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

Field Manual

v.7

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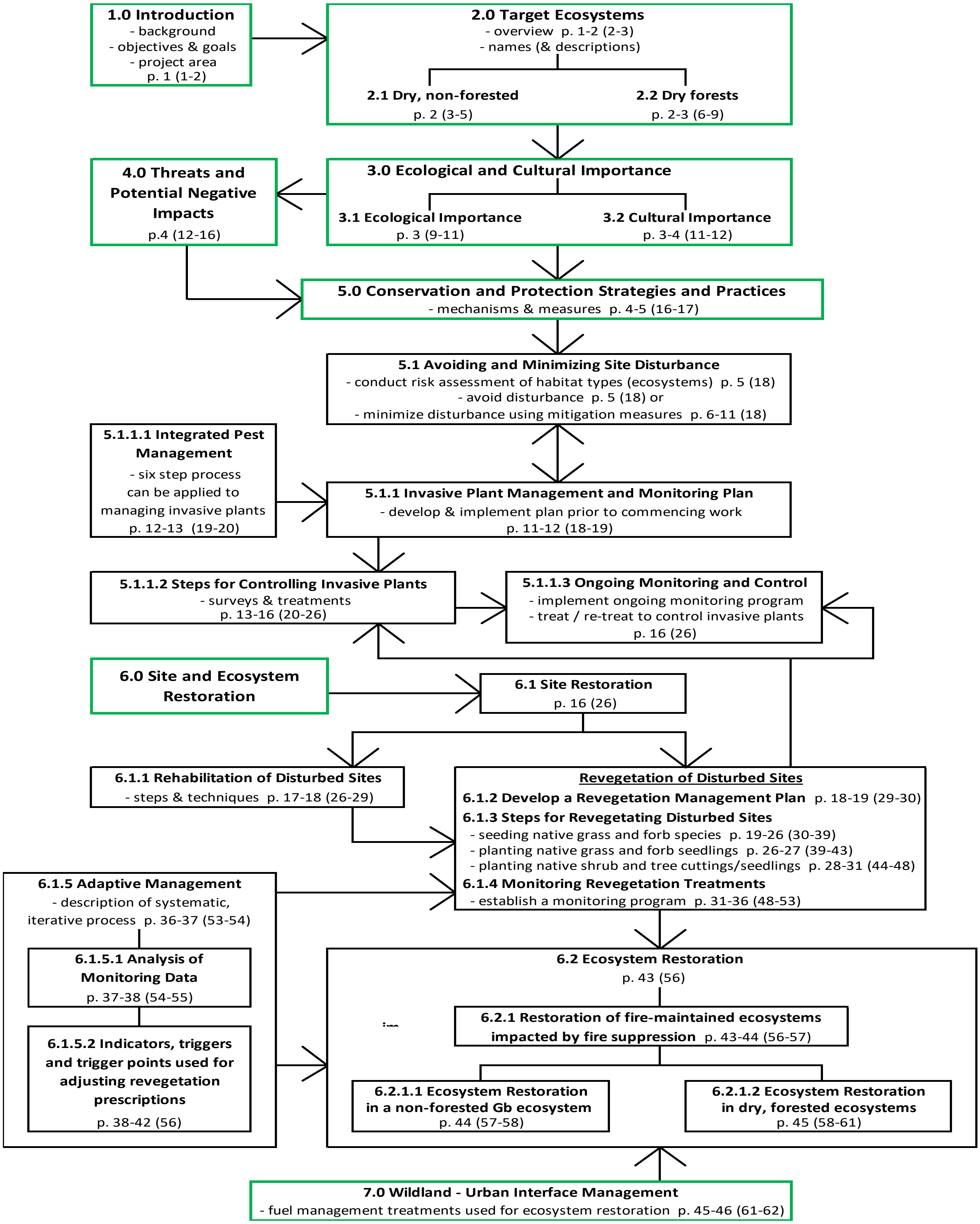

[1] first page numbers refer to the field manual (e.g., p. 1) and numbers in brackets are for the background information document (e.g., p. (1-2))

1.0 INTRODUCTION

Low elevation brushland (Gb), grassland (Gg) and dry forest ecosystems are ecologically important, uncommon on the landscape, very sensitive to human disturbance and highly threatened due to their location in valley bottoms where human activity is concentrated. The sensitive ecosystems also have low resiliency to disturbance.

This field manual was developed to provide clear and concise best management practices for conserving and protecting these sensitive ecosystems. In preparation of the manual, a number of strategies and management practices were reviewed and summarized in a supporting background information document. The field manual and supporting document were developed to guide the activities of industry and other stakeholders when conducting development, maintenance and/or restoration work, or wildland-urban interface management in the sensitive habitats. The manual summarizes best management practices for avoiding/minimizing disturbance on sensitive sites, rehabilitating, revegetating and restoring disturbed/impacted areas, and monitoring to evaluate the effectiveness and success of treatments. The background information document provides more details for many of the topics covered in the field manual including descriptions of target ecosystems, invasive plant management, specific revegetation treatments, and monitoring procedures.

The area covered by this manual is the south and central parts of the West Kootenay Region that includes the Boundary area.

The development of best management practices for low elevation Gb, Gg and dry forest ecosystems builds on the Lower Columbia Land Managers Conservation Action Forum that was held in 2018 to identify priority needs and actions that would contribute to maintaining species and ecosystems at risk in the Lower Columbia Valley which is part of the south West Kootenay Region. The workshop and field tour included participants representing a number of land management organizations who discussed management and conservation actions with respect to nine land management activities. The Lower Columbia Land Managers Conservation Action Forum Summary Report (Kootenay Conservation Program, 2018[2]) includes recommended priority actions identified to reduce impacts to species and ecosystems at risk. The background information document includes additional information from the summary report.

The field manual and supporting background information document are intended to be “living” documents that can be updated on an ongoing basis as new information becomes available. Information learned from implementing, monitoring and adapting management practices during future revegetation and restoration projects can inform updates to these documents.

2.0 TARGET ECOSYSTEMS IN THE WEST KOOTENAY REGION

The target ecosystems are fire-maintained (NDT 4[3]) ecosystems that support wildlife and plant species that are adapted to and depend on frequent, low-intensity surface fires to maintain ecosystem structure and function. In the West Kootenay, these ecosystems mainly occur at lower elevations in the **Interior Cedar-Hemlock (ICH)** biogeoclimatic zone and the following subzones, variants and phases:

- very dry warm ICH subzone **(ICHxw)**,
- warm phase of the very dry warm ICH subzone **(ICHxwa)**,

[2] https://kootenayconservation.ca/wp-content/uploads/2020/04/LCLMCAF-2018-Summary-Report-Final.pdf
[3] NDT 4 = Natural Disturbance Type 4

- West Kootenay variant of the dry warm ICH subzone **(ICHdw1)**, and
- dry mild ICH subzone **(ICHdm)** at mid elevations above the ICHdw1 east of the Creston Valley

These NDT4 ecosystems typically occur on dry, warm-aspect slopes with shallow and/or coarse-textured soils, but also occur on coarse-textured glaciofluvial terraces (Gb06, ICHxw, xwa /103), primarily in the ICHxwa in the Lower Columbia Valley. They include both non-forested ecological communities (grasslands and brushlands with < 10% tree cover) and dry forest ecosystems, often with open canopies (10% to 25% tree cover) as described in the following sections.

2.1 Dry non-forested ecosystems

Gg11 Idaho fescue – Bluebunch wheatgrass – Junegrass grassland
Gb03 Ninebark – Oceanspray – Bluebunch wheatgrass brushland
Gb05 Sumac – Bluebunch wheatgrass brushland (ICHxwa only)
Gb06 Snowbrush – Poverty oatgrass brushland (ICHxwa only)

The Gg11 grassland is very uncommon at low elevations in the ICH zone and was designated a red-listed ecological community by the B.C. Conservation Data Centre (CDC) in 2018[4]. The process of ranking the Gb03 and Gb06 brushland communities was completed by the CDC in the spring of 2023. These ecosystems have also been red-listed (B.C. CDC, 2023[4]) due to their ecological importance, limited distribution, high sensitivity to disturbance, and low resilience. Ranking of the Gb05 brushland ecosystem was not undertaken at that time due to time constraints and insufficient mapping data[5] and will be completed at a later date.

2.2 Dry forest ecosystems

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

The ICHdw1/102 forest 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, 2004[4]). The other target forest ecosystems are more common on the landscape and are not designated as at-risk ecological communities.

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

Slightly dry forests
ICHxw, xwa / 104 Fd(Py) – Douglas maple – Pinegrass

The target ecosystems are described briefly in the background information document and in more detail in the provincial land management handbook 70 – *A Field Guide to Ecosystem Classification and*

[4] BC Species & Ecosystems Explorer http://a100.gov.bc.ca/pub/eswp/
[5] D. MacKillop, pers. comm., Oct 20, 2023

Identification for Southeast British Columbia: The South-Central Columbia Mountains by MacKillop and Ehman (2016) available online at https://www.for.gov.bc.ca/hfd/pubs/docs/lmh/LMH70.pdf .

3.0 ECOLOGICAL AND CULTURAL IMPORTANCE OF TARGET ECOSYSTEMS

3.1 Ecological Importance

- Unique (and often uncommon) ecological communities that provide structural, habitat and species diversity across the landscape
- Support a high diversity of plant, vertebrate and invertebrate species
- Provide important habitat and key winter ranges for ungulates
- Support a number of at-risk wildlife and plant species

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 (2026 email from skʷkʷlal E. Tonasket[6]).

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[7]. 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 (2026 email from skʷkʷlal E. Tonasket).

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

[6] skʷkʷlal Elliott Tonasket, e-mail message to Carley Dolman, January 5, 2026.
[7] Syilx Okanagan creation story: How Food Was Given: Four Food Chiefs. https://learn.syilx.org/how-food-was-given-four-food-chiefs/

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 (2026 email from skʷkʷlal E. Tonasket). 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, (2026 email from skʷkʷlal E. Tonasket), 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[8]; Keefer and McCoy 1999[9]).

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[10]; The Narwhal 2021[11]). 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 target ecosystems occur mainly at low elevations where the prevalence of human settlement and development in the valley bottoms puts these ecosystems at significant risk of disturbance and degradation due to human activities. Primary threats (both current and past) include the following:

- direct habitat loss due to development activities,
- motorized and non-motorized recreation,
- the introduction and spread of invasive plant species,
- fire suppression resulting in tree encroachment and forest ingrowth in open habitats, and
- historic air / soil pollution in the Columbia Valley due to sulphur dioxide (SO_2) and heavy metal outputs from the Trail smelter

5.0 CONSERVATION AND PROTECTION STRATEGIES AND PRACTICES

The conservation and protection of at-risk target ecosystems (Gb brushlands, Gg11 grassland, ICHdw1/102 very dry forest) involve the following mechanisms:

- inventorying and mapping the distribution of these at-risk ecosystems and associated habitats on dry sites,

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[8] Sinixt Culture. 2022. https://sinixtnation.org/content/sinixt-culture

[9] Keefer, M. and P. McCoy. 1999. ?a.kxamis qapi qapsin All Living Things – A Ktunaxa Ethnobotany Handbook . Part One. Ktunaxa /Kinbasket Tribal Council, Cranbrook, B.C.

[10] Science World. 2021. Good Fire: Revitalizing Cultural Burning. https://www.scienceworld.ca/stories/good-fire-revitalizing-cultural-burning/

[11] The Narwhal, 2021. How Indigenous cultural burning practices benefit biodiversity. https://thenarwhal.ca/wildfires-indigenous-cultural-burning-biodiversity/

- provincial ranking of these ecosystems as vulnerable or threatened (blue or red-listed) through the B.C. Conservation Data Centre (CDC); the Gg11 grassland, Gb03 and Gb06 brushlands, and ICHdw1/102 forest ecosystem have all been designated at-risk (red-listed); the Gb05 brushland is currently not listed as an at-risk ecological community and will be ranked by the CDC at a later date,
- legally protecting intact representative areas of the at-risk target ecosystems within designated parks or reserves; this strategy must be combined with preventing recreational and human use activities in protected areas that negatively impact red- and blue-listed ecosystems

Additional measures recommended to conserve and protect all the target ecosystems are as follows:

- avoiding / minimizing activities that disturb/degrade the target ecosystems or predispose them to ecosystem conversion (i.e. road, hydro, and gas line ROW maintenance, recreational activities),
- regulating development activities that cause soil disturbance and introduce invasive plants into areas where target ecosystems occur,
- monitoring and control of invasive plant species[12] on relatively intact sites, and
- restoring disturbed sites within target ecosystems where feasible (i.e., focus on sites that are not highly degraded).

The ecological and cultural importance of target ecosystems, threats, potential negative impacts, and mechanisms for conserving and protecting Gb brushlands (and other at-risk target ecosystems) are discussed in more detail in the background information document.

Identifying risks of activities associated with soil disturbance or physical habitat alteration within target ecosystems is a key step to mitigating direct or nearby impacts. Mapping of sensitive ecosystems, minimizing disturbance, and appropriate rehabilitation and revegetation of disturbed soils are essential steps to help avoid long-term degradation.

New development activities should not be proposed within red-listed Gg11 grasslands, Gb brushlands, and ICHdw1/102 very dry forest ecosystems. Where construction or maintenance activities are proposed within other target ecosystems, proper planning is essential to identify appropriate practices. Avoiding unnecessary disturbance to sensitive sites with shallow soils and thin surface organic layers should be the primary objective. When disturbance is unavoidable, exposed mineral soil should be revegetated immediately with appropriate native seed mixes. It is important to have invasive plant control strategies in place (including a plan to revegetate sites after invasive plant treatments) coupled with pre- and post-treatment monitoring.

5.1 Avoiding and Minimizing Site Disturbance in Target Ecosystems

Avoiding site disturbance

The best management practice when working in areas with target ecosystems is to avoid them if possible. In particular, at-risk ecosystems should not be disturbed. Avoiding these sites is the highest priority during any new development project. However, industrial corridors already pass through these ecosystems in some areas and maintenance activities (resulting in disturbance) are sometimes required.

Prior to starting work activities for a new project, conduct a risk assessment of the ecosystems in the area. First, stratify the area into **habitat types** based initially on-air photo interpretation and then on

[12]Includes invasive plants that are designated as provincially or regionally noxious by the B.C. Weed Control Act, non-designated invasive species of concern, and other non-native species that are potentially invasive but currently are not being managed as problem species by the province.

field assessments of site and vegetation features. Field assessments involve describing site conditions (e.g. elevation, slope, aspect, slope position), determining the relative soil moisture regime (SMR) which potentially involves sampling soils and surveying the vegetation to determine BEC site associations or site series (e.g., Gb03 brushland or ICHxw/103 dry forest), and identifying structural stages (e.g., herb, tall shrub)[13]. A habitat type (e.g., open, low shrub) can include one or more ecosystems. Then determine the level of risk (to degradation or loss of ecosystems) based on sensitivity to disturbance, existing impacts (e.g. roads, industrial corridors, disturbed soils, invasive plants) and proximity to invasive plant-infested areas. Develop a risk assessment map that shows the distribution of habitat types with associated risk levels.

Listed (at-risk) target ecosystems are the most sensitive to disturbance and therefore have the highest level of risk (e.g., very high rating). Other target ecosystems that occur on dry, shallow soils and are also easily degraded by development activities and/or invasive plant infestations are rated as high risk. Ecosystems with deeper, moister soils that support denser covers of native vegetation are less susceptible to disturbance and are rated as lower risk (e.g., low-moderate). The level of risk increases when habitat types have existing impacts and/or are in close proximity to areas infested with invasive plants.

Identify all habitat types on the map classified as at-risk ecosystems or other target ecosystems that are at high risk of being degraded by work activities and avoid disturbing those habitats if at all possible. Locate roads, industrial corridors, equipment storage sites and parking/turn-around areas in other ecosystems with slightly dry to average moisture site conditions (submesic to mesic SMRs). Submesic and mesic sites are typically more common, less sensitive to soil 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 negative impacts to any cultural sites, wildlife and associated habitats, species at risk (SAR) habitats (e.g., critical habitats, wildlife habitat areas, and occupied SAR breeding, roosting, denning or key foraging sites), identified wildlife habitat features[14], vegetation, and soils. By minimizing site disturbance, future costs of rehabilitating degraded sites, controlling the spread of invasive plants, and restoring valuable habitats and features will be reduced. A number of mitigation measures used to minimize site disturbance in the sensitive ecosystems are described below:

- Environmental Management Plans (EMPs) – Review EMPs and/or other land use plans for specific projects and/or areas that overlap with the project area and follow all specifications, requirements and recommendations to mitigate negative impacts of work activities.

- Cultural/Heritage Values – Identify and protect archaeological and cultural/heritage sites and artifacts in the work area (see BC Heritage Conservation Act). Proponents and land managers have a duty to meaningfully engage with applicable First Nations whose traditional territories

[13] Standard methods used to survey site, soil and vegetation characteristics are laid out in Land Management Handbook 25 Field Manual for Describing Terrestrial Ecosystems 2nd Edition by B.C. Ministry of Forest and Range and B.C. Ministry of Environment (2010) https://www.for.gov.bc.ca/hfd/pubs/docs/Lmh/Lmh25/Lmh25_2015.pdf

[14] Fourteen wildlife habitat features (WHFs) identified by the Ministry of Environment and Climate Change Strategy within the Kootenay Boundary Wildlife Habitat Features (KBWHF) Order are protected under the Forest and Range Practices Act as of July 2018. https://www.bclaws.gov.bc.ca/civix/document/id/mo/hmo/m0213_2018

overlap with a proposed development area and their responses should be integrated into the planning, implementation and monitoring within target ecosystems.

- Wildlife – Identify wildlife species and any animal species-at-risk that potentially occur in the area. Conduct pre-work wildlife, wildlife habitat and wildlife habitat features (WHFs) surveys to locate species, key habitats and special features (nests of listed bird species, burrows and dens of at-risk mammals, bat hibernacula and nursery roosts, mineral licks, wallows and hot/thermal springs) protected by the KBWHF Order[7] that could be negatively impacted by work activities. Develop site-specific mitigation measures to eliminate or minimize negative impacts.

    - Avoid work during the most sensitive periods for wildlife. Ungulates are most vulnerable in late winter and spring. Birds and reptiles are most active from late April to August (although owls and some raptors start being active as early as March). Schedule timing of work to avoid disturbing nesting birds if possible; otherwise, conduct nest searches and WHFs surveys prior to commencing work at specific sites. Don't disturb active nests, roosts, dens, and hibernacula until animals have vacated. Exclude cattle from areas where at-risk bird species are nesting.

    - Mitigate for direct loss of habitat
        - Using trained professionals, conduct wildlife trapping/salvage and relocate small animals (amphibians, reptiles, small mammals, etc.) from habitats that will be lost to other areas with suitable habitat, making sure to assess recipient sites to confirm their suitability. A recipient site must be similar habitat of equal or better habitat suitability and located outside the area of impact. Appropriate animal capture and handling procedures will need to be followed and a salvage permit is required. Animal care and salvage permit application forms are available from the B.C. Ministry of Environment and Climate Change Strategy.
        - Restore/enhance existing habitat by planting trees and/or shrubs, re-seeding disturbed/bare soil areas with an appropriate native seed mix, creating wildlife trees (applying mechanical and/or fungal inoculation techniques), and erecting nest and bat boxes and BrandenBark roost slabs[15].
        - Through land acquisition, acquire similar habitat in another location to replace the lost habitat and set aside for conservation.

    - Minimize wildlife losses due to crushing, roadkill mortality, and wildlife-vehicle collisions
        - Educate workforce and public about crushing and roadkill impacts of equipment and vehicles on wildlife
        - Have a spotter walk in front of equipment to search for, pick up, and/or shepherd animals out of the away,
        - Reduce traffic speeds and volumes by promoting car-pooling for workers
        - Control speeds by reducing and enforcing lower limits, installing signage and speed bumps where appropriate
        - Use drift fences to deter and re-route small animals away from construction areas or to safe road crossing areas

[15] BrandenBark roost slabs are sleeves of synthetic bark designed to simulate the conditions, including the microclimate, that bats prefer in natural structures. These are installed high in a tree after peeling away the natural bark.

- Native Vegetation – Where disturbance will be unavoidable, ensure that a site appropriate native seed mix is procured well in advance of the project to re-seed disturbed areas. This may require multi-year seed collection and proper stratification years before the project if adequate supplies of suitable grass species are not commercially available.

  Identify at-risk plant species and ecological communities that could potentially occur in the work area. Conduct pre-work surveys to locate and map species and ecosystems of conservation concern. For each at-risk ecological community identified within the work area, conduct an invasive plant survey based on standardized methods[16] and evaluate the level of disturbance to determine the pre-development benchmark condition of the ecosystem. Areas can be rated as to their levels of degradation by assessing 1) the relative abundances of invasive and other non-native plant species compared to the relative amounts of native species and 2) the amounts of exposed mineral soil on the sites using an Ecosystem Scorecard (Appendix I)[17]. Some at-risk communities or portions of the communities may be highly degraded prior to the commencement of work activities.

  Mitigation measures that could be applied to protect listed plant species occurrences and intact ecosystems during work activities include the following:

  - Fence around at-risk plant occurrences or ecological communities (where feasible) to protect the populations or ecosystems within Environmental Protection Zones (EPZs). Avoid vegetation clearing, soil disturbance and herbicide use within the EPZs.

  - If an at-risk plant population cannot be protected by installing an EPZ, there are several other options available for conserving the plants. Two options include collecting, cleaning and stratifying seeds of the listed species and 1) spreading the seeds of annual or perennial species on suitable sites at other locations (based on site pre-assessment) or 2) propagating the seeds of perennial species at a nursery, and then out-planting the seedlings at the suitable sites. Larger quantities of seeds for at-risk plants could also be grown at a nursery.

    With respect to growing at-risk plants on-site from seed, information on the best time for seeding is included under "Timing of Seeding" (p.24) in section 6.1.3 Steps for Revegetating Disturbed Sites. When transplanting nursery stock, the seedlings have the best chance of surviving if transplanted in the spring when the plants are still dormant. The seedlings should be hardened-off by keeping them cold and relatively dry prior to planting. Information on seedling planting densities and care/maintenance of transplanted seedlings is found under "Revegetate disturbed sites using grass and forb seedlings" (p. 25-27) in section 6.1.3.

    Another option for conserving listed perennial plants is to remove some or all of the individuals in the population and transfer them to the pre-assessed suitable sites. Digging up plants and moving them to another site is a plant salvage operation carried

[16] Standardized methods for conducting invasive plant surveys are referenced below in the section "Invasive Plant Management and Monitoring Plan"

[17] E. McKenzie and T. Hill. 2014. Draft Ecosystem Scorecard developed for the Fish & Wildlife Compensation Program (FWCP) section of the BC Ministry of Water, Lands and Resource Stewardship (WLRS). Nelson, B.C.

out prior to the loss of habitat due to development. It is a last resort option for protecting at-risk plant populations when their habitats are under certain threat of destruction. The recipient sites should have site conditions similar to those of the original habitat. The success of translocating plants depends in large part on the intact removal of the plants' root structures. Therefore, it's important to retain as much of the original root systems as possible when removing plants[18]. Salvaged perennial forbs and grasses would have the best chance of surviving if transplanted in the spring when soils are still moist, and temperatures are cool. They could also be transplanted in late summer to early fall after the onset of dormancy. The plants should be transplanted when climatic conditions are favorable and as soon as possible after removing them from their original habitat. Supplemental watering may be necessary during the summer for the first two years until the plants become established[18].The likelihood of successfully translocating plants also depends on plant vigour at the time of planting and climatic conditions following the transplanting.

Permits are required to translocate at-risk species on federal, provincial and municipal lands. Species at Risk Act (SARA) permits for activities on federal lands are issued by the Canadian Wildlife Service, provincial permits are available from the B.C. Ministry of Environment and Climate Change Strategy (or Front Counter BC[19]) and permits for activities on municipal lands can be obtained by contacting local governments. Pre-translocation assessments and planning, thorough documentation of activities, monitoring, evaluation, and ongoing management are recommended when conducting a species at risk translocation project[20].

The above management options are not intended to facilitate or encourage any development activities that result in loss of species at risk populations or habitat.

During work activities, promote the maintenance of residual vegetation. Leave trees and snags wherever possible and minimize cutting and clearing of shrubs unless shrub cutting is part of an ecological restoration treatment. Along transmission line rights-of-way, do not mow vegetation to ground level to avoid soil disturbance and progressive community conversion (i.e., to bracken fern and other highly competitive species). Instead promote maintenance and/or development of low-growing shrubs and herbaceous plants that deter the growth of tall-growing vegetation (tall shrubs, trees) and invasive plants that require control. Low shrub species in target ecosystems that typically grow to a maximum height of 2 m include mallow ninebark, snowberry, Oregon-grape, birch-leaved spirea, baldhip rose, prairie rose, common juniper, snowbrush (Gb06) and falsebox (ICHdw1 and ICHdm).

- Soils – Limit work activities and retain vegetation on steep slopes that are particularly susceptible to erosion, changes to drainage patterns, and mass wasting. Minimize disturbance to shallow soils and soils (shallow or deep) with thin topsoil and/or thin surface organic (forest floor) layers that are very sensitive to soil and/or forest floor displacement. Shallow soils and thin topsoil and surface organic layers are easily displaced by heavy equipment and vehicle

[18] Native Plant Society of British Columbia. 2017. Salvaging Native Plants https://npsbc.files.wordpress.com/2017/12/npsbc_native_plant_salvaging.pdf
[19] https://portal.nrs.gov.bc.ca/web/client/home
[20] Maslovat, C. 2009. Guidelines for Translocation of Plant Species at Risk in British Columbia. B.C. Ministry of Environment, Victoria, B.C. https://a100.gov.bc.ca/pub/eirs/finishDownloadDocument.do?subdocumentId=8321

traffic and the exposed subsurface mineral layers are highly susceptible to erosion and invasive plant infestations.

Where excavation work is necessary at a site and if the site is free of invasive plants, the topsoil layer can be conserved by removing and piling it separately and then replacing it after the work is completed. **Topsoil** refers to the uppermost mineral soil layer (the organic-enriched (Ah) mineral horizon) located immediately below the surface organic (forest floor) layer. Most of the rooting zone is located in this layer. Besides organic material, it contains nutrients, microorganisms that influence soil nutrient cycling, a seed bank from plants existing on the site, and mycorrhizae that assist plants in water and nutrient exchange. If practical, conserving the topsoil and redistributing it over the site after disturbance increases the chances of successfully re-establishing vegetation cover.

For periods of up to 6 months, the piled topsoil could be covered to prevent contamination by non-native plants and seeds. If topsoil is to be stored for more than 6 months, it is recommended to seed the piles with native grasses and forbs to protect the soil from erosion and colonization by non-native plants, and to maintain the existing microorganisms and other soil constituents. Ensure that the soil is free of non-native plant material and seeds before re-spreading it on a site after the work is completed. Additional information on guidelines for handling topsoil is provided in the background information document.

- <u>Invasive Plants</u> – Assess the presence and abundance of invasive plant species[5] during pre-work vegetation surveys. Map invasive plant occurrences and patches and develop treatments. Treat invasive plant occurrences and patches in the area prior to work start-up. Management of certain species can be complex and requires considerable planning. For example, mechanical treatments on their own should be avoided for species that respond aggressively to mechanical disturbance. (e.g. black locust). Managing invasive plants is discussed in more detail below in section 5.1.1. Invasive Plant Management and Monitoring Plan.

- <u>Work Scheduling</u> – Schedule work to avoid sensitive times for wildlife, unsuitable site or climatic conditions (e.g., fire-season limitations, spring run-off or periods of prolonged wet weather when soils are saturated, creeks are full, and the risks of soil erosion and compaction are high).

- <u>Equipment Selection</u> - Select heavy equipment, machinery and vehicles most appropriate for the site and conditions of work zones. Low ground pressure equipment with high flotation tires and/or the lightest machinery and vehicles capable of carrying out the required work should be selected to minimize soil compaction and displacement of forest floor (surface organic materials) and topsoil.

- <u>Access Management</u> – Limit the number of vehicles entering and exiting the work area (e.g. carpool where possible) and identify access/egress routes and designated parking sites. Control public access into sensitive areas to protect ecological and heritage values if required.

- <u>Clean Equipment, Vehicles and Clothing</u> – Prior to entering a work area, thoroughly clean the undercarriages and tires of heavy equipment and vehicles to avoid accidentally introducing invasive plants into the area. This is important in all cases but is critical if equipment and vehicles are coming from other weed-infested sites. Check clothing and boots for plant material prior to entering work areas and dispose of any plant parts and seeds.

- Within the work area, there may be an Environmental Monitor (EM) who is responsible for communicating all specifications and requirements of the management plan to the work crews, monitoring work activities for compliance, keeping daily reports on activities, and providing periodic updates to the project management team.
  - Regularly inspect the undercarriages of vehicles; remove any plant material found, and dispose of plant parts and seeds
  - Avoid driving roads infested with invasive plants prior to invasive plant control; walk through sensitive ecosystems where it's not necessary to drive on access roads with invasive plants
  - Thoroughly inspect equipment and vehicles when leaving an invasive plant-infested area; remove any plant material found and dispose of plant parts and seeds
  - Check clothing and boots for plant material when exiting an area infested with invasive plants and dispose of any plant parts and seeds
  - Minimize vehicle movement between invasive plant-infested and non-infested areas
  - Minimize vegetation damage and soil disturbance by work vehicles by restricting off-road access. Do not park or turn vehicles and heavy equipment around in or within 50 m of sensitive target ecosystems to avoid disturbing soils and spreading invasive plants. Select level, open areas with slightly dry (submesic) to average moisture (mesic) site conditions adjacent to existing roads for designated parking/turn-around areas and delineate their boundaries in advance. Soil and vegetation disturbance can be minimized on level open sites, where it is not necessary to scrape off vegetation and topsoil with an excavator. Submesic and mesic sites have lower sensitivity to disturbance and are more easily revegetated if any disturbance occurs.
  - Avoid moving around soil that may contain invasive plant parts and seeds.
  - Spill Prevention and Response – Identify potential hazards and take measures to minimize the risk of fuel, lubricant and toxic substance spills. Carry spill kits and equipment to deal with spills and follow company protocols and/or the BC Environmental Management Act regulations re: spill response, clean-up and reporting.
  - Waste Management – Remove all waste, debris, other construction-related materials, and drift fencing from the work area and reuse or dispose of these items in an appropriate manner. Follow company waste management program protocols and/or the BC Environmental Management Act regulations.

- On exiting the work area, thoroughly inspect equipment, vehicles, clothing and boots, remove any plant material, and dispose of plant parts and seeds.

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 heavy infestations. Prior to commencing work in an area, 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 plants in the work area,
3) evaluate the effectiveness of invasive plant control treatments and use this information to inform the control program, and
4) continue to assess changes in composition, abundance, density and distribution of invasive species in the work area, and apply treatments as required during ongoing monitoring and control.

Key aspects of a plan include:

- education on preventing invasive plant introduction and spread,
- initial baseline invasive plant survey,
- site-specific prescriptions,
- various control actions (mechanical, chemical, cultural and biocontrol treatments),
- periodic invasive plant surveys (conduct annually or more frequently as required based on site-specific factors) as part of an effectiveness monitoring program, and
- adaptive management based on monitoring results.

When developing the plan, it is recommended to consult with the following resources:

- any invasive plant management plans that already exist for the area
- local land management resource specialists
- Central Kootenay Invasive Species Society (CKISS) website https://ckiss.ca/
- Invasive Species Council of BC (ISCBC) website https://bcinvasives.ca/
- B.C. Ministry of Forests and Range Invasive Alien Plant Program (IAPP) Reference Guide Part 1[21] (IAPP was B.C.'s invasive species mapping and database application between 2005 and 2023)
- B.C. Government InvasivesBC (formerly Invasive Alien Plant Program (IAPP)) https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species/invasivesbc
- B.C. Government Integrated Pest Management Program website 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
- ISCBC publications on managing invasive plants https://bcinvasives.ca/resources/publications/

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 management approach for each category are available on the CKISS website at https://ckiss.ca/species/invasive-plant-priority-lists/ .

*** When developing and implementing invasive plant management plans, collaborate with other stakeholders in the area whenever possible to optimize management efforts and maximize treatment effectiveness, while sharing program costs.**

5.1.1.1 Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is a decision-making process that can be used to manage pests, including invasive plant species, in an effective, economical and environmentally-sound way[22]. The six components of an Integrated Pest Management program that can be applied to managing invasive plants within a project area include the following:

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

[22] https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/plant-health/integrated-pest-management

1. Prevention – plan and manage activities to prevent the introduction of invasive plants into the work area and to avoid/minimize soil disturbance where invasive species can become established
2. Identification – identify existing invasive plant species and infestations that occur in the area
3. Monitoring - monitor for changes in locations, sizes and concentrations of invasive plant populations and environmental conditions
4. Action Threshold – assess levels of infestations, threats to native species and ecosystems, and cost of control methods to make decisions about if, where and when treatments are needed
5. Management Options – use a combination of mechanical, chemical, biological and cultural treatment methods coordinated into an integrated pest management program to reduce target invasive plant populations to acceptable levels
6. Evaluation – Conduct follow-up monitoring to evaluate the effects and efficacy of the management decisions to control target invasive plants

5.1.1.2 Steps for Controlling Invasive Plants

In areas where invasive plants have become established on disturbed sites, proper control and monitoring activities are essential to prevent further spread and negative impacts to surrounding ecosystems.

Conduct an initial invasive plant survey by mapping areas of infestations in the project area and collecting information on infestations in accordance with InvasivesBC. Areas of infestation can include habitat type units (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 points on the map. For each mapped area, collect information on site location, site features, size (m^2), and density and distribution pattern[23] of each invasive plant species and other non-native species of concern within the area. The abundance of each species can also be recorded as an ocular estimate of percent cover. Take photos and record photo comments to provide addition information about infestations at selected sites.

Depending on the species present and scale of the infestations, various treatments are possible. If infestations are small, mechanical treatments may be an option. This can involve hand pulling, digging, or weed whacking the target species prior to them setting seeds. For larger infestations, herbicide application is the most widely used treatment technique. There are a variety of herbicide options available and selecting the most appropriate ones will depend on what species are being targeted. When using either treatment type, a follow-up revegetation treatment of seeding native grasses and forbs or planting herb and/or shrub seedlings is essential. Biological control agents can also be used to treat large, widespread infestations of some invasive species. The different control treatments are briefly described below and in more detail in the background information document.

- Mechanical treatments include hand-pulling, digging up, or weed whacking plants before seed set. Hand-pulling and digging are useful for treating small invasive plant infestations with a

[23] Distribution and density codes are included with InvasivesBC Terrestrial Observation Field Form: https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/invasive-species/invasivesbc-resources/terrobserv_paper_field_form.pdf

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 invasive plants. If persistent herbicides are used, then the chemical treatments have residual effects and are effective at killing seeds thereby reducing the seed banks of invasive species on treated sites. CKISS can provide information to guide decision making about herbicide use (see background information document) and should be contacted prior to using chemical treatments.

- Cultural treatments – One of the most important cultural treatments to control invasive plants is to seed or plant competing native vegetation to limit the establishment of non-native species (see section 6.1.2 Develop a Revegetation Management Plan). Fertilization (e.g. using transplant fertilization paks to enhance the early growth of planted seedlings) and/or irrigation could also be used to favour the growth of the native vegetation. Other control practices may include proper grazing management, mechanical mowing on selective sites, and prescribed fire. However, these practices must be carefully evaluated based on the site and the invasive plant species of concern.

- 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.

  - Biocontrol treatments have been partially successful in controlling **spotted knapweed** and **St. John's-wort** in some parts of B.C. 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. Other invasive plant species including **hawkweeds**, **oxeye daisy**, **common tansy,** and **hoary cresses** are target species that are currently undergoing screening for potential biocontrol agents.

    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[24]. The Central Kootenay Invasive Species Society (CKISS) can also provide information about biological control of invasive plant species.

- Options for managing large dense infestations of the invasive species **cheatgrass** and other introduced **annual brome grasses** (meadow brome, soft brome, and Japanese brome) in target ecosystems are complex and challenging. Information on methods used to control the species are described under Management Considerations in Species Reviews for each species on the Fire Effects Information System (FEIS) website[25]. Contact CKISS re: treatment methods that can be used to control small infestations of cheatgrass and the other annual brome species.

[24] https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species/management/plants/biological-control
[25] https://www.feis-crs.org/feis/

North Africa grass or ventenata is another non-native annual grass that can be confused with cheatgrass. It is a relatively new invasive species in B.C designated as provincially noxious, and it occurs in the West Kootenay Region. The species 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[26,27].

Prevention is the most effective way to limit the spread of North Africa grass[27]. Treatments of infested areas should be conducted for a minimum of 3 years (seeds are viable for at least 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.

Use control treatments (mechanical, chemical and biocontrol) and cultural management practices in appropriate sequence and combination to reduce the negative impacts of invasive species on native plants, while promoting the development of desired plant communities. Continue to stay informed about ongoing invasive plant management research and new treatment options that could be used to control invasive plants and restore sites within target ecosystems in the future.

Following the initial treatments, the areas should be re-surveyed (monitored) after an appropriate amount of time to determine if the control measures are successful. This includes re-assessing the areas (polygons, points) initially mapped for density, distribution and abundance (% cover) of the target invasive species using the same methods as used during the initial survey. If there are still issues with invasive plants, then a second treatment cycle should be implemented. **Table A** outlines the necessary actions to ensure invasive plant infestations on disturbed sites are managed appropriately.

Table A. General steps to manage invasive and other non-native plant infestations on disturbed sites

Step	Action
1	Conduct an initial baseline survey to determine if invasive plant species are present in the proposed work area and along access roads to and within the work zone. Invasive and other alien plant species commonly found in the target ecosystems are included in **Table 1 of the background information document**. The other alien species are not designated as invasive, but some are very aggressive and can outcompete native species on disturbed sites.
2	Identify and map occurrences and concentrated patches of invasive plant species. Determine the extent of each infestation within the area and map using either a GPS tracklog or a hand-drawn polygon on an orthophoto. Label polygons appropriately with

[26] Invasive Species Alert! North Africa Grass https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/invasive-species/alerts/north_africa_grass_alert.pdf
[27] Okanagan Invasive Species Online - North Africa Grass https://www.oiso.ca/species/north-africa-grass/

Table A. General steps to manage invasive and other non-native plant infestations on disturbed sites

Step	Action
2 (continued)	unique identifiers. Take pictures of the infested areas to be treated and record GPS locations of photo areas and azimuth in the direction photos are taken.
3	For each invasive species (including non-designated species) within a mapped occurrence or patch, record density and distribution pattern using InvasivesBC codes[23] and estimate percent cover.
4	Based on the species identified and extent of an infestation, determine which treatment type is most appropriate (mechanical, chemical, or biological).
5	Treat invasive plant infestations along access roads, ROWs, and on other disturbed sites prior to commencing work activities and document treatments used, date, time, application rates and other relevant information. If using herbicides, determine best timeline for applications from manufacturer recommendations.
6	Seed treated areas (with a site-appropriate native species mix) as soon as possible after treatments and when appropriate to do so.
7	During monitoring, re-measure density, distribution and % cover of each invasive species, and estimate % cover of seeded native grasses (by species if feasible) and native forbs/ shrubs within each mapped area (polygons, points). Re-take photographs.
8	Assess whether or not a second treatment is required. If so, plan and implement, possibly using a modified or different treatment method.

Additional information re: steps for controlling invasive plants is included in the background information document.

5.1.1.3 Ongoing Monitoring and Control of Invasive Plants

Set up an ongoing monitoring program to periodically assess the effectiveness of control treatments. As some treatments may fail or be partly unsuccessful, and treated areas will likely continue to be re-infested with invasive plants due to seed banks and/or seed spread from surrounding areas, it's important to conduct ongoing monitoring, invasive species control, and revegetation of treated sites. Additional information on steps to take in an ongoing monitoring and control program is provided in the background information document. With respect to revegetating sites, see section 6.1.3 Steps for Revegetating Disturbed Sites.

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, both of which 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 field manual. Potential steps involved with rehabilitating disturbed sites are briefly described in the following section. Additional information on rehabilitation techniques is provided in the background information document and in the Tools and Techniques section of the Soil Rehabilitation Guidebook by the B.C. Ministry of Forests[28].

- *Recontour and restore drainage patterns on highly disturbed sites*
  Recontour highly disturbed areas to re-establish and stabilize natural slopes and restore naturally-occurring drainage patterns.

- *Retention of Topsoil*
  Topsoil could be removed and stored during excavation work at a site and redistributed after completing the work to increase the chances of successfully re-establishing vegetation.

- *Soil Tillage*
  Tillage is used primarily to decompact the soil and re-establish soil porosity, thereby 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. After tilling, leaving sites "rough and loose" (i.e., uneven ground surfaces with loose soil conditions) provides more suitable microsites and better substrates for seed germination and seedling survival.

- *Soil amendments, fertilizers and mulches*
  The productivity of mineral soils could be improved by adding organic material and nutrients.
  - **Soil amendments** are organic materials that can be added to soils to restore soil organic matter, long-term nutrient status, and soil structure. Examples of soil amendments include topsoil, manure, compost, hay, and straw. Care must be taken to ensure that amendments added to soils are not contaminated with non-native plant seeds.

  - Quick-release 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. However, the fast-release fertilizers can result in burning plants if over applied or improperly diluted and are quickly leached out of the soil by regular rain or watering. Therefore, repeat applications may be required until the internal nutrient cycle of the site is re-established and can meet the needs of the vegetation. Slow-release synthetic or organic fertilizers are preferred over fast-release chemical fertilizers for seeded/planted native species as they provide a steady supply of plant nutrients over an extended period of time, eliminate the risk of fertilizer burn, and are less likely to be leached out of the soil.

[28] https://www.for.gov.bc.ca/ftp/hfp/external/!publish/FPC%20archive/old%20web%20site%20contents/fpc/fpcguide/soilreha/rehab3.htm#begin

Transplant fertilizer paks (teabags) can also be used to fertilize tree or shrub seedlings at the time of planting[29]. The biodegradable packets include formulations of N, P, K and other nutrients specially developed for specific plants and sites. The packets placed into the planting holes next to the seedlings provide a slow-release, balanced supply of nutrients that help the seedlings quickly transition from the nursery to the site. Hydration paks are fertilizer paks that also contain moisture-retaining polymers to assist seedling establishment on dry sites. The polymers act as a sponge, absorbing moisture when available and releasing it back to the seedlings when there are soil moisture deficiencies[30].

*Fertilizers should only be added to the soil to the extent necessary to revegetate target ecosystem sites. Once established, appropriate native species that are adapted to dry, poor-nutrient soils should require minimal or no fertilization.

- **Mulches** 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:
  thick mulches - relatively thick layers (5-10 cm) of organic material often used with planted shrubs and trees on drought-prone sites
  thin mulches - thin layers (e.g. ground wood fibres) primarily applied during hydroseeding which can also be applied as a separate layer after seeding
  manufactured mulch mats – plastic and fibre matting and netting materials that are useful for erosion control, in building soil, improving surface soil conditions, and restoring soil organic matter; some products also aid in germination and vegetation establishment

6.1.2 Develop a Revegetation Management Plan

It's important to revegetate sites after soil disturbance and/or invasive plant treatments to stabilize soils and control soil erosion, deter the establishment and/or spread of invasive and other non-native plant species, maintain/enhance biodiversity on the sites, and provide forage and/or habitat for wildlife. It is recommended that a **Revegetation Management Plan** be developed for treating the various sites that will require revegetation after the work is completed. Plan development includes consideration of the following information:

- rehabilitation objectives for the different sites,
- best approaches for revegetating sites based on the objectives and goals,
- appropriate native species and native seed mixes (if available) for use in the target ecosystems,
- provisions to collect and stratify native seed (ensuring provenance) whenever possible,
- seeding techniques, seeding rates, and timing of seeding,
- species selection and planting densities if revegetating with nursery stock,
- soil amendments/fertilizers/mulches tailored to the target plants and site conditions,
- plant maintenance requirements and methods (e.g. irrigation, browse protection, staking, etc.),
- methods for establishing and documenting treatments, including any reseeding/replanting, and
- methods for setting up a monitoring program.

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[29] https://www.reforest.com/teabag-fertilizer
https://www.reforest.com/canada-forestry-products
[30] https://www.reforest.com/hydrationpak16-8-5

*During development of the plan, it would be useful to review past/ongoing revegetation trials and monitoring in target ecosystems to determine what treatments have been unsuccessful and which ones have worked or are currently working.

6.1.3 Steps for Revegetating Disturbed Sites

Depending on the ecosystem, sites can be revegetated by spreading native seed, and/or by planting native grasses, forbs and/or shrubs as supplements or alternatives to seeding. Trees may be planted to meet specific wildlife needs and/or to advance succession during restoration of target forested ecosystems. Suggested methods for revegetating disturbed sites are as follows:

- *Revegetate soils immediately after disturbance*
  The goal is to quickly establish ground cover to stabilize the soils, reduce soil erosion, and compete with 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 these are best adapted to the environmental conditions in the geographic areas where they are collected. At this time, native plant materials from local sources are not available for revegetating, restoring or enhancing sites at an operational scale. As part of the process to produce locally-sourced material to supply future revegetation projects, 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 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. A number of 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 prepared by the Kootenay Conservation Program (KCP) in 2022[31].

- *Revegetate disturbed soils initially by seeding native grass and forb species*
  Broadcast spreading of grass and forb seeds is 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 target ecosystems is highly recommended, as those species will more likely become established on the sites and contribute to the biodiversity and wildlife habitat in the area. A number of native grass and forb species suitable for revegetating target ecosystems in the West Kootenay Region are listed in **Table B** (derived from Table 2 in the background information document). The table also identifies native species that have seeds available in commercial quantities (**X**) and those that don't (*****). The commercially-available seeds are not derived from local sources in the West Kootenays.

[31] https://kootenayconservation.ca/our-publications/ (see 2022 South Selkirks–Lower Columbia Conservation Action Forum Summary Report)

Table B: Native grass and forb/low shrub species suitable for revegetating disturbed sites in target ecosystems [a]

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 (Seeds Available in Commercial Quantities)								
bluebunch wheatgrass [b]	*Pseudoroegneria spicata*	X	X	X		X	X	
Idaho fescue, (rough fescue) [b]	*Festuca idahoensis, (F. campestris)*	X	X			X	X	
junegrass [b]	*Koeleria macrantha*	X	X		X	X	X	
Sandberg's bluegrass [b]	*Poa secunda* ssp. *secunda*	X	X			X	X	
slender wheatgrass [b]	*Elymus trachycaulus* ssp. *trachycaulus*	X	X			X	X	X
hair bentgrass [b]	*Agrostis scabra*	X	X		X	X	X	X
needle-and-thread grass	*Hesperostipa comata*			X				
western fescue	*Festuca occidentalis*							X
blue wildrye	*Elymus glauca*							X
Grasses (Seeds Not Available in Commercially Quantities)								
stiff needlegrass	*Achnatherum occidentale ssp. pubescens*	*	*	*	*	*	*	
poverty oatgrass	*Danthonia spicatum*	*	*		*	*	*	*
mountain brome	*Bromus carinatus* var. *marginatus*	*	*				*	*
Scribner's witchgrass	*Dichanthelium oligosanthes ssp. scribnerianum*			*	*			
porcupinegrass	*Hesperostipa spartea*				*		*	
pinegrass	*Calamagrostis rubescens*		*			*	*	*
Forbs/*Low shrubs (Seeds Available in Commercial Quantities)								
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		
silky lupine	*Lupinus sericea*	X	X	X		X	X	X
yarrow	*Achillea millefolium*	X	X	X		X	X	X
*shrubby penstemon	*Penstemon fruticosus*	X	X			X		
fireweed	*Chamaenerion angustifolium*							X
pearly everlasting	*Anaphalis margaritacea*							X
western Canada goldenrod	*Solidago lepida*							X
Forbs/*Low shrubs (Seeds Not Available in Commercial Quantities)								

Table B: Native grass and forb/low shrub species suitable for revegetating disturbed sites in target ecosystems [a]

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**
selaginella	*Selaginella spp.*	*	*	*		*		
golden-aster	*Heterotheca villosa*	*	*	*		*	*	
pink fairies	*Clarkia pulchella*	*	*			*	*	
nodding onion	*Allium cernuum*	*	*			*	*	
thread-leaved phacelia	*Phacelia linearis*	*	*	*		*	*	
nine-leaved desert-parsley	*Lomatium triternatum*	*	*			*	*	
fern-leaved desert-parsley	*Lomatium dissectum*	*	*			*	*	
showy daisy	*Erigeron speciosus*	*	*				*	*
*kinnikinnick	*Arctostaphylos uva-ursi*	*	*		*	*	*	*
round-leaved alumroot	*Heuchera cylindrica*	*	*			*	*	
lanced-leaved stonecrop	*Sedum lanceolatum*	*	*			*	*	
paintbrush	*Castilleja* spp.	*	*			*	*	
Ross's sedge	*Carex rossii*	*	*	*		*	*	*
showy pussytoes	*Antennaria pulcherrima ssp. pulcherrima*		*					
silverleaf phacelia	*Phacelia hastata*		*	*		*	*	
northwestern sedge	*Carex concinnoides*		*			*	*	*
spreading dogbane	*Apocynum androsaemifolium*			*	*		*	*
Scouler's hawkweed	*Hieracium scouleri*					*	*	*
wild strawberry	*Fragaria virginiana*						*	*
wood strawberry	*Fragaria vesca*						*	*
rosy pussytoes	*Antennaria rosea*						*	*
pussytoes	*Antennaria spp.*						*	*
Howell's pussytoes, (field pussytoes)	*Antennaria howellii ssp. howellii, (A. neglecta)*						*	*
white hawkweed	*Hieracium albiflorum*							*
showy aster	*Eurybia conspicua*							*
heart-leaved arnica	*Arnica cordifolia*							*

a – derived from Table 2 in the background information document
b – grass species included within the interior native dryland seed mix
X = seeds available in commercial quantities, * = seeds not available in commercial quantities
yellow highlight = nursery stock available

Until locally-sourced seeds are available for operational-level revegetation projects, using native seeds collected from non-local sources is the next best option for revegetating disturbed sites.

These non-local 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. The non-native species can also spread into other habitats where they may outcompete native plants and degrade ecosystems. **Seeding areas with native plant seeds derived from non-local sources is an interim measure until locally-sourced seeds become available in sufficient quantities to supply the needs for revegetating, restoring and enhancing sites in the target ecosystems.**

Based on species suitability and availability of seed (Table B), a custom interior native dryland seed mix was developed for revegetating sites in a number of the target ecosystems. The trial seed mix includes six native grass species and the composition of the mix is shown in **Table C.** This interior native dryland mix (with additions of native forb seeds) could be used as an interim option to revegetate 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 C: 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**

Other native grass and forb seed mixes can be developed for target ecosystems using the information in Table B. The interior native dryland mix could 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.

Other custom seed mixes could be developed for revegetating sites in the Gb06 and the dry to slightly dry forest ecosystems (ICHdw1/103 and ICHxw, xwa/104). For the Gb06 ecosystem, seeds for some of the suitable native grass species (poverty oatgrass, stiff needlegrass, porcupinegrass) are not commercially available and would need to be collected from local areas and produced in larger quantities by growing plants at a nursery. Seeds of those species could be combined with junegrass, hair bentgrass and some native forb seeds to create a custom Gb06 brushland native seed mix. For revegetating disturbed sites in dry to slightly dry forests, another custom mix could be developed by adding poverty oatgrass and appropriate native forb seeds to a mix that includes seeds of slender wheatgrass, hair bentgrass, western fescue and blue wildrye.
Seeds of native forb species should be added to the custom grass seed mixes described above to enhance species diversity and provide plants for pollinators when revegetating disturbed sites. Both grass and forb species are necessary to restore and maintain ecosystem integrity. Native forb/low shrub species suitable for revegetating sites in target ecosystems and that have commercially-

available seed (derived from sources outside the West Kootenays) are identified with an "**X**" in Table B. Some of the native forbs could also serve as **cover crops** to provide quick ground cover to reduce erosion and compete with invasive plants as the slower growing species in the mix become established. Golden-aster and pink fairies are two native forbs that could potentially serve as cover crops[32] when revegetating Gg11, Gb03, Gb05, and dry (102, 103) forest sites although their seeds are not available in commercial quantities at this time. Fireweed 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.

Additional information on native species and seed mixes suitable for revegetating sites in target ecosystems is provided in the background information document.

Native grass and forb seeds derived from sources located outside the West Kootenays are available in commercial quantities 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 purchasing seed from commercial suppliers, review Certificates of Seed Analysis to identify contamination by non-native plant seeds and ensure appropriate composition and quality of the mixes. Suppliers do not provide the certificates unless requested by the buyer[33]. Kinseed http://www.kinseed.ca/seeds/ located in Nelson sells small quantities of locally-sourced seed for some of the native forb species included in Table B. Seeds of those species could be added to native grass seed mixes used to revegetate small areas of disturbance within target ecosystems.

<u>Seeding Techniques, Seeding Densities, and Timing of Seeding</u>

- <u>Seeding Techniques</u>

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

  The **seed drill** is a device usually towed behind a tractor that evenly distributes seeds in rows, plants them at the desired rate (density), and buries them at a specified depth. Drill seeding is the most efficient and economical way to sow seeds in large areas of highly disturbed soils (e.g. cleared lands) with relatively gentle, smooth terrain. It is typically used in agriculture to sow seeds for crops but can also be used in reclamation and rehabilitation work (e.g. mine reclamation sites, portions of highway or pipeline corridors). The method would not be cost-effective for revegetating small areas and is not practical for use on steeper slopes and/or rough, uneven sites, which are typical in most of the target ecosystems.

  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 (e.g. push-type or hand-crank spreaders) to achieve a more even seed distribution. These methods are practical and cost-effective for seeding smaller areas (up to a few hectares in size), including those

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[32] V. Huff, pers. comm.

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

difficult to access. Seeds spread on the ground surface can dry out, blow away, be washed away, and/or be eaten by insects, birds, and small mammals. Raking seeded areas to lightly scarify the seeds and improve seed to soil contact can improve broadcast seeding results.

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 a) seeds can be carried by the water jet to cover larger areas more quickly, b) better seed dispersal, and c) enhanced seed germination. However, this method requires a source of water and can't be used on steep slopes.

Hydroseeding (hydraulic seeding) spreads seeds in a slurry with a binding agent (tackifier) that binds the seeds to the ground. Mulch may or may not be included in the slurry. This method has the following advantages over other seeding methods:

- seeds can be spread on steep slopes as the binding agent tacks the seeds to the soil,
- the binding agent 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 seed desiccation and enhancing germination,
- fertilizers can be added to the mix, and
- seeds can be evenly distributed on sites through the spraying of the slurry.

The disadvantages of hydroseeding are the high cost, a source of water is required for the slurry, and adding mulch to the slurry can result in poor seed-soil contact and seedling mortality after germination. Mulch could be applied after seeding to avoid this problem, at an increased cost.

- Seeding Densities (Rates)

Seeding rates for seed mixes depend on the species in the mixes, seeding method, and reclamation objectives. Information (see background information document) suggests that dry broadcast seeding densities appropriate for dry sites in the interior of B.C. range from ~ 550 seed/m^2 (~50 seeds/ft^2) to ~1500 seeds/m^2 (~140 seeds/ft^2) based on pure live seed (PLS)[34]. Additional information indicates that a rate of 10 kg/ha corresponds to a seed density of ~350 - 450 PLS/m^2 for dryland seed mixes. The following rates are suggested to meet seed density targets using different seeding methods (**Table D)**.

Table D. Recommended seeding densities and rates by seeding method for revegetating disturbed sites in target ecosystems

Seeding Method	Seed Density Targets	Seeding Rates	Comments
seed drill	400 - 700 PLS/m^2 (~37 - 65 seeds/ft^2)	12 – 20 kg/ha	This efficient method for sowing seeds requires lower seeding rates compared to dry broadcast seeding.
dry broadcast seeding	800 – 1400 PLS/m^2 (~75 – 130 seeds/ft^2)	25 – 40 kg/ha	Several sources recommend that the seeding rates be double the rates for drill seeding.
wet broadcast seeding	1050 – 1850 PLS/m^2 (100 – 175 seeds/m2)	35 – 55 kg/ha	Seeding rates recommended to be 1.33 times higher than dry broadcast seeding rates.[35]

[34] % pure live seed (PLS) = germination rate (%) X purity (100% - % inert material) for each species
[35] https://www.for.gov.bc.ca/ftp/hfp/external/!publish/FPC%20archive/old%20web%20site%20contents/fpc/fpcguide/soilreha/app2.htm

Seeding Method	Seed Density Targets	Seeding Rates	Comments
hydroseeding	1400 – 2100 seeds/m^2 (~130 – 200 seeds/ft^2)	40 – 60 kg/ha	Seeding rates recommended to be 1.5 times higher than the dry broadcast seeding rates (3 times higher than the drill seeding rates).

Applying seed at the lower rate initially is recommended, with an increase if necessary to achieve adequate vegetation cover on a site. Applying too much seed can result in excessive competition for limited resources among germinants, leading to lower seedling survival. More information on seeding techniques and seeding densities is provided in the background information document.

- 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, depending on the year) is the best time for seeding as seeds 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 strong seed germination, 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. 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 loss of seed to birds (including wild turkeys) and other wildlife at different broadcast seeding times is briefly discussed in the background information document.

- Post-seeding Treatment
  A slurry of mulch with a binding agent could be applied to a site immediately after seeding. As with hydroseeding (see above under "Seeding Techniques"), the thin layer of mulch sticks to the soil. It 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.

  Additional information on revegetation techniques for grass and forb seeding can be found in the background information document and in Appendix 2 of the B.C. Ministry of Forests Soil Rehabilitation Guidebook[35].

- Documentation of Seeding Treatments
  At each treatment site, the following information could be recorded at the time of seeding:
  - Date, Project I.D., Site I.D., Surveyors
  - Location (general location description and UTM coordinates)
  - Site features (elevation, slope, aspect and slope position)
  - Target ecosystem (e.g. ICHxw/Gb03)
  - Initial or repeat application #
  - Total area seeded (m^2)
  - Seed mix used

- Seeding rate (e.g. 0.25 kg/100m^2 or 25 kg/ha)
- Seeding method (e.g. dry broadcast seeding and seeding device)
- Mulching treatment if applied after seeding
- Type and timing of any herbicide treatment applied to the site to manage invasive plants prior to seeding
- Alien (non-native) species present on the treatment site and/or in the vicinity of the site and the abundance (% cover) of each
- Distribution and density of each invasive plant species on the site (use codes in InvasivesBC: Terrestrial Observation Field Forms)[23]
- Total % cover of invasive plant species on the site
- Total % cover of other (non-invasive) alien plant species on the site
- Native plant species on the site and % cover of each
- Photos of site taken from pre-determined photo point locations
- Comments (e.g. site, substrates, soil, weather conditions, wildlife use in area, other)

Data forms for documenting seeding treatments are included in Appendix II.

- *Revegetate disturbed sites using native grass and forb seedlings*
  Small areas of disturbance and/or areas difficult to revegetate using a seed mix could be revegetated by planting grass and forb seedlings grown in a plant nursery. Although this treatment is more expensive, it has several advantages over spreading seeds:
  - planting nursery stock may result in better establishment and faster growth of desired species,
  - it can promote establishment of species difficult to establish from seed (e.g. bluebunch wheatgrass, silky lupine),
  - seedlings can be planted at the desired densities, and
  - it can facilitate achieving a species composition similar to that of the target ecosystem.

  Grass and forb species suitable for revegetating target ecosystem sites and available as nursery stock are highlighted in yellow in **Table B.** Most of the species are available at Nupqu Native Plant Nursery https://nupqu.com/native-plants-inventory/ near Cranbrook, 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.

These commercially-available seedlings are currently grown in nurseries from seeds sourced outside the West Kootenay region. Planting these seedlings provides an interim treatment option until 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, species, and their associated sizes and growth habits. Recommended planting densities for herbaceous species range from 10-15 plants/m^2 (~0.3-0.25 m spacing between plants) for grasses and 5-9 plants/m^2 (~0.5-0.3 m spacing) for forbs[36], and 10-1 plant/m^2 using 0.3-1 m (1-3 feet) spacing for both grasses and forbs[37].

  Intact (undisturbed) native plant communities on similar sites should be evaluated to determine plant densities for particular species. Densities observed on similar undisturbed sites can be used as a guide for determining planting densities on revegetated sites.

[36] https://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/agdex6123/$FILE/580_3.pdf
[37] https://green2.kingcounty.gov/gonative/Article.aspx?Act=view&ArticleID=24&PgNum=1

Native grass and forb seedlings could also be planted at higher overall densities (to compete with invasive plants in areas susceptible to infestations) or in denser patches (clusters) with wider spacing between the patches (to take advantage of favourable microsites). See cluster planting under shrub planting densities below.

- Timing of Planting
  Native grass and forb seedlings have the best chance of surviving if transplanted in the spring when they are still dormant. Transplants should be hardened-off (kept cold and relatively dry) prior to planting[29].

- Species Composition
  Benchmark ranges of abundance (% cover) for grass and forb species in target ecosystems are shown in **Table 4 in the background information document**. These ranges can be used to inform the appropriate composition (proportions) of native grass/forb species when revegetating disturbed sites. They are based on vegetation tables and descriptions for target ecosystems included in the Land Management Handbook (LMH) 70 ecosystem field guide for the south-central Columbia Mountains[38].

- Seedling care/maintenance
  Native grass/forb seedlings may require some care and maintenance for establishment, including the following steps:
  - *Improve soil nutrient levels* on poor-nutrient sites to enhance growth by applying a slow-release synthetic or organic bulk fertilizer prior to planting or by using repeat applications of fast-release chemical fertilizers (see “Soil amendments, fertilizers and mulches” in section 6.1.1). **Native herbaceous species adapted to dry shallow soils with low nutrient availability in target ecosystems may require minimal or no fertilization.**
  - *Supplemental watering* may be required in the first growing season during drought periods, and for up to three growing seasons if drought conditions persist[39]. Hydration paks (fertilizer paks with moisture-retaining polymers) could also be added during planting to provide moisture to seedlings during times of moisture stress (see section 6.1.1 as above).
  - *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 complement to supplemental watering and/or using hydration paks. 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 to detect new occurrences of invasive plants and treat/retreat to prevent new infestations from developing. Also, treat invasive plants in surrounding areas to eliminate neighbouring seed sources. Manage for healthy native plant seedlings that can out-compete invasive and other non-native plant species[39].

[38] https://www.for.gov.bc.ca/hfd/pubs/docs/lmh/LMH70.pdf
[39] Section 7 in Appendix 4 of Riparian Areas Regulation (RAR) Implementation Guidebook https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/riparian-areas-regulations/rar_reveg_guidebk_sept6_2012_final.pdf

- *Revegetate disturbed sites using shrub and/or tree seedlings*

  Although shrubs would likely recolonize disturbed brushland and dry open forest sites naturally over time, it may be desirable to plant native shrubs (as a stand-alone treatment or in conjunction with establishing native grass and forb cover) to accelerate shrub re-establishment and advance succession. Planting cuttings and/or nursery-grown shrubs is considerably more expensive than spreading native grass/forb seeds to revegetate sites, but it has some advantages. Shrub thickets tend to exclude invasive plants more effectively than grasses and forbs, while also providing habitat (food source, protective cover) for ungulates and other wildlife species. Also, planting shrubs could be used as a treatment to restore already degraded sites where it is difficult to establish a ground cover of grasses and forbs, and to provide structural deterrents to recreational disturbance (e.g., dirt bikes, ATVs, mountain bikes) where needed.

  Native shrub species that are suitable for revegetating dry to slightly dry sites associated with the target ecosystems are listed in **Table 5 in the background information document**. Some of the species that typically grow to a maximum height of 2 m and may be preferred for growing along transmission line corridors include mallow ninebark, snowberry, Oregon-grape, birch-leaved spirea, baldhip rose, prairie rose, common juniper, snowbrush (Gb06) and falsebox (ICHdw1 and dm units). The other suitable species that grow taller than 2 m are saskatoon, ocean spray, mock orange, redstem ceanothus, chokecherry and smooth sumac on dry sites, and Douglas maple and willow species in dry to slightly dry forest ecosystems (ICHdw1/103, ICHxw, xwa/104).

  Flammability is another characteristic to consider when selecting suitable shrub species and planting densities for revegetation. For example, snowbrush burns "quite hot" as the foliage contains volatile oils, so the shrubs could contribute to the fire hazard on a site[40].

  Many of the native shrubs are available at Nupqu Native Plant Nursery https://nupqu.com/native-plants-inventory/ , Sagebrush Nursery https://sagebrushnursery.com/stock/7 and Bron & Sons Nursery Co. https://www.bronandsons.com/info/native-plant-list-new.html. Shrub nursery stock is grown from seeds sourced outside the West Kootenays and cuttings for suitable shrub species are also currently not available locally. As soon as locally-sourced seeds and/or cuttings become available, they should be prioritized for shrub revegetation.

  In some circumstances, the restoration objectives could include planting trees on disturbed sites in forested target ecosystems to meet specific wildlife needs and/or to advance succession.

  - Shrub and Tree Seedling Planting Densities

    Densities for planting native shrubs and trees depend on the target ecosystems, site conditions (moisture and nutrient availability, competition), and the species-specific requirements.

    Shrub seedlings

    Recommended shrub planting densities range from 1-2 plants/m^2 (1-0.7 m spacing between plants)[36] to a much lower density of 1 plant/2-5 m^2 (1.5-3 m spacing)[37] that may be suitable for larger shrub species. As for planting native grass and forb seedlings, **assess target shrub densities by species in comparable undisturbed sites and use these densities as a guide for planting on revegetated sites**.

[40] Fire Effects Information System (FEIS) *Ceanothus velutinus* Fire Ecology https://www.fs.usda.gov/database/feis/plants/shrub/ceavel/all.html

Shrubs can be planted in a grid using even spacing or in clusters. Grid planting provides even coverage of an entire area but does not represent natural distribution of structure and is not visually appealing. Cluster planting involves planting shrubs in denser patches within a clumped pattern resulting in a more natural distribution and appearance. The technique can be used to plant shrubs at higher densities on favorable microsites and avoid planting in less desirable areas between those sites. It is also useful for controlling invasive plants on microsites susceptible to infestations, providing shaded habitat for later successional plant species, and creating a range of microhabitats, from dense shrub thickets to more open areas, thereby increasing site level biodiversity[41].

Within clusters, shrubs could be planted at higher densities of 10-16 plants/m^2 by using a spacing of 0.3-0.25 m between plants. The spacing between clumps would be determined based on maintaining a predetermined overall density for the site. For example, if the desired overall density was 2 shrubs/m^2, the spacing would be ~1.25 m between clumps of 10 plants and ~ 1.8 m between denser patches with 16 plants[41,42].

Tree seedlings

Recommended tree planting densities for the forested target ecosystems are based on provincial target and minimum stocking standards (for well-spaced trees in a free growing condition)[43]. For very dry, open forest site series (ICHxw, xwa/102, 103 and ICHdw1/ 102), target (and minimum) stocking standards are 600 (and 400) stems/ha. A spacing of 4-3.5 m (average 3.75 m) between seedlings 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 ecosystems (ICHdm/102, ICHdw1/103, ICHxw, xwa/104), the target (and minimum) stocking standards are 1000 (and 500) stems/ha. A spacing of 3-2.5 m (average 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

  Woody shrub and tree seedlings have the best chance of surviving if transplanted in the spring while still dormant. They 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[29]. Ensure all transplants are hardened-off prior to planting.

- 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 (e.g. ICHxw/102) in the LMH70 ecosystem field guide for the south-central Columbia Mountains[38]. The amounts can inform the appropriate composition (proportions) of native shrubs and/or trees to plant in treatment areas. An approximate proportion or *relative abundance* of each species in the shrub

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[41] https://publicdocs.nait.ca/sites/pd/_layouts/15/DocIdRedir.aspx?ID=4NUSZQ57DJN7-208515216-7464

[42] 10 plants in 1 m^2 clusters spaced ~1.25 m apart results in a density of 10 plants per 5 m^2 areas (2 plants/m^2) [(1 m + 1.25 m)^2 = (2.25 m)^2 = 5 m^2]; 16 plants in 1 m^2 clumps spaced ~1.8 m apart results in 16 plants per 8 m^2 areas (2 plant/m^2) [(1 m + 1.8 m)^2 = (2.8 m)^2 = 8 m^2]

[43] Reference Guide for Forest Development Plan Stocking Standards, Sept 7, 2021 https://alpha.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/silviculture/stocking-standards

or tree layer can be determined by dividing the average % cover of the species by the average total % cover for the layer.

- Seedling care/maintenance
  Native shrub and tree seedlings may require some care and maintenance before they become established. The following steps can aid in plant establishment[39]:
  - *Improve soil nutrient levels* to enhance seedling growth rates by applying a slow-release synthetic or organic bulk fertilizer to sites prior to planting, or by using small fertilizer paks (teabags) placed into the planting holes next to the seedling roots at the time of planting. Repeat applications of fast-release chemical fertilizers are less desirable as they can chemically burn the plants and are quickly leached out of the soils (see "Soil amendments, fertilizers and mulches" in section 6.1.1). **Native shrubs and trees appropriate for dry, nutrient-poor sites may require minimal or no fertilization, so fertilizers should only be used to the extent necessary.**
  - *Supplemental watering* may be required for one to three growing seasons during times of drought. Hydration paks could also be included during planting to provide moisture to seedlings during times of moisture stress (see section 6.1.1 as above).
  - *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 be used as a complement to supplemental watering and/or using hydration paks. Ensure that materials used for mulching are not contaminated with non-native plant seeds.
  - *Protect shrub and tree seedlings from wildlife browsing* by using stem collars, seedling covers, and/or and tree guards (netting, wire cages, stem guards) that are commercially available through nurseries and forestry supply outlets. Spray repellents to inhibit ungulate browsing and scare tactics such as sensor-controlled sprinklers or radios can also provide effective protection from animal damage. Selecting non-palatable species for revegetating sites is another way to reduce browsing losses.
  - *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 areas surrounding the treatment sites.
  - *Brush* around seedlings to reduce interspecific competition.
  - S*pace and thin* plants once they achieve a certain size to reduce competition and increase growth rates.

Record detailed information about treatments using planted nursery stock at the time of implementation. Also, document any care and maintenance steps taken to aid in seedling establishment.

- Documentation of Treatments using Planted Nursery Stock/Cuttings
  At each treatment site, the following information could be recorded at the time of planting:
  - Date, Project I.D., Site I.D., Surveyors
  - Location (general location description and UTM coordinates)
  - Site features (elevation, slope, aspect and slope position)
  - Target ecosystem (e.g. ICHxw/103)
  - Initial or repeat treatment #
  - Total area planted (m^2)
  - Species planted
  - Planting density (e.g. 2 stems/m^2) and total number of stems planted for each species

- % cover of each planted species and total % cover for all planted species
- Planted species composition by vegetation layer (based on % cover)
- Planting distribution pattern (e.g. grid or cluster planting for shrub species)
- Quality of planted species (use vigour codes 0 - dead, 1 - poor, 2 - fair, 3 - good, 4 – excellent)[44]
- Steps taken to aid in seedling establishment (see Seedling care/maintenance above)
- Native species (not planted) present on the site and % cover by species
- Non-native species (invasive and others of concern) present on and in the vicinity of the site and % cover by species
- Distribution and density[23] of each invasive plant species on the site
- Total % covers of invasive plants and other non-native plant species of concern on the site
- Photos of site taken from pre-determined photo point locations
- Comments (e.g., site, substrates, soil, weather conditions, wildlife use in area, effects of steps taken to aid in seedling establishment, other)

Appendix II includes data forms for documenting treatments using planted stock/cuttings.

6.1.4 Monitoring Revegetation Treatments

After the initial revegetation efforts are completed, it is essential to monitor for efficacy of treatments. Successful revegetation of disturbed soils using native species is the primary goal and often requires more than one treatment to be accomplished. Mineral soil must be adequately covered on seeded and or planted sites such that competitive effects are in place to prevent the establishment of invasive plant species. It is important to document the type of revegetation treatment used, and the timing of application and environmental conditions at the time of treatment. This information will aid in interpreting monitoring results.

A monitoring program could include reconnaissance surveys, photo monitoring, and/or systematic sampling.

Reconnaissance surveys involve walkthroughs of a treatment area noting changes in vegetation and site conditions that relate to the treatment objectives. The surveys provide a fast and effective way to assess relative changes within an area and include a) tracking the route walked noting specific locations of observations and b) photographing and recording notes about vegetation attributes (e.g., plant survival, condition, density, distribution, abundance and species composition), as well as invasive plant occurrences, wildlife use, and site and soil features.

Photo monitoring is a relatively easy, inexpensive and effective way to document vegetation and ecosystem change. It consists of repeat photography of vegetation features, the site or landscape over a period of time, with photographs taken from the same location and with the same field of view as the original photos. At a treatment area, photographs are taken prior to or at the time of the treatment and during post-treatment monitoring to document changes in the site conditions and vegetation composition, cover and condition over time. Permanent photo point locations should be established before the first treatment is applied so that photographs can be replicated during monitoring and compared to previous photos taken of the same area. Photo monitoring can include photo point monitoring and photo plot (quadrat) monitoring.

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[44] https://www.for.gov.bc.ca/hfd/pubs/docs/Lmh/Lmh25/Lmh25_2015.pdf (p. VEG.14)
When assessing vigour for each species, consider relative plant size, growth rate, leaf size, abundance of flowers or fruit, and amounts of wilting, chlorosis (yellowing) and necrosis (death of tissue due to disease).

Photo point monitoring typically involves taking profile (landscape) photos that show visual changes to a site over time due to changes in vegetation cover, density, distribution, and species composition, as well as height and plant vigour. The repeated photos can also show larger-scale changes to sites caused by erosion or disturbance by humans or wildlife. Photo point monitoring is typically used to provide qualitative information about a site but the photos can also be analyzed to provide quantitative data. Several quick guides to photo point monitoring are available online[45]. This type of monitoring can also be carried out using repeated aerial photos taken from a drone[46,47]. The qualitative information collected at photo points in combination with quantitative monitoring data is useful for assessing progress toward revegetating sites.

Photo plot (quadrat) monitoring involves taking repeated photographs looking straight 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 cover, species composition, plant vigour, 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 by *transect photo sampling*, where photo points are established at set intervals along a transect and photos are taken of the quadrat at each point along the line[48]. Photo plots can also be laid out systematically using a grid or located randomly within a sample area. Taking repeated photos of many small plots along transects, on a grid or at random locations within a treatment area provides sets of data that can be used to quantify ecosystem changes over time.

Photo monitoring can also be used for tree cover sampling[49]. The repeated photos are taken looking straight up from a permanently established plot location on the ground to show changes over time in crown size and canopy closure of trees (and/or tall shrubs). The overstories within plots could potentially be monitored by taking repeated photos from a drone as well.

Additional photos may be taken from the plot centre directed outward in each of four cardinal directions (north, east, south, west). Other photos can be taken looking downward to show proportions of substrates (e.g., organic matter, rocks, mineral soil) on the ground.

Systematic Sampling

Where more intensive sampling is appropriate for monitoring larger areas, systematic sampling can be used to collect detailed information for quantifying progress towards revegetating/restoring disturbed sites. General methods for conducting systematic sampling[50] are as follows:

1. Determine plot size and spacing based on size of treatment area and establish enough plots to cover a minimum of 5% of treated areas < or = 1 ha. in size. Sampling intensity in larger areas could be lower (1-5% of total area) depending on the variability within the units.
2. Stratify plots by habitat type/treatment unit if appropriate.

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[45] https://co-co.org/wp-content/uploads/2020/07/Photopoint_monitoring.pdf ; https://www.nrmsouth.org.au/wp-content/uploads/2014/08/Photo-Monitoring-Fact-Sheet-NRM-South.pdf ; https://efotg.sc.egov.usda.gov/references/public/NM/bio61a6_PhotoDocumentation_Protocol.pdf

[46] https://www.foresightdrones.com/photo-point-monitoring

[47] https://www.oregon.gov/oweb/Documents/Photo%20Point%20Monitoring%20Guide.pdf

[48] https://www.fs.usda.gov/pnw/pubs/pnw_gtr503.pdf

[49] https://www.fs.usda.gov/pnw/pubs/pnw_gtr526.pdf

[50] https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/riparian-areas-regulations/rar_reveg_guidebk_sept6_2012_final.pdf

3. Establish sample transects, plots and reference points in the field; permanently mark and collect GPS locations.
4. Establish photo points and/or plots if also collecting photo monitoring data.
5. Collect and record data pre-treatment and immediately post-treatment to capture baseline conditions.
6. Re-sample plots (repeat measurements) at intervals described within the monitoring program. Plots are usually sampled annually for the first 3 to 5 years, after which sampling may be repeated at extended intervals.
7. Determine analysis methods while designing the monitoring program to ensure data will provide accurate results.

Several monitoring techniques that are often used to systematically sample ecosystem parameters (response variables) include the line intercept method, the Daubenmire method, and fixed-radius plots[50,51]. The three techniques are briefly described below and discussed in more detail in the background information document.

The ***line intercept method*** is used to collect horizontal, linear measurements of plant intercepts along a transect. During sampling, a measuring tape is stretched out along the transect line and the horizontal linear length of each plant (by species) that intercepts the line is measured and recorded. The method can be used to assess species % cover and composition for herbs, shrubs, trees, and invasive species, but is best suited for assessing the shrub layer in a sample area. Other features such as average height and condition of each species can be recorded while photo monitoring can be used to document visual changes in vegetation (and substrates) along the lines. Additional information on establishing transects and calculating % cover by species, total cover, and species composition (based on % cover) is provided in the background information document.

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. Photo points and/or plots could also be established during transect lay out to conduct photo monitoring along the lines. Methods for collecting cover data within the quadrat areas and calculating species % cover, frequency, and composition along the transect lines are described in the background information document.

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 in both forested and non-forested habitats. Within a sample area, plots are often established in a systematic pattern using a grid (systematic or stratified systematic sampling) or located randomly. Plots can also be located subjectively to sample small or uncommon habitat types (e.g., grasslands, brushlands, wetlands), or target sites that might be missed by using a systematic or random sampling method. 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 and the plot size depends on the size and density of the plant species being assessed. Plot sizes used to sample different

[51] https://www.ntc.blm.gov/krc/uploads/296/TR%201734-04%20Sampling%20Veg%20Attributes%20%20(1996,%20revised%201999).pdf

vegetation layers, the types of data collected within plots, and the methods used to calculate ecosystem attribute values (e.g. mean % cover, species frequency, species composition) are briefly discussed in the background information document.

Documenting changes in vegetation on seeded and/or planted sites between monitoring times by collecting and assessing qualitative and/or quantitative data will indicate levels of revegetation success and the effectiveness of the treatments. If initial attempts to revegetate exposed mineral soil are not successful, second treatments should be planned using different application times, methods, and/or treatment types to achieve the desired outcome (see section 6.1.5 Adaptive Management). Monitoring should continue until the disturbed areas have been successfully revegetated. The number of attempts required to revegetate disturbed sites is expected to increase with accelerating climate change and its effects on local climatic conditions.

- Monitoring Seeding Treatments

  When monitoring seeding treatments, the following protocols are recommended:

  - Assess treatment areas in the 1st growing season after seeding and periodically in subsequent years (e.g., years 1, 2, 3, 5).
  - Assess seeding treatments in the early- to mid-summer when grasses have seed heads and forbs are flowering.
  - Schedule monitoring surveys to re-sample plants at similar stages of development each monitoring year

  Questions and points to consider when monitoring seeding treatments are presented in detail in the background information document and summarized as follows:

  - Consider the total % cover of seeded grasses and forbs at the site to determine if the seeding method resulted in good coverage of the treated area.

    - A suggested range for the total cover of seeded grasses is 15-50% . With forbs added to the seed mix, a suggested range for total cover of both seeded grasses and forbs is 20-50%, with forbs accounting for 5% to 20% and grasses accounting for 15% to 30% of the total. The total covers could also be higher than 50% where a) the low shrub kinnikinnick and/or the matted selaginella species naturally recolonize and spread on sites where the species were previously abundant, and/or b) seeded early-seral forbs, including cover crop species (e.g., silky lupine, yarrow, golden-aster, pink fairies, fireweed), are initially very abundant.

    - 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 might 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.

  - Consider the distribution of vegetation on the site; if the cover is patchy, determine why some soil patches are bare and re-treat.

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

- The composition of the seeded grass and forb species on a revegetated site should be comparable to the natural species composition in the target ecosystem. Guidelines for herb community composition within target ecosystems that can be used to evaluate seeded areas are shown in **Table 4 in the background information document**. A substantial difference in the herb community composition on a revegetated site (e.g., substantially higher covers for some of the more competitive species) could potentially result in a departure from the desired trajectory of succession. In those situations, the proportions of seeds in the seed mixes may need to be modified to alter the species composition on treated sites.

- Consider the % cover for each alien (invasive and non-invasive) plant species in treatment areas to determine changes in the diversity and abundance of non-native species since seeding occurred.

- Consider the % cover of each native species during monitoring to determine if the abundances of other native species (not in the seed mix) are changing in the treatment areas.

- Consider wildlife use in the treatment areas, including signs of birds and other wildlife feeding on seeds or vegetation.

- Based on the above points, the following information could be collected during monitoring of seeding treatments:
  - Date, project I.D., site I.D., surveyors
  - Location (general location description and UTM coordinates)
  - Monitoring time (e.g. Year 1)
  - Total % cover of seeded grasses and forbs
  - Distribution of seeded grasses and forbs (use distribution codes in the InvasivesBC Terrestrial Observation Field Forms)[23]
  - % cover of each seeded grass and forb species (if ID is possible)
  - Total % cover of other native species (not in the seed mix)
  - % cover of each of the other native species
  - Total % cover of invasive plant species
  - % cover of each invasive plant species
  - Density and distribution[23] of each invasive plant species
  - Total % cover of other (non-invasive) alien species
  - % cover of each of the other (non-invasive) alien species
  - Photos of site taken from pre-determined photo point locations (see the section on Photo Monitoring above)
  - Comments (site conditions, substrates, disturbance, wildlife use in treatment area, other)
  - If the site was reseeded (yes/no); if yes, total area reseeded, seed mix, seeding density, and seeding method

  Data forms for monitoring seeding treatments using fixed-radius plots are included in Appendix III.

- <u>Monitoring Treatments Using Planted Nursery Stock/Cuttings</u>

  - During monitoring of revegetation treatments using planted nursery stock, collect similar information as for monitoring seeding treatments including the following:

- Date, project I.D., site I.D., surveyors, location, and monitoring time
- Abundance (% cover) values for each (a) planted species, (b) other native species (not planted), (c) invasive species and (d) other (non-invasive) alien species
- Total % cover for each of the four species groups listed above
- Density and distribution[22] of each invasive plant species
- Photos and comments

Also, record information on the densities, vigour, and composition by vegetation layer (based on % covers) of planted species, and details about any replanting that takes place. **Appendix III includes data forms for monitoring planting treatments using fixed-radius plots.**

Data collected and summarized for ecosystem attributes (response variables) during monitoring of seeding and planted nursery stock/cuttings treatments can be compared to assess changes over time, and the results can be evaluated to determine treatment effectiveness.

For **seeding treatments**, compare data for the following attributes to assess changes over time:
- the density and distribution of native grass/forb seedlings to determine germination success and seedling survival after the first growing season,
- total % cover of seeded species to determine if cover is within suggested target range of % covers,
- distribution of seeded grass/forb cover to determine if vegetation is continuous or patchy,
- % cover of each seeded native species to determine if species proportions are similar to those on undisturbed sites of similar ecosystems.

For **planted nursery stock/cuttings treatments**, compare data for the following attributes:
- total live stem count per species to determine survival rates of planted seedlings/cuttings
- distribution of surviving plants/cuttings on site to identify site issues,
- vigour of planted species,
- total % cover of planted seedlings/cuttings to determine if site is becoming adequately revegetated,
- % cover of each planted species to determine species abundance and composition.

For **both seeding and planted nursery stock/cuttings treatments**, compare the following attributes:
- total % cover of other native vegetation not seeded/planted,
- % cover by species of native vegetation not seeded/planted,
- total % cover of invasive plant species,
- % cover, distribution and density of each invasive plant species,
- total % cover of other non-invasive alien plant species,
- % cover of each of the other non-native species.

6.1.5 Adaptive Management

Revegetation treatments on disturbed sites 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 outcomes (e.g. vegetation cover is within the suggested range of % covers for adequately revegetated sites). If the management objectives are not being met, then adjustments will need to be made to the site prescriptions. This approach corresponds to the passive adaptive management process[52], where actions considered to be the best

[52] 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

available options for meeting management objectives are implemented, and then effectiveness is informed by monitoring and evaluating the results. Evaluation outcomes are used to adjust the prescriptions and improve management practices. Additional information on the Adaptive Management process is included in the background information document.

6.1.5.1 Analysis of monitoring data

As part of the Adaptive Management process, monitoring data are collected, summarised and analysed at specified time intervals to determine treatment effectiveness. Methods used to analyse data collected during photo point and photo plot monitoring, reconnaissance surveys and systematic sampling, and the evaluation of results are described below.

Photo point monitoring data: Qualitative analysis of profile (landscape) photos is most common. The repeated photos show visual changes to a site over time with respect to changes in vegetation attributes (e.g., cover, density, distribution, height, vigour, species composition) as well as larger-scale changes due to erosion or disturbance by humans or wildlife. The relative changes are visually apparent and can be described qualitatively but are not measured. Replicated photos taken on different, but similar sites can also be used to compare responses to similar treatments in qualitative terms. Visual changes documented by photo point monitoring are useful for identifying "triggers" – pre-determined amounts of change indicating that treatment outcomes will likely not meet prescription goals and objectives, and that new or modified management actions (treatments) are needed (see section 6.1.5.2). The triggers can be further investigated by evaluating quantitative monitoring data, either derived by analysing repeat photography (see below) or collected during systematic sampling.

Photo grid analysis is used to collect quantitative data from landscape photos by placing a standardized grid over a photo and counting the number of intersects between grid lines and the feature of interest[53]. This type of analysis can be used to measure 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.

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 within small plot areas. The repeated digital photos show visual (qualitative) changes but can also be used to measure quantitative changes by means of photo grid analysis or by analysing 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 (response variables) such as vegetation cover and percentages of substrates within a plot (quadrat) area. The pixels of a specified color range within a sample set of an image (e.g., green of live vegetation in contrast to brown of soil on a recently revegetated site) can be counted to get a quantitative measurement of the area or proportion of an attribute (e.g. total % cover) within a plot[54].

In transect photo sampling, a number of plots located at pre-determined intervals along a transect are photographed 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 and then the quantitative data derived for different

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[53] https://www.fs.usda.gov/pnw/pubs/pnw_gtr526.pdf

[54] Ground-Based Image Collection and Analysis for Vegetation Monitoring. Technical Note 454. Part 2 https://www.blm.gov/sites/blm.gov/files/docs/2021-10/TN%20Samplepoint.pdf

attributes can be pooled for all plots to provide more accurate results with respect to changes in the response variables over time.

Repeated photographs taken in plots (either looking straight up from the ground or vertically down from a drone) to document changes in crown size and canopy closure of trees (and/or tall shrubs) can also be analysed using photo grid or digital image analysis to derive quantitative data. The data for each attribute can then be compared to assess changes over time.

Reconnaissance sampling monitoring data: Notes and photos collected at GPS-referenced points along a tracked route through a treatment area can be collected over multiple monitoring years to evaluate qualitative changes in vegetation and site conditions over time and treatment effectiveness. Visual changes documented during the surveys are used to inform management decisions about collecting and analysing additional monitoring data to evaluate quantitative changes, and/or adjusting prescriptions to improve the treatment outcomes. The observed changes can also be used to identify "triggers" – pre-determined conditions indicating that treatment responses have deviated away from the desired outcomes and management intervention is required (see section 6.1.5.2).

Systematic sampling monitoring data: Ecosystem data collected using the line intercept, Daubenmire and fixed radius plot sampling methods can be analysed to assess quantitative changes in species cover and composition over time. The Daubenmire and fixed radius plot methods can also be used to evaluate changes in other attributes including 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 compare tree density, size distribution and condition between monitoring times. The steps used to calculate attribute values for the three systematic sampling methods are described under "Systematic Sampling" in section 6.1.4 of the background information document.

Changes in attribute values over time can be described in terms of relative differences and trends, and where the sample sizes are sufficient, quantitative data can be analysed using statistical techniques to test for significance. The sampling unit is the transect in the line intercept sampling method, either the plot (quadrat) or transect in the Daubenmire method, and the plot when sampling areas using fixed radius plots. For analysing data collected using the above sampling methods, the paired t-test or the non-parametric Wilcoxon signed rank test can be used to test for significant changes in attribute values between two years, and repeated measures analysis of variance (ANOVA) is used to analyse data for three or more years[55].

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. **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 (e.g., adjust prescriptions) if monitoring results show that treatment responses are not progressing towards the desired outcomes. **Trigger points** identify when (at what point in the process) monitoring information is assessed to determine if thresholds have been reached or crossed, and if so, when new management actions are initiated to improve treatment

[55] https://www.ntc.blm.gov/krc/uploads/296/TR%201734-04%20Sampling%20Veg%20Attributes%20%20(1996,%20revised%201999).pdf

outcomes[56,57,58]. **Table E** provides examples of indicators, triggers and trigger points that could be used to determine if revegetation prescriptions require adjustments and when alternative actions would be implemented. The table also includes recommended actions for adjusting prescriptions to improve their effectiveness to meet management objectives.

Learning that takes place from evaluating monitoring results, adjusting prescriptions to improve treatment outcomes, and assessing the effectiveness of new treatments to achieve management goals is part of the adaptive management process. The information gleaned from the process should be incorporated into best management practices for revegetating disturbed sites in target ecosystems.

[56] https://besjournals.onlinelibrary.wiley.com/doi/pdf/10.1111/1365-2664.12734
[57] https://carlycookresearch.files.wordpress.com/2016/01/cook-et-al-2016-biol-cons.pdf
[58] https://besjouals.onlinelibrary.wiley.om/doi/10.1111/1365-2664.13042

Table E: Indicators, triggers, trigger points and recommended actions to improve outcomes of revegetation treatments

Revegetation Treatment Type	Indicators	Triggers	Trigger Points	Recommended Actions to Adjust Prescriptions
Seeding and/or planting nursery stock	total abundance (% cover) of invasive plant species	abundance of invasive species increases to > or = 1% cover	- end of 1st growing season (monitoring year 1) - end of subsequent growing seasons (monitoring years 2,3,5, …)	- treat invasive plants to control spread and prevent future infestations (invasive species are listed in **Table 1 of the background info document**) - determine total % cover in each subsequent monitoring year and treat as required
	abundance (% cover), density & distribution of individual invasive plant species	increase in abundance to > or = 1% cover, increase in density from low to medium (InvasivesBC density code 2) or higher, or increase in distribution (InvasivesBC code 3 or higher)	as above	- treat individual species that increase to the specified level of % cover, density or distribution - eliminate noxious and other aggressive invasive plant species were possible
	total abundance (% cover) of all other alien plant species (not designated as invasive)	abundance of other alien plant species increases to > or = 1% cover	as above	- assess potential for aggressive alien plant species to outcompete seeded/planted native species and take over the site and treat as required (other alien plant species that are common in the project area are included in **Table 1 of the background information document**)
	abundance (% cover) of individual other aggressive nuisance & alien species	abundance of any individual aggressive alien species increases to > or = 1% cover	as above	- assess potential for individual aggressive nuisance and other alien species to spread and outcompete seeded/planted native species and treat as required
	total abundance (% cover) of all other native species not seeded/planted	site filling in with other native species that are outcompeting seeded /planted species	end of 2nd growing season (monitoring year 2)	- no fill-in seeding or planting required if site becoming revegetated by other native species considered desirable (see below)
	abundance (% cover) of individual native species not seeded/ planted	site filling in with opportunistic native species in areas where not previously dominant	as above	- may require treating undesirable native species that are reducing biodiversity and cover of seeded/planted or other desired native species (e.g. cutting bracken twice during the growing seasons); reseed/replant and treat competing vegetation until the seeded/planted or other desirable native species become established on the site
Seeding	density of seedlings	low density (e.g., < 2-5 seedlings/ft^2) indicating poor seed germination and/or seedling survival	- end of 1st and 2nd full growing seasons (monitoring years 1, 2)	- determine reasons for poor germination (low seed viability, unfavorable climatic conditions at the time of seeding, loss to wildlife) and/or poor seedling survival (unfavorable climatic conditions during growing season, harsh site conditions, competing vegetation) -treat competing vegetation (e.g., invasive plants) if required; improve

Table E: Indicators, triggers, trigger points and recommended actions to improve outcomes of revegetation treatments

Revegetation Treatment Type	Indicators	Triggers	Trigger Points	Recommended Actions to Adjust Prescriptions
Seeding (continued)				site conditions if feasible; reseed, potentially adjusting the timing of seeding during the growing season and/or increasing the seed application rate; protect seeds from wildlife if necessary
	distribution of seedlings	patchy distribution of seedling cover	as above	- determine reasons for poor germination and/or poor seedling survival in some areas of the site - remediate portions of the sites (e.g., treat competing vegetation, decompact, add soil supplements) if required and then reseed bare patches, potentially adjusting the timing of seeding and/or increasing the application rate
	abundance (% cover) of seeded species	total cover of grasses/ forbs not in the range of 20-50%	end of 2nd full growing season (monitoring year 2)	- determine reasons for low cover (e.g., poor germination, poor seedling survival and/or poor growth due to factors described above), or high cover due to proliferation of seeded and/or other native species
		cover < 20%		- treat competing vegetation if required; improve site if feasible; reseed with a modified seed mix and/or higher application rate; protect seed from wildlife if necessary
		cover > 50%		reduce seeding rate for future treatments on similar sites
	relative abundance (proportions) of seeded species	species proportions not similar to those found in intact ecosystems on similar sites	end of 3rd full growing season (monitoring year 3)	- reseed site with species that have substantially lower abundances (% covers) than in intact (reference) ecosystems on similar sites - modify seed mix (adjust species proportions) for future treatments on similar sites to change species composition (**refer to Table 4 in the background information document**)
Planting nursery stock	density of all planted species	low stem count due to poor survival	- end of 1st full growing season (monitoring year 1 - end of 2nd full growing season (monitoring year 2)	- determine reasons for poor survival (poor-quality stock; unfavorable climatic conditions at the time of planting, during the growing season or over the winter; harsh site conditions, competing vegetation) - treat competing vegetation if required; replant good-quality stock, potentially at a different time during the growing season when climatic conditions are more favorable for survival and growth
Planting nursery stock (continued)	density of individual planted species	as above	as above	- determine reasons for poor survival of individual species (poor-quality stock; unfavorable climatic conditions for species; harsh site conditions) - fill-in plant species that had poor survival using good-quality stock and potentially at a different time during the growing season when climatic conditions are more favorable - consider replanting alternative species if poor survival observed at the end of 2nd growing season

Table E: Indicators, triggers, trigger points and recommended actions to improve outcomes of revegetation treatments

Revegetation Treatment Type	Indicators	Triggers	Trigger Points	Recommended Actions to Adjust Prescriptions
	distribution of planted species	patchy distribution	as above	- determine reasons for lack of survival in some parts of the site - remediate portions of the sites as required (as for distribution of seedlings) and replant, potentially at a different time in the growing season and/or using alternative species on harsh sites
	condition (vigour) of planted species	all species with low vigour	as above	- determine reasons for low vigour (poor-quality stock; unfavorable climatic conditions (e.g., drought); unfavorable site conditions (e.g., poor-nutrient availability); forage/browse by wildlife; competing vegetation) - treat competing vegetation if required; water plants in drought conditions if practical; provide soil supplements on poor-nutrient sites, protect plants from wildlife use
		individual species with low vigour	as above	- determine reasons for low vigour of individual species - take actions (as above) - consider using alternative species if low vigor persists at the end of the 2nd growing season after adjustments
	abundance (% cover)	low cover due to poor survival and/or poor growth	- end of 2nd full growing season (monitoring year 2)	- determine reasons for low cover (poor-quality stock, unfavorable climatic conditions, harsh site conditions, forage/browse by wildlife - improve site conditions if required; replant species with higher survival rates using good-quality stock and potentially at a different time during the growing season when climatic conditions are more favorable; provide protection from wildlife use if necessary and feasible
			- end of 3rd full growing season (monitoring year 3)	- re-assess % cover and vigour of species in year 3 and if required, fill-in plant with appropriate native species that demonstrate good survival and growth rates on the site
	relative abundance (proportions) of planted species	species proportions not comparable to those found in intact ecosystems on similar sites	end of 3rd full growing season (monitoring year 3)	- replant site with species that have substantially lower abundances (% covers) than in intact (reference) ecosystems on similar sites - modify planting (adjust species proportions) for future treatments on similar sites to change species composition (see **Table 4 in background information document** for species composition in herb layers of intact target ecosystems; see BEC unit and grassland group **Vegetation Tables in LMH70**[31] for species compositions in shrub and tree layers)

6.2 Ecosystem Restoration

Ecosystem restoration can be a valuable conservation tool for restoring "fire-maintained" ecosystems and maintaining representative areas of the target ecosystems. In the absence of invasive plants, prescribed fire can be used to restore and maintain the open habitat structures of grasslands, brushlands, and dry open forests that were prevalent before fire suppression. Slashing prescriptions can also be used to partially emulate fire effects 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. 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

The loss of frequent fires on the landscape about 80 years ago due to systematic fire suppression resulted in a gradual shift in ecosystem structure where open grasslands and shrublands became treed habitats and open forests became closed forests. Ecosystem Restoration takes the corrective action necessary to reduce tree encroachment and forest ingrowth and restore the open habitats to their natural conditions prior to fire exclusion.

General steps used to meet the goals of an Ecosystem Restoration (ER) project are as follows:

- identify sites in the area of interest that are suitable for ecosystem restoration
- develop treatment prescriptions for the areas
- evaluate occurrences of invasive and other non-native plant species of concern and potential for spread in proposed treatment units and modify/change prescriptions if required
- conduct pre-treatment wildlife habitat features (WHFs) surveys (during the breeding season, if possible) and nest sweeps (if surveys are scheduled during the bird breeding season) and use the information to adjust treatment unit boundaries and delineate retention patches or individual trees/shrubs for buffering specific WHFs.
- conduct pre-treatment (baseline) surveys to identify at-risk ecological communities and plant species within treatment units that could be negatively impacted by treatments (slashing, stand thinning and/or introduced fire); adjust prescriptions to minimize potential unintended impacts to listed ecosystems and species caused by piling and burning of slashing/harvesting debris and/or a hot fire
- establish permanent sample plots in the ER units and outside the units (control plots) and complete pre-treatment monitoring surveys (collect ecosystem and potentially SAR/wildlife data) to document baseline conditions and use of sites prior to treatments
- treat entire units or selected areas within units using fuel management treatments including slashing to reduce understory fuel loads, stand thinning and/or prescribed burning*
- set up a monitoring program to resample plots (recollect ecosystem and potentially SAR/wildlife data) at set time intervals after treatments; the program would also include post-treatment monitoring of WHFs and at-risk ecological communities and plant species to ensure that any special features and listed ecosystems and plants were not harmed by the effects of treatments (e.g., proliferation of invasive plant species, major shifts in dominance of native plants)
- use the monitoring information to document ecosystem changes over time and determine site impacts and the effectiveness of the treatment prescriptions to achieve the restoration goals
- summarize the methods and results of the monitoring surveys and incorporate findings into the best management practices for restoring fire-maintained ecosystems

*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 FLNRORD (2022)[59].

Several examples of ecosystem restoration currently being carried out in the south West Kootenay Region include ER projects in non-forested Gb brushlands and in dry forest ecosystems.

6.2.1.1 Ecosystem Restoration in a non-forested Gb ecosystem

Ecosystem restoration was carried out in a Gb06 ecosystem 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 Water, Lands and Resource Stewardship (WLRS) in cooperation with The Land Conservancy. Slashing treatments were used to remove young ponderosa pine (Py) and Douglas-fir (Fd) trees encroaching into the habitat to restore an open-growing brushland with well-spaced mature and veteran Py and Fd (< 10% cover) and a healthy, productive understory of native shrubs, grasses and forbs. Prescribed fire was not used at this site due to the risk of invasive plant establishment/spread and the possibility of past soil contamination by heavy metals from the Teck smelter. Best management practices for working in this sensitive ecosystem include avoiding/minimizing disturbance to wildlife and plant species at risk (SAR), and minimizing disturbance to the thin, organic-enriched (Ah) soil horizons (uppermost layers of mineral soils) and the lichen (cryptogamic) crusts growing on the surface of the dry, coarse-textured soils.

The following mitigation measures are recommended to avoid/minimize disturbance to SAR species:

- conduct pre-treatment surveys to identify wildlife species-at-risk, their habitats and WHFs that could be negatively impacted by work activities and use the information to:
  - avoid work during the most sensitive periods for identified wildlife species,
  - schedule timing of treatments to avoid disturbing nesting birds; otherwise, conduct nest sweeps prior to commencing work
  - potentially adjust treatment unit boundaries and prescriptions to protect critical habitats and WHFs used by the SAR species; if disturbance is unavoidable, then don't disturb active nests, roosts, burrows and dens until animals have vacated
- conduct at-risk plant surveys prior to treating the site; delineate and protect any listed plant occurrences that could be negatively impacted by the effects of treatments (e.g., avoid slash piling and soil disturbance within any listed plant populations and surrounding buffer zones)

Mitigation measures that can be used to minimize damage to the lichen crusts in Gb06 ecosystems include:

- excluding motorized vehicles from the treatment area,
- minimizing the number of people walking in the treatment area, and
- training personnel to identify areas dominated by cryptogamic crusts and to avoid those areas by walking on areas with more herb (grass, forb, kinnikinnick) and moss cover.

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

[59] https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/invasive-species/publications/prescribed_fire_and_invasive_plants_manual.pdf

6.2.1.2 Ecosystem Restoration in dry forested ecosystems

Ecosystem Restoration (ER) is also being used to restore dry open forests negatively impacted by fire exclusion and forest ingrowth in the Lower Arrow Lake Reservoir area. The **Lower Arrow NDT4-ER Project** was initiated in 2011 and is a collaborative effort supported by the FWCP section of the Ministry of Water, Lands and Resource Stewardship (WLRS) and BC Parks. The target ecosystems in the project area are the dry 103 forest site series within the ICHxwa, xw, and dw1 biogeoclimatic units, and the desired condition of the restored ecosystems is open Douglas-fir – Ponderosa pine (FdPy) stands with rejuvenated understories of fire-adapted native shrub and herb species.

As for ER projects in non-forested ecosystems, on-the-ground operations usually involves thinning of trees and/or the re-introduction of low-intensity prescribed fire. Trees are maintained during the prescribed burns by disrupting horizontal and vertical fuel continuity through the management of surface and ladder fuels. 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.

The monitoring program for the Lower Arrow ER project was initiated in 2014 and has been ongoing to the present. Detailed methods used to establish pre-treatment monitoring plots and sample plots pre- and post-treatment are described in the initial monitoring report *Natural Disturbance Type (NDT) 4 – Ecological Restoration (ER) – 2014 Project: Summary of Pre-treatment Monitoring Survey*[60]. The monitoring results have been summarized in reports for each survey year since 2014 and document changes in a number of ecosystem parameters observed between the pre- and post-treatment surveys. Substantial differences in parameter values (% covers, species relative abundance, tree counts, CWD measurements) between monitoring years indicate ecosystem changes due to the effects of the treatments, variations in climatic conditions, and/or variations in other factors such as wildlife use (e.g. browsing) and timing of the surveys during the growing season.

Additional information on ecosystem restoration and the ER project examples are provided in the background information document. Ecosystem restoration projects are also being conducted by the Slocan Integral Forestry Cooperative (SIFCo) in the Slocan Valley https://www.sifco.ca/type-4 and in the East Kootenays as part of the Rocky Mountain Trench Ecosystem Restoration Program https://www.trench-er.com/about.

7.0 WILDLAND – URBAN INTERFACE MANAGEMENT

The Wildland-Urban Interface (WUI) is a zone of transition between wilderness and lands developed by human activities where human-built structures and infrastructure meet or are interspersed with the undeveloped wildlands. As wildfires in the WUI have the potential to destroy structures and infrastructure and cause severe damage and loss when they spread into adjacent settlements, it is important to mitigate the risk of wildfire in WUI zones 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. Fuel

[60] McKenzie, E. 2014. Natural Disturbance Type (NDT) 4 – Ecological Restoration (ER) – 2014 Project: Summary of Pre-treatment Monitoring Survey. Report prepared for the Fish and Wildlife Compensation Program – Columbia Basin, Nelson, B.C. Available at: https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/libraries-publication-catalogues/ecocat

reduction treatments include thinning of conifer trees to create reduced stand densities, pruning lower branches that act as ladder fuels, removing downed trees, slashing and pruning debris, and reducing accumulations of pre-existing surface fuels (e.g., fallen stems, branches, needles). When conducting the WUI management treatments, best management practices should be followed to minimize disturbance and protect sensitive ecosystems and species within the treatment areas.

At low elevations, the dry target ecosystems can be incorporated into the management of WUI areas to reduce the risk of large, destructive wildfires. Non-forested grasslands and brushlands are low-fuel areas that can be included within fire breaks, and they also provide structural, habitat, and species diversity within WUI areas and the surrounding wildland matrix. Ecosystem restoration of fire-maintained (NDT4) ecosystems (e.g., brushlands and dry forest ecosystems) includes treatments that reduce fuels and create fire resilient ecosystems. Therefore, restoring NDT4 sites can also contribute to the objective of wildfire hazard reduction in WUI areas and adjacent wildlands. Fuel management for habitat restoration and ecosystem resiliency is one of the five treatment types being used in WUI management in the Slocan Valley by the Slocan Integral Forestry Cooperative (SIFCo)[61]. The treatment regime (type 4) is designed to facilitate the return of fire to NDT4 ecosystems and includes:

- hand treatment (slashing) of conifer regeneration and shrubs to reduce fuel loads in the understory; heavy accumulations of slash can be disposed of by piling and burning,
- hand treatments as required to reduce fuel loads adjacent to the stems and above the rooting area of large trees to reduce fire intensity and soil and bark heating (e.g., vegetation removal, pruning of lower branches, raking needles away from the bases of trees),
- establishment of reserves that are not treated to retain structural, habitat and species diversity,
- creation of fire breaks along the boundaries of proposed burn areas,
- development of a professional burn plan and reintroduction of fire, and
- conducting pre-treatment (baseline) and post-burn surveys and documenting the monitoring results and effectiveness of the treatments to restore sites.

When conducting fuel management treatments for habitat restoration within a WUI area, general steps for meeting the goals of an ER project identified in section 6.2.1 should be followed. If monitoring results indicate that the project goals are not being met, then the management prescription should be adjusted to improve treatment outcomes (see Adaptive Management in section 6.1.5).

[61] https://www.sifco.ca/wui-treatment-types