dry Forests	
		Gb03	Gb05	Gb06	ICHxw, xwa/102	ICHdw1 /102	ICHdm /102	ICHxw, xwa/103	ICHdw1 /103	ICHxw, xwa /104
saskatoon	*Amelanchier alnifolia*	X	*	X	X	X	X	X	X	X
common snowberry	*Symphoricarpos albus*	X	*	X	X		X	X	X	X
tall Oregon-grape	*Mahonia aquifolium*	X	*	X	X		X	X	X	X
mallow ninebark	*Physocarpus malvaceus*	X	*		X	*		*		X
oceanspray	*Holodiscus discolor*	X			*	X		*	*	X
mock orange	*Philadelphus lewisii*	*	*		*	*				
choke cherry	*Prunus virginiana*	*	*	X				*		
bitter cherry	*Prunus emarginata*	*						*		
common juniper	*Juniperus communis*	*								
smooth sumac	*Rhus glabra*		X							
snowbrush	*Ceanothus velutinus*			X						
birch-leaved spirea	*Spiraea lucida*				X	X	*	X	X	*
baldhip rose	*Rosa gymnocarpa*					X	X	X	X	X
prairie rose	*Rosa woodsii ssp. ultramontana*						X	*		
redstem ceanothus	*Ceanothus sanguineus*							X		
falsebox	*Paxistima myrsinites*					X	X		X	
Douglas maple	*Acer glabrum*					X			X	X
Scouler's willow	*Salix scouleriana*								*	*
Bebb's willow	*Salix bebbiana*								*	*

X = recommended, * = suitable and may be desirable based on shrub composition on similar sites in surrounding undisturbed areas

In some circumstances, the restoration objectives for a target forest ecosystem site could include planting trees to meet specific wildlife needs and/or to advance succession.

- Shrub and Tree Seedling Planting Densities

  As for planting native grass and forb seedlings, shrub and tree planting densities depend on the target ecosystems, site conditions (moisture and nutrient availability, competition) and species-specific characteristics (size and growth habit).

  Shrub seedlings

  Recommended planting densities for shrubs are 1-2 plants/m^2 which corresponds to a 1-0.7 m spacing between plants (Smreciu et al, 2002). Another source suggests a considerably lower density of 1 plant/2-5 m^2 by using a 1.5-3 m spacing. (King County, Washington, 2022). The lower density planting may be suitable for larger shrub species.

  Shrubs can be planted in a grid using even spacing or in clusters. Grid planting provides even coverage of an entire area while cluster planting involves planting shrubs in clusters or patches with higher densities in the patches and fewer or no shrubs planted between the denser clumps. Cluster planting can be used on problem sites with few suitable planting spots, where planting shrubs at higher densities in favorable microsites is more important than adhering to a rigid grid spacing. (B.C. Min. of Forests, 1997). Also, planting in a grid pattern is not visually appealing, nor does it represent natural distribution of structure. Planting in clusters using preferred microsites produces a more natural appearance (B.C. MOFLNRO, 2012). Planting shrubs in higher-density patches can also be useful for controlling invasive plants on microsites that are susceptible to infestations, providing shaded habitat for later successional understory plant species, and creating a range of microhabitats, from dense shrub thickets to more open areas, that increases site level biodiversity (Pinno et al, 2017). Two examples of spacing within and between clusters are provided in the Field Manual.

  Tree seedlings

  Recommended tree planting densities for the forested target ecosystems are based on provincial target and minimum stocking standards (B.C. Government, 2021). For the very dry, open forest site series (ICHxw, xwa/102, 103 and ICHdw1/102), the target stocking standard is 600 stems/ha with a minimum stocking of 400 stems/ha of well-spaced trees in a free growing condition. A spacing of 4-3.5 m between seedlings could be used to meet the target density. An average spacing of 3.75 m corresponds to ~700 stems/ha, which would achieve the target density with 85% survival of seedlings and meet the minimum stocking standard with 57% tree survival. For dry-slightly dry forest site series (ICHdm/102, ICHdw1/103, ICHxw, xwa/104), the target stocking standard is 1000 stems/ha with a minimum stocking of 500 stems/ha of well-spaced, free-growing trees. A spacing of 3-2.5 m would achieve the target density. The average spacing of 2.75 m corresponds to ~1325 stems/ha, which achieves the target density with a 76% survival rate and the minimum stocking standard if only 38% of the trees survive to the free growing condition.

- Timing of Planting

  As for herbaceous plant material, woody shrub and tree seedlings have the best chance of surviving if transplanted in the spring when they are still dormant. The woody species can also be transplanted in later summer or early fall if climatic conditions are favourable (seasonable temperatures and enough rainfall to provide adequate soil moisture). Plant deciduous species after the leaves have dropped and evergreen species after the onset of dormancy, which allows the plants time to establish roots prior to freeze up but reduces moisture loss (Smreciu et al, 2002). Ensure all transplants are hardened-off (kept cold and relatively dry) prior to planting out at revegetation sites.

- Species Composition
  The amounts (mean % covers) of shrub and tree species that occur in target ecosystems are shown in the vegetation tables for brushlands and forest site series in MacKillop and Ehman (2016). The amounts can be used as a guide for determining the appropriate composition (proportions) of native shrubs and trees to plant in treatment areas to be comparable to the natural composition of the vegetation layers in target ecosystems.

- Seedling care/maintenance
  As for grass/forb seedlings, native shrub and tree seedlings may require some care and maintenance before they become established. Soil nutrient levels could be improved to aid in plant establishment by applying a slow-release synthetic or organic bulk fertilizer to the site prior to planting. Small fertilizer paks (teabags) placed into the planting holes next to the roots can also be used to fertilize tree or shrub seedlings at the time of planting (see Soil amendments, fertilizers and mulches in section 6.1.1). Repeat applications of fast-release chemical fertilizers could also be used to enhance growth rates of the seedlings, but they are less desirable. Planting nitrogen-fixing species, deciduous species for litter fall, and species with strong root systems provides a slower but effective way to improve soil nutrient levels without the use of chemical fertilizers. (B.C. MOFLNRO, 2012).

  The native species planted should be well-adapted to growing on dry sites. However, during times of drought, the plants may require supplemental watering for one to three growing seasons. Hydration paks can also be used to provide moisture to seedlings to assist in establishment during times of moisture stress. (see section 6.1.1 as above).

  As a complement to supplemental watering and/or using hydration paks, mulch placed around new seedlings can assist with soil moisture retention and provide the added benefits of weed suppression, frost protection, moderation of soil temperature, and protection of the soil from erosion. Mulching can also be used as a treatment on its own. Ensure that materials used for mulching are not contaminated with non-native plant seeds.

  Shrub and tree seedlings may also need protection from wildlife browsing. Stem collars, seedling covers and/or tree guards (netting, wire cages, stem guards) can be used to protect new transplants from animal damage and they are commercially available through nurseries and forestry supply outlets. Spray repellents can inhibit ungulate browsing and scare tactics such as sensor-controlled sprinklers or radios can also provide effective protection from animal damage. Selecting plant species that are less or not at all palatable to wildlife is another way to reduce losses due to browsing (B.C. MOFLNRO, 2012).

  Treat invasive plants on the site prior to planting. Monitor sites at regular intervals after planting and re-treat sites as necessary to prevent new infestations. Also, control invasive plants in the vicinity of the treatment sites to limit seed spread from surrounding areas. (Dorner, 2002 in B.C. MOFLNRO, 2012).

  Other treatments that could aid in shrub and tree seedling establishment include (a) initial brushing to reduce interspecific competition, and (b) spacing and thinning once plants achieve a certain size to reduce competition and increase growth rates (B.C. MOFLNRO, 2012).

As for seeding treatments, record detailed information about the treatments using planted nursery stock to revegetate disturbed sites at the time of implementation. Also, any care/maintenance steps taken to aid in the establishment of the seedlings should be documented when the steps are initiated.

- Documentation of Treatments using Planted Nursery Stock
  The information that could be recorded to document a planting treatment, including any steps taken to aid in seedling establishment (seedling care/maintenance), is included in the Field Manual.

6.1.4 Monitoring Revegetation Treatments

It is highly recommended to monitor treated sites to determine the success of the revegetation efforts, including prescription implementation (how well the treatments were carried out as to the prescription objectives), and the effectiveness of the treatments to revegetate the sites. The monitoring program must identify key response variables (e.g. frequency, % cover, density, distribution patterns, species composition, survival of planted stock, condition of vegetation) that are measurable and used to evaluate how effective the treatments are in meeting the goals (desired outcomes) for the sites.

Successful establishment of vegetation will depend on the treatments, site features, the environmental conditions at the time of the treatments, and the quality of seed and/or planted stock. If initial treatments are unsuccessful or only partially successful at meeting site goals and objectives, adapt and modify treatments and re-seed/re-plant areas. Monitoring treatment areas will also include monitoring for invasive plants and may result in recommending treatments to control invasive and other alien plant species.

A monitoring program may include reconnaissance surveys, photo monitoring, and/or systematic sampling. A reconnaissance survey involves a walkthrough of a treatment area noting changes in vegetation and site conditions that relate to the treatment objectives. It is a fast and effective way to assess relative changes within an area. The survey includes tracking the route walked noting the specific locations of observations, and at each observation point, photo documenting and recording information about plant survival, vigour, density, distribution, abundance (% cover) and species composition, as well as invasive plant occurrences, wildlife use and soil erosion issues.

Photo monitoring is a relatively easy, inexpensive and effective way to document changes in vegetation and ecosystems. It consists of repeat photography of an area of interest over a period of time, with the photographs taken from the same location and with the same field of view as the original photos. It provides a standardized and precisely replicable result that can be achieved at different points in time by different personnel (Hamilton, 2020). The repeated photos document changes at sites over time and provide a long-term visual record of vegetation and site conditions. They are also an effective communication tool for showing change. Photo monitoring can include photo point monitoring and photo plot (quadrat) monitoring.

Photo point monitoring typically involves taking profile (landscape) photos that show visual changes to a site over time with respect to vegetation attributes as well as larger-scale changes due to erosion or disturbance by humans or wildlife. Photo point monitoring is typically used to provide qualitative information about a site but the repeat photography can also be analyzed to provide quantitative data. Several brief guides to photo point monitoring that are available online include Hamilton (2020) and

USDA (2007). Photo point monitoring can also be carried out using repeated aerial photos taken from a drone (Foresight Drone Services, 2022; Ciannella et al, 2021). The qualitative information collected at photo points in combination with quantitative monitoring data can provide a valuable assessment of progress toward meeting site goals and objectives.

Photo plot (quadrat) monitoring involves taking repeated photographs looking vertically down on a small plot or quadrat that has a permanently established location on the ground. The quadrat is typically a 1m X 1m frame but could also be 0.5m X 0.5m or a Daubenmire frame (0.5m X 0.2m) in size. This type of photo monitoring shows more precise changes over time of vegetation attributes and substrates (e.g., exposed mineral soil, organic matter) within a small plot area. It is useful for collecting more detailed quantitative data that can be compared between monitoring times. Photo plot monitoring is often carried out using transects. With *transect photo sampling*, photo points are established at set intervals along a transect and photos are taken of the quadrat at each point along the line (Hall, 2021). Photo plots can also be laid out systematically using a grid or located randomly within a survey area. Photo monitoring of many small plots established along transects, on a grid, or randomly located with a treatment area provides data sets that are useful for quantifying ecosystem changes over time.

Photography can also be used to show changes over time in crown size and canopy closure of trees (and/or tall shrubs) within a plot area by taking repeated photos looking straight up from a permanently established location on the ground. Tree cover sampling using overhead photography is described in Hall, 2002. Tree/tall shrub overstories in plots could potentially be monitored using repeat photography taken from a drone as well.

<u>Systematic Sampling</u>

Where more intensive sampling is appropriate for monitoring larger areas, systematic sampling can be used to collect detailed information for quantifying progress towards achieving prescription goals and objectives. General methods for conducting systematic sampling are described in B.C. MOFLNRO (2012) and are included in the Field Manual.

Several monitoring techniques that are useful for systematically sampling ecosystem attributes (response variables) include the line intercept method, the Daubenmire method, and fixed-radius plots. The three techniques are briefly described in B.C. MOFLNRO (2012) and the line intercept and Daubenmire methods are discussed in more detail in USDA (1999).

In the ***line intercept method***, horizontal, linear measurements of plant intercepts are collected along a transect. The method is used to assess species % cover and composition of herbs, shrubs, trees and invasive species, but is best suited for assessing the shrub layer in a sample area. The transect lines can be laid out perpendicular to a baseline or from a plot centre at a random bearing for a predetermined distance (e.g. 20, 30, 50, 100 m or longer) depending on the density and homogeneity of the vegetation. Permanent stakes mark the ends of the transects so that the exact same locations can be repeatedly assessed. A measuring tape is stretched out along the transect line and the horizontal linear length of each plant that intercepts the line is measured and recorded by species. The % cover of each species is calculated by totaling the intercept measurements for all individuals of that species along the line and converting the total to a percentage of the total transect distance. The total cover measured on the transect is calculated by adding the cover percentages for all the species. Species composition is based on % cover and is calculated by dividing the % cover for each species by the total % cover for all plant species. Other features such as average height and plant condition of each species can be recorded during sampling, and photo points can be established to take both close-up and general view photographs to provide visual evidence of vegetation (and substrate) changes over time.

The ***Daubenmire method*** of sampling vegetation includes placing a Daubenmire frame (20 X 50 cm quadrat frame) at defined intervals along permanently located transects to assess species % cover, frequency, and composition. The method is useful for assessing vegetation that does not exceed waist height, so is suitable for sampling low shrubs, herbs, invasive plants, and moss/lichen layers. The transects can be laid out as for the line intercept method, and on some sites, the same transects could be used to sample vegetation using both methods. For example, the species composition at a particular site may make it suitable to use the line intersect method to assess shrubs and the Daubenmire frame to assess herb species (B.C. MOFLNRO, 2012). During set up, photo points can be established to take repeat overview photographs of the site and transects, and photo plots can be established at each quadrat location to visually document finer-scale changes in vegetation (and substrates) over time.

Cover data are collected using 6 cover classes (0-5%; 5-25%; 25- 50%; 50-75%; 75-95%; and 95-100%) or sometimes 10 classes. Place the Daubenmire frame along the transect at the specified intervals and estimate the % cover of each species within the quadrat. Record the data by quadrat, species and cover class. Calculate the % cover for each plant species along the line by 1) counting the number of quadrats in which each cover class was recorded (e.g., cover class 1 (0-5% with a midpoint of 2.5%) was recorded in 10 quadrats), 2) multiplying the cover class midpoint by the number of quadrats where recorded (e.g. 2.5 X 10 = 25) to get a sum for cover class 1, 3) add together the sums for each cover class to get a total for all cover classes, and 4) divide the total for all cover classes by the total number of quadrats sampled along the transect to determine the % cover of an individual species. Calculate the frequency for each plant species by dividing the number of occurrences of a species (the number of quadrats in which the species was observed) by the total number of quadrats sampled along the transect and convert the value to a percentage. Species composition is based on % cover and is calculated by dividing the % cover of each plant species by the total cover of all species along the transect (USDA, 1999).

Fixed-radius plots are often used to sample trees in forest ecosystems, but can also be used to assess shrub, herb and moss/lichen layers on both forested and non-forested sites. Within an area of interest, plots are often established in a systematic pattern using a grid or located randomly. With respect to systematic sampling, one grid can be used to establish plots within a homogeneous sample area or separate grids can be used to locate plots in different strata (e.g., ecosystems, forest age classes, treatment types) that occur together in a sample area (stratified systematic sampling). Plots can also be located subjectively to sample small or uncommon habitat types, or target sites that might be missed by using a systematic or random sampling method. For example, plots could be located subjectively within small areas of brushland habitat that occur within a mosaic of dry forest and non-forest ecosystems. As for monitoring using transect sampling methods, plot centres and reference points are permanently marked in the field and identified with GPS locations. Sample plots can also be laid out as squares or rectangles rather than circles. The size of the plot depends on the size and density of the plant species being assessed. For example, 2000 m^2 (0.2 ha) circular plots with a radius of 25.23 m can be used to survey large trees (e.g., >40 cm dbh), 400 m^2 plots (20 X 20 m or 11.28 m radius circular plots) are often used to sample all vegetation layers in a forest stand, 100 m^2 (5.64 m radius) circular plots can be used to assess the tree understory, herb, and moss/lichen layers, and 10 m^2 circular plots with a 1.78 m radius can be used to sample germinants (seedlings). Different sized plots to sample different vegetation layers can be nested using one plot centre.

The plots can be used to collect quantitative data (by species) for the following vegetation attributes: density (number of stems/area), height, stem diameter, plant condition, % cover, frequency, and species composition within the vegetation layers. Total % covers of vegetation layers and % cover of each species in plots are visually estimated. Data on soils and % covers of substrates can also be collected at plots. Guidelines for collecting plot ecosystem data are provided in the Field Manual for Describing Terrestrial Ecosystems 2nd Edition (B.C. Ministry of Forests and Range and B.C. Ministry of Environment, 2010). Repeat photography may be used to visually document changes in a plot area. A photo point is typically located at the plot centre and photos are taken in the four cardinal directions. One or more photos can also be taken looking straight up to document overstory characteristics and vertically down to show the ground cover.

The mean value for a vegetation attribute (e.g. density or % cover) of a species within a sample area is determined by adding the values of the attribute in all sample plots and dividing the sum by the total number of plots. Species frequency is calculated by dividing the number of plots where the species occurs by the total number of plots sampled and converting the number to a percentage. Species composition (also expressed as a percentage) within a vegetation layer in a plot is determined by dividing the % cover of each species by the total % cover of all species in the layer. The mean species composition by layer in the sample area is determined by adding the values for each species in all plots and then dividing each sum by the total number of plots.

When time and budget are limiting factors, it may be possible to evaluate the effectiveness of treatments by monitoring changes in attributes for selected indicator species. The plant species selected must be related to the project goals and objectives (B.C. MOFLNRO, 2012).

- <u>Monitoring Seeding Treatments</u>

  Monitoring is important for assessing the effectiveness of seeding treatments on disturbed sites. Some <u>questions and points to consider</u> when monitoring treatments are as follows:

  - Did the broadcast seeding (or other seeding method) result in good coverage of the treatment area? This can be determined by recording total % cover of seeded grasses (and forbs) at the site.

    - As most of the native grasses considered suitable for revegetating target ecosystem sites are bunchgrasses or tufted perennials (the exception being the rhizomatous species pinegrass), a suggested range for the total cover of seeded grasses is 15% to 30%. A higher total grass cover (up to 50%) would still be within a recommended range if no forbs are added to the seed mix and/or if pinegrass naturally recolonizes and spreads on a site where it was previously abundant.

    - Cover of forbs could account for 20% to 70% of the total native grass and forb cover on a revegetated site. A suggested range for total cover of seeded forbs is 5% - 20%. Therefore, the suggested range of total cover for both native grasses and forbs on seeded sites is 20% to 50%. Total vegetation cover on revegetated sites could also be higher than 50% for several reasons. The total herb cover could be higher where the low shrub kinnikinnick and/or the matted selaginella species naturally recolonize and spread on sites where the species were previously abundant. Also, on grassland, brushland and drier forest sites, seeded silky lupine, yarrow and the potential cover crop species golden-aster and pink fairies could initially be very abundant. On the slightly moister forest sites, the cover crop species fireweed, as well as pearly everlasting and goldenrod, could initially have high covers as well.

    - If the total cover of seeded grasses (and forbs) is < 15 (20)%, the site may need to be reseeded (and the seeding density potentially increased for future treatments on similar sites), or the treatment may need to be changed. If the density of the vegetation is considerably higher than the suggested maximum (50%), then the seeding density could be decreased.

- Is the seeded vegetation cover evenly distributed or patchy? If the distribution is patchy, why do some patches have low or no cover? Are there microsites with unfavorable conditions for seed germination and or seedling growth? The bare soils patches may need to be reseeded with a modified seed mix and/or with the same or higher seed density.

- Is the composition of the seeded grass (and forb) species on a revegetated site similar to the species composition in the target ecosystem or are the species present and/or species abundances (% covers) considerably different? A substantial difference in the herb community composition on a revegetated site could potentially set up a departure from the desired trajectory of succession.

    - The goal of the seeding treatments is to achieve species compositions of the seeded grasses and forbs comparable to the natural compositions in the herb layers of the target ecosystems. Guidelines for herb community composition within benchmark target ecosystems that can be used to evaluate seeded areas are shown in **Table 4**. If species abundance (% cover) values on revegetated sites are considerably different than the suggested values for target ecosystems (e.g., substantially higher covers for some of the more competitive species), then the proportions of seeds in the seed mixes may need to be modified to alter the species composition on treated sites.

    - Recording the % cover of each seeded grass (and forb) species would be necessary to determine (a) which species are getting established on the sites and (b) the composition of the herb community at each treatment area.

- Are the numbers and total covers of invasive and other non-native species of concern in treatment areas changing? Are the non-native species spreading into treatment areas from surrounding areas? Recording the % cover for each invasive and other alien species in treatment areas would provide the information necessary to determine changes in the diversity and abundance of non-native species since the time of seeding.

- Are the abundances of other native species (not in the seed mix) changing in the treatment areas? Are other native plant species colonizing the sites from surrounding areas? Record the % cover of each native species during monitoring to answer these questions.

- Are there signs of wildlife use in the treatment areas? Signs of wild turkeys, other birds, and animals that might be feeding on seeds or vegetation could be recorded as comments.

Recommended protocols and information to collect when monitoring seeding treatments are included in the Field Manual.

- Monitoring Treatments Using Planted Nursery Stock

  Information recommended to collect when monitoring treatments using planted nursery stock is included in the Field Manual.

Data collected and summarized throughout the monitoring period can be compared to assess changes over time, and the results can be evaluated to determine treatment effectiveness. If the treatment responses are not progressing towards meeting the management objectives, then prescriptions can be adjusted, and new actions taken to improve the treatment outcomes (see Adaptive Management below).

6.1.5 Adaptive Management

Adaptive Management (AM) is a tool that can be used to address uncertainty about the effectiveness of management actions to meet project goals and objectives. It is a systematic process of gathering and using scientific information to evaluate and continually improve management decisions, practices and policies by learning from the outcomes of operational programs[14]. Reducing the uncertainties and knowledge gaps through learning is one of the objectives of the process and the learning is used to inform decisions and adjust practices to improve future outcomes. In theory, the process of learning and adaptation leads to an increased understanding of ecological processes and improved management. Adaptive management is a cyclical and iterative process that continually runs through six steps in the cycle as listed below:

1. Assess the problem and determine goals
2. Design the management plan
3. Implement the actions
4. Monitor the outcomes
5. Evaluate the results, and
6. Adjust the actions as needed to respond to changing conditions.

There are two types of Adaptive Management: passive and active[15]. Passive AM is an approach whereby, faced with uncertainty, managers implement the alternative action they think is 'best' with respect to meeting management objectives, and then monitor to determine the results. Adjustments are made if the desired objectives are not being met. Active AM is an experimental approach whereby, when faced with uncertainty, managers implement more than one alternative as concurrent experiments to see which one will best meet the management objectives. It is characterised by "actively probing" the system in order to distinguish between competing hypotheses (where the different hypotheses suggest different "optimal" actions). The key to active AM is that there are alternatives that can be more confidently compared than others.

Treatments to revegetate disturbed sites by seeding and/or planting seedlings, are largely experimental and there is uncertainty as to how effective the treatments will be. Follow-up monitoring and data evaluation will determine if the recommended treatments are successful at meeting the desired

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[14] B.C. Government Adaptive Management website https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/land-based-investment/forests-for-tomorrow/adaptive-management

[15] Forests for Tomorrow Introduction to Adaptive Management https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/land-based-investment/forests-for-tomorrow/forests-for-tomorrow-_extnote1_apr-29-2008.pdf

outcomes (e.g., vegetation cover is within the suggested range of % covers for adequately revegetated sites), or if the management objectives are not being met. If the desired objectives are not being achieved, then adjustments will need to be made to the site prescriptions. This approach corresponds to the passive adaptive management process described above, where actions considered to be the best available options for meeting management objectives are implemented, and then monitoring and evaluating the results inform the effectiveness the recommended actions. Information learned from evaluating the response to treatments is used to adjust the prescriptions and improve management practices.

Additional information on Adaptive Management can be found in Williams et al (2009) and Murray and Marmorek (2003).

6.1.5.1 Analysis of monitoring data

Monitoring data collected at specified time intervals during photo monitoring, reconnaissance surveys and systematic sampling can be used to evaluate changes over time and determine treatment effectiveness. Methods used to analyse the different types of monitoring data, and the evaluation of results are described in the following section.

Photo point monitoring data: Qualitative analysis of profile (landscape) photos is most common. The repeated photos are useful for showing visual changes to a site over time due to changes in vegetation attributes as well as larger-scale changes due to erosion or disturbance by humans or wildlife. Replicated photos taken on different, but similar sites can also be used to compare responses to similar treatments. The visual changes documented on repeated photographs are useful for identifying “triggers”, which are pre-determined conditions (levels of change) indicating that treatment outcomes will not meet prescription goals and objectives, and that new or modified management actions (treatments) are needed. The triggers can be further investigated by evaluating quantitative monitoring data, either derived by analysing repeated photos (see below) or collected during systematic sampling.

Quantitative data analysis of landscape photos is possible using **photo grid analysis.** The method involves placing a standardized grid over a photo and counting the number of intersects between grid lines and the feature of interest. This type of analysis is useful for measuring changes in the size or area of (a) vegetation (e.g., sizes of individual shrubs or trees or the area of an invasive plant infestation) or (b) a site disturbance such as erosion. Changes in the number of intersects between monitoring periods provides a quantitative measure of the change in size or area of the feature over time. A detailed discussion of photo grid analysis is found in Photo Point Monitoring Handbook: Part B–Concepts and Analysis by Hall (2002).

Photo plot (quadrat) monitoring data: Photos taken of small plots or quadrats looking straight down can show more precise changes over time in ground cover (%), species composition (%), plant condition (vigour), and substrates (%) at a finer scale. The repeat photography shows visual (qualitative) changes but can also be used to analyse quantitative changes. Digital photos can be analysed using photo grid analysis (as describe above) or digital image analysis, as the photos also provide pixel data.

Digital image analysis uses computers and image processing software to analyse data captured within pixels of the digital images. This type of analysis is useful for deriving quantitative data for attributes such as vegetation % cover and percentages of substrates within a plot (quadrat) area. The pixels of a specified color range in an image can be counted to get a quantitative measurement of the area or proportion of an attribute (response variable) within the plot. For example, on a recently revegetated site, the proportion of pixels (in a sample set of the image) that are green colors representing live vegetation (in contrast to brown colors representing soil) is a quantitative measure of the total % cover of the plant foliage within a plot. An example of manual digital image analysis using the SamplePoint computer software package is described in Part 2. Image Analysis in "Ground-Based Image Collection and Analysis for Vegetation Monitoring" by Cox et al (2021).

In transect photo sampling, repeat photos are taken of a number of plots located at pre-determined intervals along a transect to obtain a set of photos for each monitoring time. Each photo within the set can be analysed using photo grid or digital image analysis. Quantitative data derived for each attribute can be combined for all plots to provide more accurate results about changes in response variables (e.g., vegetation and substrates) over time.

Plot photos taken looking straight up are used to document visual changes in crown size and canopy closure of trees (and/or tall shrubs) between monitoring periods. The photos can also be analysed using photo grid or digital image analysis to compare changes in quantitative values over time. Repeated photographs of overstory conditions taken looking straight down from a drone can be analysed using the same techniques.

Reconnaissance sampling monitoring data includes notes and photos of observed changes collected at points marked along a route during a walkthrough of a treatment area. The notes and photos can be collected at the same points over multiple monitoring years to evaluate qualitative changes in vegetation and site conditions observed over time and the effectiveness of the treatments. The observed changes can inform management decisions about collecting and analysing additional monitoring data to evaluate quantitative changes, and/or adjusting prescriptions in treatment areas to improve outcomes.

Systematic sampling monitoring data collected along transects and in fixed radius plots can be analysed to evaluate quantitative changes in a number of ecosystem attributes (response variables). The line intercept, Daubenmire and fixed radius plot methods of sampling can be used to assess changes in species cover and composition over time. The Daubenmire and fixed radius plot methods are also useful for evaluating changes in frequency, mean % cover, density, and distribution of species within vegetation layers, as well as changes in proportions of substrate types. Fixed radius plots are also used to measure and compare density, size distribution and condition of tree species between monitoring times. Steps used to calculate attribute values using the different systematic sampling methods are described under "Systematic Sampling" in Section 6.1.4 above.

Changes in attribute values over time can be determined by comparing data summarized in tables and/or graphs for the different monitoring times. The changes in values can be described in terms of relative differences and trends, and where sample sizes are sufficient, the quantitative data can be analysed using statistical techniques to test for significance. In the line intercept sampling method, the transect is the sampling unit, and in the Daubenmire method, either the quadrat or the transect can be considered the sampling unit. When sampling an area with fixed radius plots, each plot is a sampling unit. For the above sampling methods where the data have been collected in permanently located sampling units, the paired t-test or the non-parametric Wilcoxon signed rank test can be used to test for significant changes in attribute values (response variables) between two years, and repeated measures analysis of variance (ANOVA) can be used to test for significant differences in values between three or more years (USDA, 1999).

6.1.5.2 Indicators, triggers and trigger points used for adjusting revegetation prescriptions

Indicators are the environmental parameters or attributes (response variables) that are measured and assessed during the monitoring of treatments to provide information about the conditions of the site or ecosystem. They include:

- total % cover for plant species groups (seeded/planted species, invasive and other aggressive alien plants, and other native plants not seeded or planted)
- % cover of individual species within the groups
- density and distribution of seeded/planted seedlings and invasive and other alien plant species
- condition (vigour) of planted seedlings
- species composition – relative abundance (proportions) of seeded/planted species

Triggers within the adaptive management process are limits or thresholds in response variables (numerical values and/or trends in values) that indicate when management intervention is required to prevent undesirable ecosystem changes. Reaching or crossing a threshold (pre-determined level of change) triggers the initiation of a specific action or management response. The thresholds serve as pre-established commitments to take actions when monitoring information indicates that treatment responses are progressing away from the desired outcomes. **Trigger points** identify when (at what point in the process) the monitoring information for response variables is evaluated to determine if thresholds have been reached or crossed, and if so, when management intervention is required to improve treatment outcomes (Addison, Cook and de Bie, 2016; Cook et al, 2016; de Bie, Addison and Cook, 2017). **Table E in the Field Manual** summarizes examples of indicators, triggers and trigger points that could be used within an adaptive management process. The table also includes recommended actions for adjusting revegetation prescriptions when triggers are reached or crossed.

6.2 Ecosystem Restoration

Ecosystem restoration can be a valuable conservation tool for restoring dry open habitats to help maintain representative areas of the target ecosystems. In the absence of invasive plants, prescribed fire can be used to restore and maintain the habitat structures that were prevalent before fire suppression. The habitats were generally more open with productive understories, both in the low elevation Gb and dry forest ecosystems. Slashing prescriptions can also be developed to partially emulate fire effects under scenarios where fire is not an option due to the presence of invasive plants, contaminants or other constraints. Both treatment types increase the resiliency of the target ecosystems by managing fuels in a controlled manner, resulting in less severe impacts to habitat structure in the event of a wildfire. This is accomplished by managing surface and ladder fuels and disrupting horizontal and vertical fuel continuity. There are many areas where ecosystem restoration is occurring in the region as well as many other candidate sites that would benefit from this action.

6.2.1 Restoration of fire-maintained ecosystems impacted by fire suppression

Low elevation grasslands, brushlands and dry open forests in the West Kootenays are "fire-maintained" (NDT 4[16]) ecosystems that became adapted to fire over thousands of years due to repeated low-intensity surface fires ignited by lightning strikes and First Nations people. That frequent-fire regime ended in B.C. around 1940 when organized fire suppression largely removed fire from the landscape (Rocky Mountain Trench Ecosystem Restoration Program, 2013). The loss of frequent fires resulted in a gradual shift in ecosystem structure, and after many years, open grasslands and shrublands became treed habitats and open forests became closed forests. Ecosystem Restoration takes the corrective

[16] NDT 4 = Natural Disturbance Type 4

action necessary to reduce tree encroachment and forest ingrowth and restore the open habitats to their natural conditions prior to fire exclusion.

Restoration of "fire-maintained" ecosystems usually involves thinning and/or the re-introduction of fire. Mechanical thinning is used to reduce tree densities within forest stands and open up brushlands and grasslands, as well as to cut tall forage shrubs that are inaccessible to ungulates. Once a site has been thinned, fire can be re-introduced with a prescribed burn (where appropriate) to further reduce regenerating trees, rejuvenate native shrubs, grasses and forbs, remove slash debris left after thinning, and recycle nutrients to the soil. Fire can also be used without the initial thinning treatment to open up habitats and stimulate the re-growth of native vegetation.

Monitoring is also an important part of the ecosystem restoration process as it provides information about the impacts and effectiveness of the treatments. Pre-treatment monitoring is used to document existing site conditions and provide baseline data for which to compare future conditions after applying the treatments. Post-treatment monitoring conducted after the slashing and/or burn treatments indicates how the sites are changing over time and if the restoration objectives are being achieved.

General steps used to meet the goals of an Ecosystem Restoration (ER) project are described in the Field Manual.

During the planning of any restoration project using prescribed fire, it's important to determine if invasive plants are present in and surrounding the project area. Best management practices for preventing the introduction and spread of invasive plants throughout all phases of a prescribed fire project are described in "Prescribed Fire and Invasive Plants – A Reference Guide and Manual of Best Practices" by the Invasive Plant Program, B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development (2022).

Several examples of ecosystem restoration projects being carried out in the south West Kootenay Region are provided below.

6.2.1.1 Ecosystem Restoration in non-forested Gb ecosystems

Ecosystem restoration (ER) in Gb ecosystems can be conducted using several different mechanisms and is intended to emulate the effects of natural wildfire on the landscape. Fire suppression has led to changes in the structure and function of Gb habitats in the region, resulting in forest encroachment into open areas, a reduction in habitat suitability on ungulate winter ranges, reduced productivity in grass/forb communities, and more generally, a shift in plant community composition as the diversity and abundance of fire-adapted plants change. The objective of ER within the Gb ecosystems is to mimic natural fire disturbance and create open-growing shrublands dominated by well-spaced mature and veteran ponderosa pine and Douglas fir trees (with <10% cover), healthy vigorously-growing shrub layers, and productive herb layers dominated by native grasses and forbs. This can be achieved by using prescribed fire where appropriate, or mechanical slashing if fire is deemed inappropriate. Factors such as the presence of invasive plants, sensitive ecosystem attributes, or in the case of the lower Columbia Valley, contaminated soils, can all limit the use of fire as an ER tool.

ER treatments in the Gb ecosystems focus on removing young ponderosa pine and Douglas fir tree encroachment into open areas while maintaining the largest trees on site, protecting wildlife trees and stimulating the growth of native shrubs, grasses and forbs. Broadcast burning with low intensity fire in the spring and fall is an effective way to restore these structural attributes and is cost effective with respect to the amount of area that can be treated. Slashing is also an effective way to emulate fire effects but lacks the ability to stimulate serotinous seeds in seed banks. From an ecological perspective, the treatment is less desirable than prescribed fire as species with phenological adaptations to high fire frequency benefit more when sites are burned.

Ecosystem restoration in a Gb06 ecological community was carried out in the Fort Shepherd area south of Trail by the Okanagan Nation Alliance (ONA) and the Fish & Wildlife Compensation Program (FWCP) section of the Ministry of Forests (MOF) in cooperation with The Land Conservancy. Slashing treatments were used to remove young Py and Fd trees encroaching into the open habitat to facilitate the restoration of the brushland area. Prescribed fire was not used at this site due to the risk of invasive plant establishment/ spread and the potential for past soil contamination by heavy metals from the Teck smelter. Photo 18 shows the open Gb06 habitat in the Fort Shepherd Conservancy area where the ER treatments were carried out.

Photos 18: Open Gb06 brushland on the large glaciofluvial terrace in the Fort Shepherd area where ecosystem restoration was implemented.

At-risk wildlife and plant species must be protected when conducting work activities within Gb habitats. Mitigation measures recommended to avoid/minimize disturbance to species at risk (SAR) when working in Gb06 and other Gb ecosystems are included in the Field Manual.

During ER operations, it is also important to minimize disturbance to the dry, coarse-textured soils on glaciofluvial terraces associated with the Gb06 ecosystems. In particular, care must be taken to avoid disturbing the cryptogamic crust on the soil surface that stabilizes the surface layer and prevents soil erosion. Common matte lichen (*Trapeliopsis granulosa)* is a prominent component of the soil crust in the Fort Shepherd area. It is a widespread species that is an important colonizer of exposed soils. The pale grey- to white-colored lichen reflects sunlight away from the soil surface keeping it cooler with lower evaporation rates (Iverson, 2016). The cryptogamic crust also creates a poor-quality seedbed that impedes ongoing recruitment of conifers (thereby maintaining the open structure of the Gb) and limits the establishment of invasive plant species. Mitigation measures that can be used to minimize damage to the lichen crusts on Gb06 sites are briefly described in the Field Manual.

Any soil disturbance resulting from ER work should be revegetated immediately using a custom (site-appropriate) native seed mix to help mitigate the threat of invasive plant introduction and spread.

6.2.1.2 Ecosystem Restoration in dry forested ecosystems

Ecosystem Restoration (ER) is being undertaken on Crown land and within Syringa Creek Provincial Park in the Lower Arrow Lake area to restore dry open forests negatively impacted by forest ingrowth. The

Lower Arrow Natural Disturbance Type (NDT) 4 – Ecological Restoration (ER) Project is a collaborative effort supported by the Fish and Wildlife Compensation Program (FWCP) section of the Ministry of Forests and BC Parks. The project was initiated in 2011 and is ongoing.

The project area is located along the east side of the Lower Arrow Reservoir between Syringa Creek Park in the south and Octopus Creek to the north. It includes lower elevation terrain from ~445 m at the reservoir shoreline to 1170 m at the summit of Deer Park Mountain. The area includes open to semi-open forests, shrublands and grasslands on dry, warm-aspect slopes with shallow soils, and closed-canopy forests on more gentle terrain and in gullies with deeper, moister soils. South of Sunshine Creek, the area is classified as the Very Dry Warm Interior Cedar Hemlock subzone (ICHxw) above 800-900 m and the warm phase of the subzone (ICHxwa) at lower elevations. To the north, the area is classified as the West Kootenay variant of the Dry Warm Interior Cedar Hemlock subzone (ICHdw1) (MacKillop and Ehman, 2016).

The objective of the Lower Arrow NDT4-ER project is to restore fire-maintained (NDT4) ecosystems to pre-fire exclusion conditions by achieving the following goals: improve habitat for a variety of wildlife species, increase natural forage for ungulates, reduce the risk of severe wildfires across the landscape, produce healthier forests (by spacing trees) that are less susceptible to disease and insect attack, and produce ecosystems that are more resilient to warmer and drier conditions due to climate change. The target ecosystems in the project area are the dry 103 forest site series within the ICHxwa, xw, and dw1 biogeoclimatic units. Dry forests transitional to very dry 102 forests or slightly dry ICHxw, xwa /104 forests are also considered acceptable target ecosystems. The desired condition of the restored ecosystems is open Douglas-fir – Ponderosa pine (FdPy) stands with fire-adapted shrub and herb species in the understories.

Ecological restoration projects require a prescription that identifies the restoration objectives, followed by detailed planning to organize the treatments and monitoring. On-the-ground operations usually involves thinning of trees and/or the re-introduction of low-intensity prescribed fire. Mechanical thinning treatments can be used to reduce forest stands to an open forest density or to open up shrublands and grasslands. The treatments include (a) industrial logging on sites with higher volume, merchantable timber or (b) machine thinning and hand slashing on sites with low volume, non-merchantable wood. For the Lower Arrow NDT4-ER Project, thinning treatments involve slashing trees < or = 15 cm dbh[17] and palatable shrubs to stimulate suckering and re-growth of the shrubs. In areas of heavy slash, the debris is piled and burned to reduce fuel loads and the fire intensity.

Other treatments to protect trees from being burnt during the re-introduction of fire include removing ladder fuels and raking needles away from the rooting areas and bases of large trees to reduce soil and bark heating. Fire breaks (guards) with very low fuel loads may also need to be created along the boundaries of treatment areas to protect adjacent ecosystems from being burned. Once an area has been mechanically thinned and prepared for burning, fire can be re-introduced using a controlled burn when a suitable weather "window" is available in the spring or fall. The burn can be ignited from the ground or from the air using a helicopter. Prescribed fires control tree regeneration, rejuvenate native shrubs, grasses and forbs, recycle nutrients to the soil, and remove slash debris left after thinning (Rocky Mountain Trench Ecosystem Restoration Program, 2013).

Monitoring for the Lower Arrow project began in 2014 when pre-treatment surveys were initiated in several treatment units. Detailed methods used to establish and sample pre-treatment monitoring plots

[17] dbh = diameter at breast height

are described in the initial monitoring report *Natural Disturbance Type (NDT) 4 – Ecological Restoration (ER) – 2014 Project: Summary of Pre-treatment Monitoring Survey* (McKenzie, 2014). The report is available from the FWCP section of the Ministry of Water, Lands and Resource Stewardship (WLRS), Nelson, B.C. The same methods are used to recollect ecosystem data at plots after the treatments.

Post-treatment monitoring has been conducted after both slashing and prescribed burn treatments. The objective for post-burn monitoring was to re-survey plots in years 1, 2, 3, 5, 7 and 10 after the fires. Control plots with no treatment were also established and are re-sampled each year. The Tulip Creek South treatment unit was burned prior to 2014 before monitoring was initiated. Post-burn monitoring started in the summer of 2016 after the previously-slashed Grey Wolf South unit was burned earlier that spring. Two other previously-slashed units (Sunshine Creek, Twobit Creek 1) were burned between the fall of 2016 and the spring of 2018. The results of slashing and prescribed burning in several of the treatment units are shown in photos 19 and 20.

Post-burn monitoring has been ongoing in the three treatment units since 2016 and monitoring results have been summarized in a report for each survey year. The reports compare and highlight changes in (a) the abundance (% cover) values for each vegetation layer (tree, regen, shrub, herb, non-native species, moss/lichen), (b) individual species within layers, (c) the amounts (% cover) of substrates (organic matter, decaying wood, exposed mineral soil), (d) the numbers of trees by size class and (e) coarse woody debris (CWD) pieces in plots between the pre-burn and post-burn monitoring years.

Relative abundance values (RAVs) for individual species and groups of species (e.g., palatable shrubs, bunchgrasses) within layers are also compared between pre- and post-burn survey years. Comparing the RAVs is useful for assessing how the abundance (% cover) of a species or group of species changes over time relative to the changes in abundance of all other species in the layer. Changes in the values between monitoring years can indicate the rate of recovery of a species relative to the recovery rates of other species in a layer and show shifts in the dominance of species within layers that occur as a result of the treatments and/or changes in other factors.

Photo 19: (left) The effects of slashing and a prescribed burn in the Tulip Creek South treatment unit in Syringa Creek Provincial Park; Photo 20: (right) The Grey Wolf South treatment unit in the park in the 5th monitoring year after the burn. Both sites are classified as the ICHxw/103 forest ecosystem.

Substantial differences in ecosystem parameter values (% covers, tree counts, CWD measurements, RAVs) between monitoring years indicate ecosystem changes due to the effects of the treatments, variations in climatic conditions and/or variations in other factors (e.g., wildlife use, timing of surveys during the growing season). The annual reports discuss substantial changes in ecosystem parameters observed between the pre-burn and post-burn surveys. The report *Lower Arrow Natural Disturbance Type (NDT) 4 – Ecological Restoration (ER) Project – 2022: Summary of Pre- and Post-Treatment Monitoring Surveys* by McKenzie and Hill (2023) was completed following monitoring in 2022. It summarizes data collected in the 7th year and 5th year post-burn at the Grey Wolf South and Twobit Creek 1 treatment units respectively and compares the results of five years of post-burn monitoring for all three units (including the Sunshine Creek unit) as well as for control plots. The report also summarizes pre-treatment monitoring data collected at new ecosystem plots established in the Twobit Creek 4 treatment unit and three units located within the Deer Park Conservation Area (DPCA). This most recent project report is available from the FWCP in Nelson, B.C.

There are also plans to burn the large Deer Park Mountain treatment area and the Twobit Creek 2/3 and 4 treatment units within the project area in 2024 or later. Post-treatment monitoring will be conducted in these units if and when the prescribed burns are carried out successfully.

Ecosystem restoration projects are also being conducted by the Slocan Integral Forestry Cooperative (SIFCo) in the Slocan Valley and in the East Kootenays as part of the Rocky Mountain Trench Ecosystem Restoration Program. In the Slocan Valley, fuel management for habitat restoration and ecosystem resiliency is one of the five wildland-urban interface treatment types being used by SIFCo to reach the goals of their strategic fuel management plan. Further information about the habitat restoration (type 4) treatments is available at https://www.sifco.ca/type-4 . The Rocky Mountain Trench Ecosystem Restoration Program has been operating since 1998 to restore East Kootenay/Columbia Valley low-elevation grasslands and dry Ponderosa pine/Douglas-fir forests to their natural state. Information about the program and past and future restoration projects is available at https://www.trench-er.com/about.

7.0 WILDLAND – URBAN INTERFACE MANAGEMENT

Wildland-urban interface (WUI) management is another land management category where best management practices to protect sensitive ecosystems and species should be applied. The WUI is a zone of transition between wilderness and land developed for human use – an area where human-built structures and infrastructure meet or are interspersed with undeveloped wildlands. Wildfires within WUI zones have the potential to destroy human structures and infrastructure and can cause extreme damage and loss when they spread into adjacent communities. As a result, it is important to mitigate the risk of wildfire in the WUI by reducing the hazards that contribute to the expansion of fires into settled areas. Wildfire hazard reduction treatments applied within and around WUI areas include landscaping, fuel reduction, and the creation of fire breaks and fuel breaks.

Ways to incorporate fire-maintained (NDT4) target ecosystems into the management of WUI areas to reduce the risk of large, destructive wildfires are briefly described in the Field Manual. A fuel management treatment regime developed for habitat restoration and enhancing ecosystem resiliency in NDT4 ecosystems (SIFCo 2022) is also summarized in the same section.

When conducting fuel management treatments for habitat restoration within a WUI zone, follow the general steps to meet the goals of an Ecosystem Restoration (ER) project identified in Section 6.2.1 of the Field Manual. The steps include (a) evaluating the risks of introducing and spreading invasive and other non-native plant species due to the treatments, and changing the management prescriptions if necessary, (b) surveying to identify at-risk ecological communities, plants and animals, and wildlife habitat features (WHFs) in the project area, (c) adjusting the treatments to minimize negative impacts to listed ecosystems and species, and special habitat features, (d) documenting baseline conditions prior to commencing the work, (e) carrying out the prescribed treatments, and (f) monitoring to determine the effectiveness of the treatments to meet management goals and protect sensitive ecosystems, species and WHFs.

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