# FOREST CARBON INFORMATION NOTES

## MODULE 3: REFORESTATION

### KEY TAKE-AWAYS

- A greenhouse gas (GHG) benefit can be created by reforesting understocked areas that would otherwise not be planted
- GHG benefits from underplanting are accrued faster than from other reforestation approaches associated with salvage logging and knockdown which produce immediate GHG emissions and delay the time before benefits are accrued
- Underplanting of fire-killed stands is cost-effective when compared to salvage logging or knockdown planting methods
- To ensure planting crew safety, WorkSafe BC guidelines for wildlife/danger tree protocols should be followed

### UNDERPLANTING: A REFORESTATION OPTION WITH FASTER GHG BENEFITS

Healthy young forests have a positive carbon balance; they draw down more carbon dioxide (CO2) from the atmosphere than they emit. However, when disturbances occur such as wildfire or insect attack, many trees die, tree growth decreases, decomposition rates increase, and the stands shift to having a negative carbon balance. Compared with natural regeneration, the prompt underplanting of fire-killed stands can accelerate the shift back to a carbon sink and achieve greater future carbon storage capacity.

In the case of commercial harvesting, tenure holders are responsible for reforesting the stands that they harvest. However, many forests in the province not under tenure have been impacted by insects and wildfires or transformed indefinitely to other land cover types. The responsibility of reforesting these areas belongs to government programs. Without such programs, the area of non-satisfactorily restocked (NSR) stands would increase. Understocked stands that do not have a legal reforestation obligation provide an opportunity to increase carbon sinks and thus are potential candidates for inclusion in the Forest Carbon Initiative (FCI). The primary objective of reforestation projects funded by the FCI is to maximize long-term carbon sink rates and GHG benefits, while simultaneously achieving multiple co-benefits such as improved air quality, wildlife habitat and watershed hydrological function.

Planting beneath fire-killed overstories, without any salvage logging or knockdown, is known as underplanting. In underplanting projects, the GHG emissions that occur in salvage logging and knockdown (associated with felling, piling, and burning), can be avoided by leaving the fire-killed overstory to decay slowly over time. By avoiding these emissions, underplanting provides the highest GHG benefit for reforesting understocked fire-killed stands. The FCI funds the underplanting of stands that were severely burned, where tree mortality approaches 100 percent, and the seed source is rendered unviable. Under these conditions, there is a strong degree of certainty that the project will result in a GHG benefit once a plantation has been successfully established.

The GHG benefit is similarly high for any type of reforestation project that avoids felling, such as the silviculture rehabilitation of sparsely-vegetated roads. Additional information about silviculture road rehabilitation can be found in module 4.

Safe work conditions during planting and surveying are important to consider in underplanting projects due to the hazard presented by standing dead trees. Guidance has been created to manage safety concerns on such projects [1,2].



[1] Wildlife/danger tree assessor's course workbook: Forest harvesting and silviculture course module / an initiative of the Wildlife Tree Committee of BC, in cooperation with WorkSafeBC – Rev. Feb 2017 (2017).

[2] Dangerous tree management in preparation for silviculture activities. Wildlife Tree Committee of BC (2007)

## HOW IS THE GHG BENEFIT ESTIMATED?

The net forest sector GHG benefit from reforestation is calculated from the difference between estimates of the GHG balance for two scenarios, including a project scenario, where the stand is planted, and a baseline scenario, where the stand is left to regenerate naturally. The benefit is expressed as tonnes of carbon dioxide equivalent (tCO2e), which accounts for the greater potency of non-CO2 greenhouse gases.

Information about current stand conditions are compiled from regeneration surveys and B.C.'s Vegetation Resource Inventory. The TASS/TIPSY modelling framework is used to predict stemwood volume/biomass yields for the regenerating forest. The initial stand density is estimated from the number of trees planted and the number of natural trees (ingress) estimated on a per-hectare basis. Based on consultation with surveyors and forest carbon advisors, estimates of ingress in the baseline scenario are defined by a regeneration delay of 2 years, a clumped spatial pattern of establishment, and eventually reaching a stand density of 200 stems/hectare. Stand density in the project scenario is calculated from the sum of the planting density and the same level of ingress as in the baseline scenario. Once the yield curves for the baseline and project scenarios have been calculated with TASS/TIPSY, they are used to drive models that estimate the cycling of carbon through forest ecosystems and harvested wood products sector, including mills, in-use products, and landfills. The GHG benefit is then calculated for the period between the year that management activities begin and a future reporting year, such as 2030, 2050, or 2080.

The GHG benefit of reforestation activities varies according to site productivity, conditions in the baseline scenario, and the nature of the planting, including planting density and genetic worth. The following examples provide a sense of scale and timing of GHG benefits as well as the impacts of modifying the underlying baseline conditions. The examples illustrate the effects of existing understory conditions and the removal of an overstory on cumulative ecosystem carbon stocks (tCO2e).

## WHAT ARE THE GHG AND ECONOMIC BENEFITS OF REFORESTING UNDER STOCKED STANDS?

### EXAMPLE 1: STANDS TARGETED FOR SALVAGE LOGGING

Among stands impacted by insect outbreak and/or wildfire, many are mature with only moderate or low mortality, and may be targeted for salvage. As an example, consider a mature lodgepole pine stand severely damaged by Mountain Pine Beetle attack (Figure 1). In the baseline scenario, the standing dead wood will fall over and decay over time. Natural regeneration may be limited and take many years to re-establish a productive stand, while surviving mature trees will continue to grow. In the project scenario, salvage logging occurs, transferring some of the fibre that is felled to a mix of in-use products and bioenergy, while the remainder is piled and burned.

Tracking the cumulative GHG benefit over time, the example suggests that the salvage logging scenario continues to have a lower GHG balance than the baseline scenario until approximately 2060 (Figure 1b). Although salvage logging does eventually create a GHG benefit, there is a substantial time lag between the time of project implementation and when a GHG benefit is accrued.

**Example 1: Stands targeted for Salvage Logging - Interior**

| | |
|---|---|
| Location: | Prince George Natural Resource District |
| Overstory: | Lodgepole pine |
| Stand Age: | 100 years |
| Site Index: | 18 |
| Disturbance: | Mountain pine beetle attack in 2005 with 75% mortality |
| Salvage: | Salvage logged in 2018, followed by planting of 2,000 sph of lodgepole pine. |

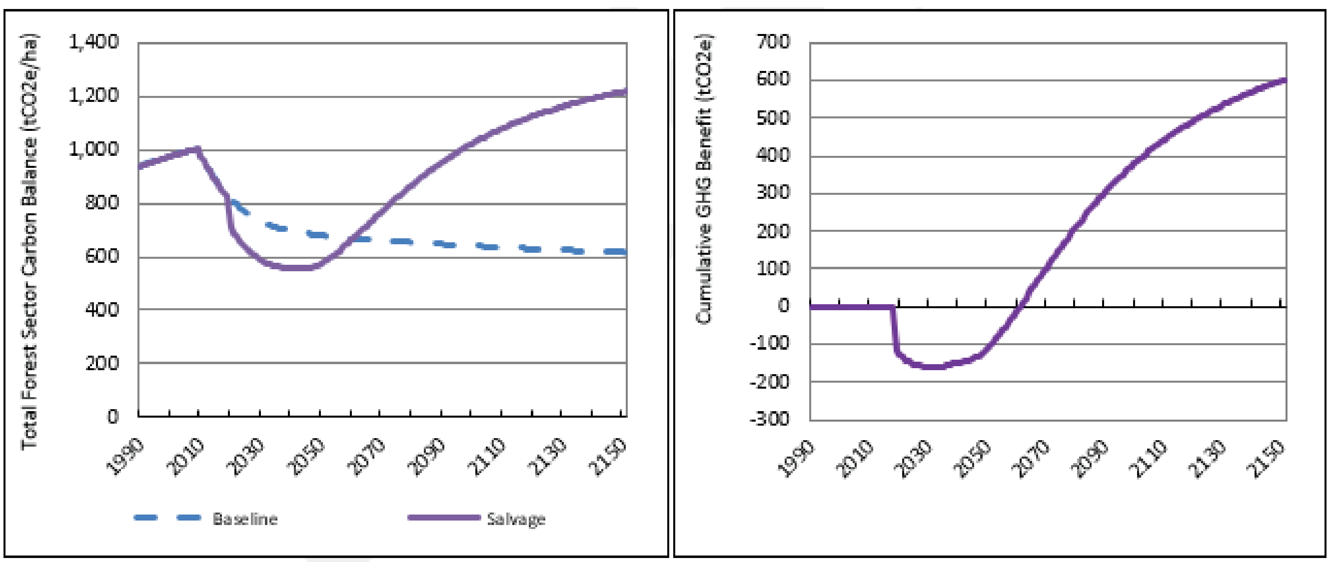



**Figure 1: (a) Total forest sector carbon stocks (including storage in harvested wood products) and (b) cumulative GHG benefit (project GHG balance minus baseline GHG balance).**

### EXAMPLE 2 & 3: STANDS TARGETED FOR KNOCK DOWN AND BURN

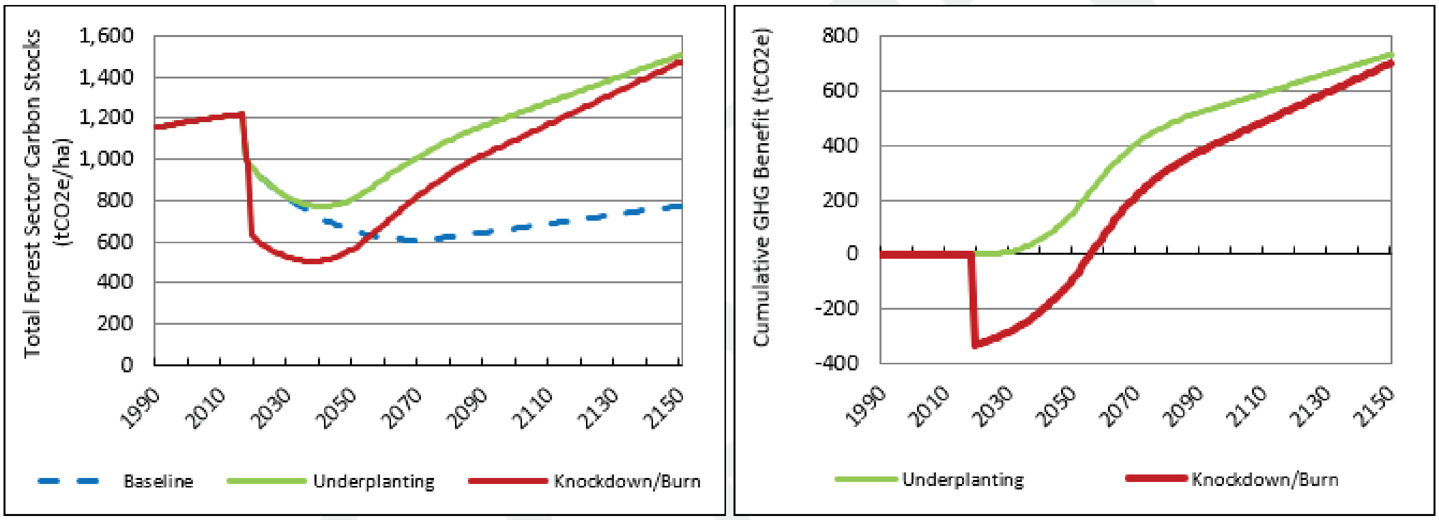
In some cases, salvage logging is a less desirable option or not possible, and foresters must choose between leaving the stand to recover naturally, knocking it down and planting, or underplanting (Figure 2a).

Following discussions with surveyors, the examples below (interior and coast) assume a low future stocking (200 stems/hectare) in the baseline scenario, reflecting cases where the seedbed was largely eliminated by fire, and where there were no adjacent seed sources.

Like salvage logging, the knockdown and burn (i.e., laying to waste) project creates immediate emissions, as a proportion of fibre that was felled is piled and burned, or emitted to the atmosphere over the next year as bioenergy (Figures 2 and 3). Conversely, underplanting involves no felling or burning so there is no immediate emission of carbon dioxide or more harmful greenhouse gasses. Both examples demonstrate that the GHG benefit of underplanting is significantly higher than knockdown treatments.

**EXAMPLE 2: STANDS TARGETED FOR KNOCK DOWN AND BURN – INTERIOR**

| | |
|---|---|
| Location: | Central Cariboo Natural Resource District |
| Overstory: | Lodgepole pine |
| Stand Age: | 120 years |
| Site Index: | 18 |
| Disturbance: | Hanceville Fire in 2017 with 100% mortality |
| Treatments: | Underplanting of lodgepole pine at 2000 sph<br>Knockdown, burning of piles, and then planting of lodgepole pine at 2000 sph |




**EXAMPLE 3: STANDS TARGETED FOR KNOCK DOWN AND BURN – COAST**

| | |
|---|---|
| Location: | Sea to Sky District |
| Overstory: | 100% Douglas-fir |
| Stand Age: | 120 years |
| Site Index: | 28 |
| Disturbance: | Stand-replacing wildfire in 2017 with 100% mortality |
| Treatments: | Underplanting of Douglas-fir at 1600 sph<br>Knockdown, burning of piles, and then planting of Douglas-fir at 1600 sph |

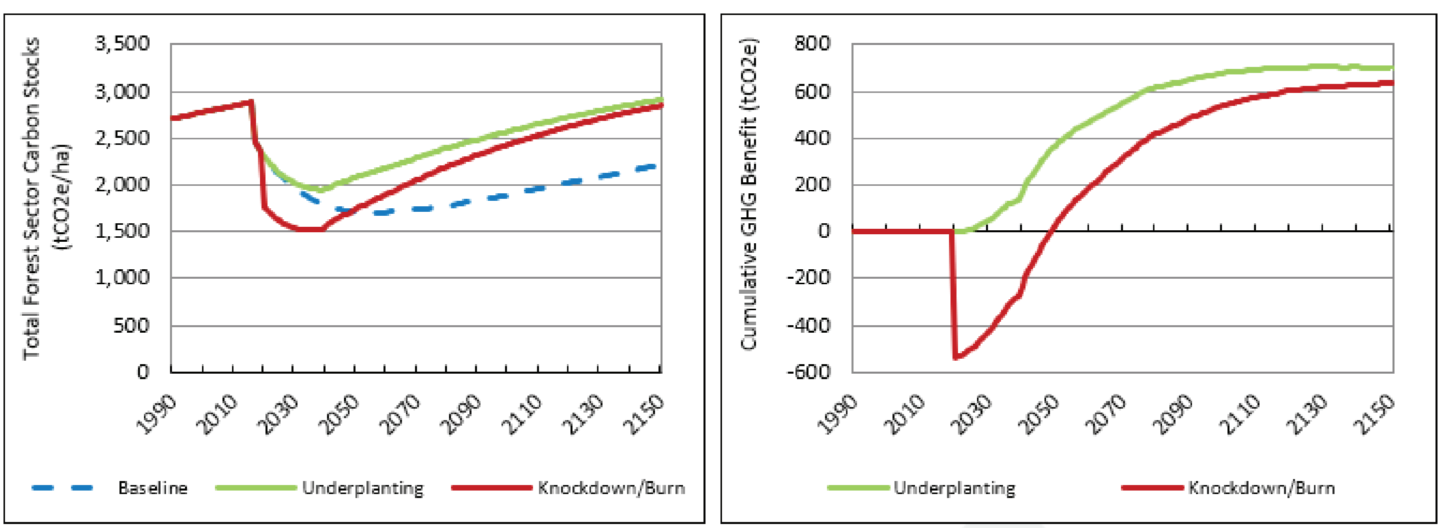



**Figure 3. (a) total forest sector carbon stocks and (b) cumulative GHG benefit.**

While both fire- and insect-killed stands have been underplanted in B.C., survey results show that seedlings do much better under fire-killed overstories than under insect-killed overstories. This is because the low light levels and unreduced grass and/or brush competition associated with insect-killed stands create intense competition for planted seedlings. Underplanting is, therefore, not typically recommended for insect-killed stands.

Although all reforestation projects can be a GHG benefit in the long-term, only underplanting can entirely avoid contributing to GHG emissions in the short term (Table 1).

Examples of stands from the interior and coast of B.C. demonstrate similar patterns in terms of GHG benefits of reforestation treatments. The main difference is that the GHG benefit can be even greater on the coast than the interior due to greater site productivity.

Reforestation also provides economic benefits. For every 10,000 ha underplanted, approximately 82 jobs (person-years) are created. Because minimal site prep is needed for underplanting, it is a cost-effective method of reforestation.

**Table 1. Summary of net forest sector GHG benefit and economic benefits for reforestation project examples.**

| Project Scenario | Cumulative net forest sector GHG benefit (tCO2e/ha) | | |
|---|---|---|---|
| | 2030 | 2050 | 2080 |
| Salvage logging, interior[a] | -161 | -111 | 209 |
| Knockdown and burn, interior[b] | -282 | -90 | 310 |
| Knockdown and burn, coast[c] | -428 | 30 | 419 |
| Underplanting, interior[b] | 0 | 84 | 399 |
| Underplanting, coast[c] | 1 | 368 | 618 |

[a] see Example 1 for details
[b] see Example 2 for details
[c] see Example 3 for details

## HOW CAN WE IMPROVE OUR CHANCES OF SUCCESS?

Reforestation projects reflect beneficial practices when the following approaches are used:

- Avoid activities that have negative effects on forest carbon, such as felling and piling of over-stories and burning of waste piles
- Where it is necessary to remove over-story trees to ensure seedling survival, utilize the over-story fibre to avoid emissions from burning
- Select fire-killed stands with enough ground disturbance and adequate light that provide good underplanting site conditions
- Select fire-killed sites rather than insect-killed sites for underplanting because the survival and growth rate of under–planted seedlings are generally higher under fire-killed over-stories
- Use survey results to focus reforestation treatments on areas that are not regenerating naturally
- Enhance carbon sequestration and adaptation to climate change in reforested stands using improved genetic gain seedlings, and increased planting densities
- Where applicable, create resilient and diverse stands that are well adapted to the site, future disturbances and climate change by planting a diversity of species, using the Climate Change Informed Species Selection tool and Climate Based Seed Transfer system
- Consider surveying cone bearing pine stands with suitable seed beds 3-5 years after a wildfire to identify not satisfactorily restocked (NSR) areas
- Consult local forest health experts to help identify forest health issues and appropriate silviculture strategies
- Include wildlife danger tree assessments (WDT) using well-established and accepted Work Safe BC protocols as part of planting projects - it is most cost effective and efficient to complete WDT assessments immediately prior to planting as part of the planting contract

## CO-BENEFITS

- Increased timber supply
- Increased employment by providing jobs
- Improved wildlife habitat by reforestation of disturbed areas
- Improved structural diversity resulting from underplanting which benefits wildlife habitat, shade, lichen, perching cover, etc.
- Reduced hydrological impacts of disturbed areas and enhanced protection of downstream aquatic ecosystems
- Reduced erosion and mass wasting by increasing soil stability in disturbed areas

## FOR MORE INFORMATION

For more information, please see the FCI website

Inquiries about the Forest Carbon Initiative may be directed to: forest.carbon@gov.bc.ca

This information note was prepared for Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) staff, the Forest Enhancement Society of British Columbia, contractors, Indigenous Nations and stakeholders to communicate the potential benefits and opportunities in mitigating climate change through such activities, and to offer robust, evidence-based advice on best practices.

BRITISH COLUMBIA

Ministry of Forests, Lands, Natural Resource Operations and Rural Development