Draft Tree Farm Licence 37 Forest Landscape Plan

Area-Based Stewardship: Connected Planning
in an Adaptive Management Framework

Part 2 of 3: Establishing Clear Outcomes Describing the Desired Future Forest Condition

July 25, 2025

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Welcome to the Forest Landscape Plan

We are pleased to share the updated Forest Landscape Plan (FLP) for the area of Tree Farm Licence 37 (TFL 37) within ‘Na̱mg̱is territory on northern Vancouver Island. We acknowledge and appreciate the support of the Province of British Columbia, who through the TFL 37 Pilot Project (TFL 37 pilot), provided an opportunity for the collaborative development of a local, relevant, and multi-generational focused FLP and Forest Operations Plan (FOP). It is rewarding to see the new predictability already being realized - supporting healthy ecosystems, communities, businesses, and forestry workers on northern Vancouver Island.

This is the second of three documents. For background information on the TFL 37 pilot, please reference the Companion Document to the draft Tree Farm Licence 37 Forest Landscape Plan and Forest Operations Plan. This FLP is consistent with the Gwa'ni Project and the Tree Farm Licence 37 Forest Operations Plan.

Signed. See original hard copy.

July 25, 2025 - Rachel Dalton, RPF

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July 25, 2025 – Mike Davis, RPF

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July 25, 2025 – Stuart Glen, RPF

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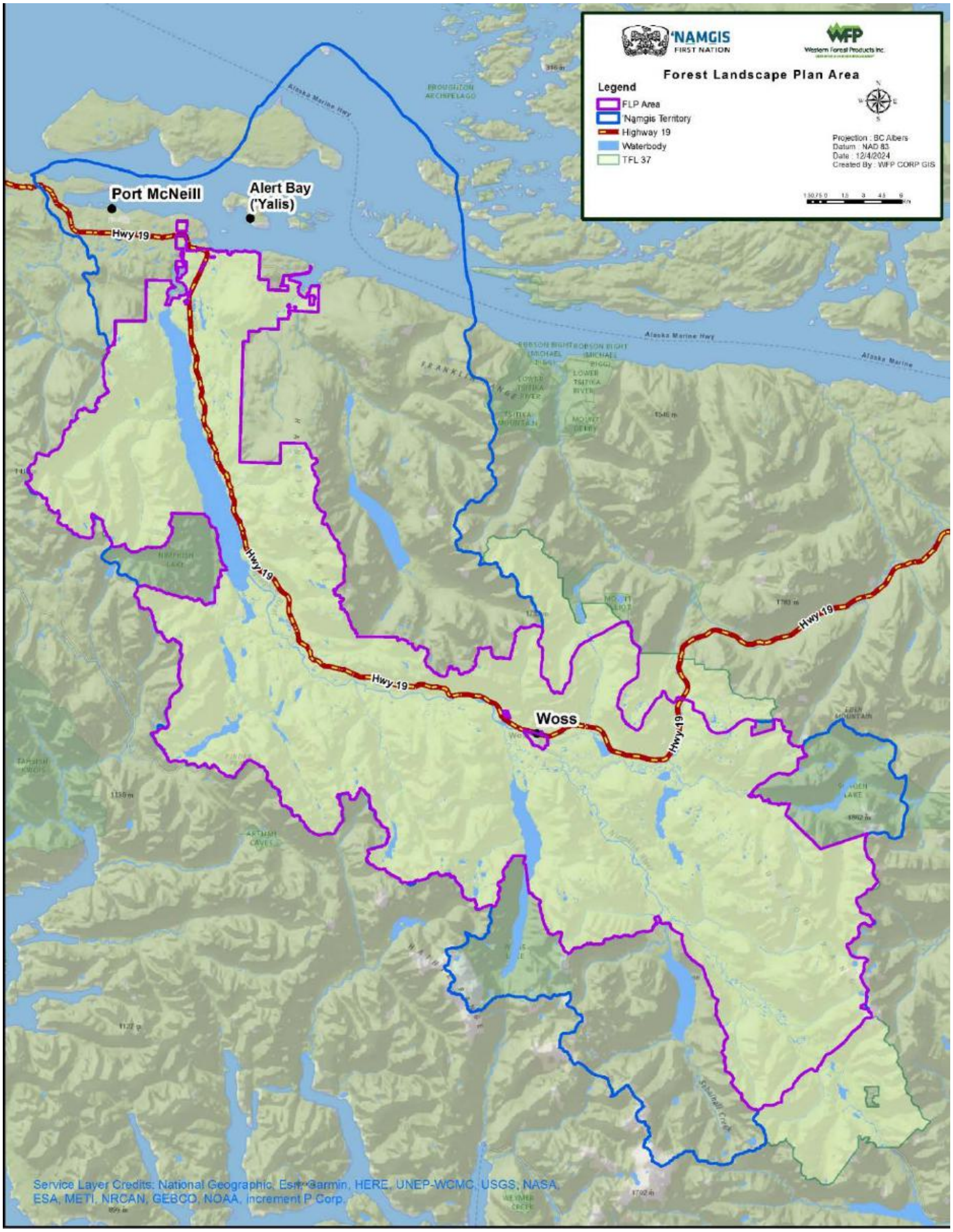
July 25, 2025 – Brian Svanvik
Director of Natural Resources, ‘Na̱mg̱is First Nation

Map of the Forest Landscape Plan Area

FPPR Section 2.28 (1) (a)



Gwa'ni, Land Act, and FRPA Section 2.22 Objectives

FRPA Section 2.22 and 2.28 (3)

There are three sources of objectives that inform the future forest outcomes established in the Forest Landscape Plan. The three sources are the Gwa'ni Project recommendations, objectives in FRPA Section 2.22, and objectives established under Section 93.4 of the *Land Act*.

Gwa'ni Project Recommendations

The Gwa'ni Project is a modernized land use planning project (MLUP) being developed by 'Na̲mg̲is First Nation and the Province of British Columbia. At the time of making the final refinements to the FLP and Forest Operations Plan (FOP), the recommendations from the Gwa'ni Project have not yet been finalized. Despite this, the 12 future forest outcomes achieve these recommendations given the connected approach to planning enabled through the concurrent development of the Gwa'ni Project, FLP, and FOP. This was made possible by integrating the technical teams for the TFL 37 FLP and the Gwa'ni Project and reflecting the collective work into one spatially and temporally explicit forest planning model.

The same 'Na̲mg̲is technical team members and leadership provided consistency across both projects and additionally, during some of the planning phases, a technical advisor from Western attended relevant Gwa'ni Project planning sessions. Recommendations from the Gwa'ni Project reflected in the future forest outcomes include:

- Updated Zones: The Gwa'ni Project recommendations will modify and update the zoning established through the Vancouver Island Land Use Plan (VILUP) Order dated December 1, 2000. The MLUP will remove the Enhanced Forestry Zone (EFZ) designation of Resource Management Zone (RMZ) 10 - Nimpkish, and it will rearrange the spatial locations of the Special Management Zones (SMZ). A newly designed Gwa'ni SMZ will be identified which is more directly focused on the primary and secondary rivers along the valley bottoms. The SMZ will be divided into two subzones:
    - Dza̲'wa̲n subzone: This portion of the Gwa'ni SMZ follows the lower reaches of significant rivers that flow into the Nimpkish River. These watersheds are comprised of the smaller streams that extend higher up the side valley drainages. Coho are present in many of these streams at a greater proportion than other species inspiring the name dza̲'wa̲n which translates to coho.

- **Mał̲ik subzone:** This portion of the Gwa'ni SMZ has the greatest concentration of planning values and the most productive forest growing sites. It contains the main stem of the Nimpkish Valley's four largest, sockeye producing rivers which are the Nimpkish River, Woss River, Davie River, and Sebahall River, and the associated lakes inspiring the name mał̲ik which translates to sockeye. Portions of this zone contain all five salmon species and important cultural sites and features.

The remaining Gwa'ni Project area will be identified as a General Management Zone (GMZ).

- **Updated Objectives:** The Gwa'ni Project is expected to contain objectives relating to the planning values that supported development of the Gwa'ni Project, FLP, and FOP. Where recommendations are related to forest practices, the coordination across planning tables enabled them to be addressed directly within the FLP and FOP. These include considerations such as western redcedar and yellow cedar, deer populations, herbicide use, and opportunities relating to carbon. Each of these objectives are linked to the relevant future forest outcomes in the FLP.
- **Cultural and Cedar Strategy:** The Gwa'ni Project recommendations require development of a cultural and cedar strategy in collaboration with 'Na̱mgis. Suitable practices have been designed to enhance the management of western redcedar and yellow cedar for the purpose of 'Na̱mg̱is-centric outcomes that go beyond the contribution of western redcedar and yellow cedar towards timber values. The cultural and cedar strategy is reflected by the relevant stewardship strategies in the TFL 37 FOP.
- **Conservation Network:** The Gwa'ni Project requires development of a multi-value conservation network in collaboration with 'Na̱mg̱is. This network includes the inherent capacity to sequester carbon while connecting existing legally designated areas of Old Growth Management Areas (OGMA), Wildlife Habitat Areas (WHA), Ungulate Winter Ranges (UWR), and Riparian Reserve Zones (RRZ). The conservation network is intended to largely be excluded from commercial timber harvest and mineral exploration and will provide landscape level retention and function across zones. The Gwa'ni objective for a conservation network is linked to stewardship strategy (SS 1) in the associated TFL 37 FOP.

Section 93.4 Land Act Objective

There is currently one Section 93.4 Land Act Objective that the FLP must be consistent with as required by FRPA Section 2.28 (3) which is the Order for the Recovery of Marbled Murrelet dated November 2021. This objective is addressed in the future forest outcome for species at risk (FF 9).

The Old Growth Management Areas (OGMAs) in the plan area are currently established under Section 4 of the Forest Practices Code of British Columbia Act. The TFL 37 pilot has refined the location of the OGMAs in coordination with the Ministry of Forests (MoF) and Ministry of Water, Land and Resource Stewardship (MWLRS), and an amendment was submitted for approval on December 6, 2023. The future forest outcomes reflect the refined OGMAs and upon approval of the amendment, they will also be established under Section 93.4 of the Land Act.

FRPA Section 2.22 Objectives

There are five objectives in FRPA Section 2.22 that need to be considered when establishing outcomes as required by FRPA Section 2.28 (1) (c). As the individual objectives were being considered, it became apparent that culturally, ecologically, socially, and economically, that these objectives are all interconnected and require consideration over multiple generations. For example, the desire for a predictable forest sector and healthy communities is directly connected to resilient ecosystems and requires consideration well beyond the 10-year time frame of the FLP or five-year time frame of the FOP.

Connected planning proved to be an effective approach for considering the Section 2.22 objectives because they are all integrated into the desired future forest condition reflecting the desired balance across the objectives. We have therefore approached documentation of the description of how the Section 2.22 objectives were taken into consideration in establishing the outcomes in two ways:

- Individual Future Forest Outcomes: Each of the 12 future forest outcomes include a detailed description of how the FRPA Section 2.22 objectives were considered in establishing the outcome.
- Desired Future Forest Condition: The desired future forest condition itself, as reflected through all 12 of the individual future forest outcomes is considered in the context of the FRPA Section 2.22 objectives as it reflects the overall desired balance across the objectives reflecting the stewardship of all the planning values.

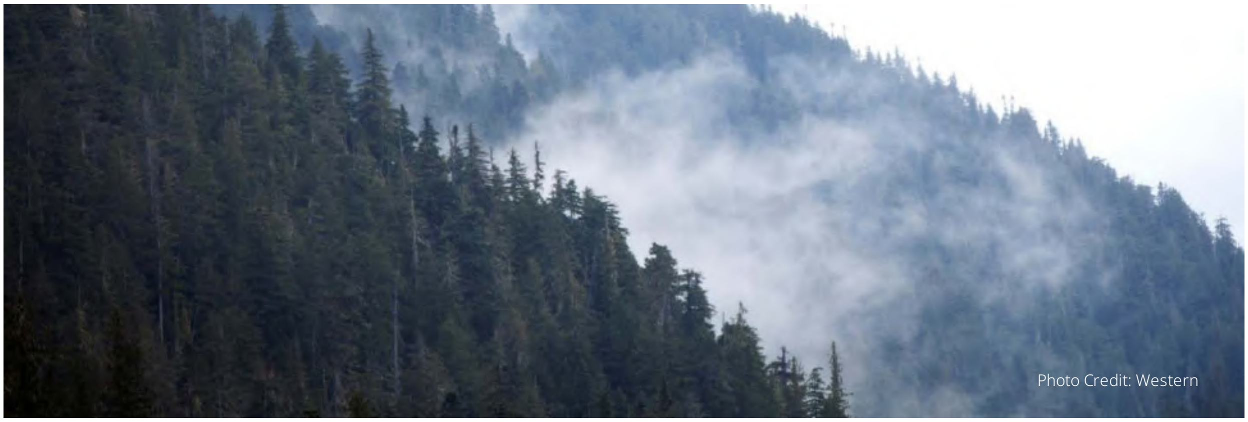


Photo Credit: Western

How the FRPA Section 2.22 Objectives Were Considered in Establishing the Outcomes

FRPA Section 2.28 (1) (c)

The desired future forest condition itself, as reflected through all 12 of the individual future forest outcomes, needs to be considered in the context of the FRPA Section 2.22 objectives as it reflects the overall desired balance across the objectives and stewardship of values. This aligns with the principles of ‘Na̱mg̱is Forest Values which respect the interconnected nature of ecosystems, values, and people. ‘Na̱mg̱is Forest Values encompass the duty to ensure the cultural, environmental, and spiritual vitality of the waters, lands, and resources are protected and used sustainably for future generations of people, plants, and animals.

A description of how the FRPA Section 2.22 Objectives were considered in the development of the desired future forest condition is summarized below. Each FRPA Section 2.22 objective is identified by a symbol which is also carried through to the future forest outcomes to identify the relevant connections between the future forest outcomes and the FRPA Section 2.22 objectives.

△ **Supporting the production and supply of timber in the forest landscape plan area.**

- In recognizing that the allowable annual cut for TFL 37 has not been achieved for at least the last six years, the public consistently mentioned the importance of harvest predictability during engagement. The desired future forest condition provides for a sustainable harvest flow aligned with the stewardship strategies in the FOP.

- ‘Na̱mg̱is have expressed concerns with the Vancouver Island Land Use Plan (VILUP) and the direction provided on old-growth harvest and long-term management of late seral plant communities. This has been addressed in the desired future forest condition as described in the Companion Document through the 10 future forest that are elements of biodiversity and ecosystem health.

- Recognizing the limitations of the current planning framework, ‘Na̱mg̱is expressed the importance of understanding the landscape context of individual cutblocks and roads before making land use and forestry decisions about the territory. It was critical that the TFL 37 FLP pilot find a new approach that shifts from cutblock and road decisions late in the planning process to cutblock and road decisions early in the planning process. This has been achieved by the tenure holders directly developing the FLP and FOP in collaboration with ‘Na̲mg̲is and reflecting the future harvest pattern directly in the 12 future forest outcomes. The benefits of this approach are described in the Proactively Advancing Stewardship section of the Companion Document. This is a transformative process improvement over hierarchical planning that supports a predictable harvest flow, as decisions are not deferred to late in the planning process, which can lead to bottlenecks at the time of cutting permit and road permit preparation.

The desired future forest condition provides the foundation needed to make informed investments in harvest equipment, manufacturing facilities, and even the future seed supply supported by spatial and temporal data for a wide range of economic related attributes.


Photo Credit: Mike Green

Supporting the protection and conservation of the environment.

- Connected planning makes the transformative shift from planning around constraints to recognizing the complex and dynamic nature of ecosystems. This is achieved by building up from a foundation of values in a way that respects the natural landscape and characteristics of the local ecosystems. This makes the fundamental shift of building to a desired future forest condition that reflects what the land is telling us.
- Given the inherent complexity and dynamic nature of ecosystems, there is no single element that defines biodiversity and ecosystem health. The desired future forest condition is therefore described through 10 future forest outcomes that function together to sustain biodiversity and ecosystem health. This includes elements of biodiversity and ecosystem health such as western redcedar, yellow cedar, stream channel condition, ecosystem integrity, wildlife habitat types, species at risk etc. which all function together to increase diversity and resiliency.

- Cumulative effects are an important aspect of supporting the protection and conservation of the environment as it is the combined impact of past, present, and potential future changes caused by a combination of human activities, natural variability, and climate change. The desired future forest condition reflects cumulative effects including specific climate change adaptation measures being implemented to sustain biodiversity and ecosystem health.
- Engagement completed as part of the Gwa’ni Project confirmed the desire for balance, and the importance of conserving and protecting the natural environment, which in turn provides for responsible human use.
- The desired future forest condition recognizes the importance of old growth forests. A detailed description of how the desired future forest condition and 12 future forest outcomes implement the 14 recommendations from that report is provided in the Proactively Advancing Stewardship section of the Companion Document.

Managing the values placed on forest ecosystems by Indigenous peoples.

Extensive engagement was undertaken with ‘Na̱mg̱is members and leadership to support the TFL 37 pilot and Gwa’ni Project which confirmed ‘Na̱mg̱is Forest Values.

> ‘Na̱mgis Forest Values encompass the duty to ensure that the cultural, environmental, and spiritual vitality of the waters, lands, and resources are protected and used sustainably for future generations of people, plants, and animals.

From this engagement the following key themes emerged for the need to:

- Balance the health of the lands, water, and natural ecosystems, with economic activities that never outweigh natural values.
- Protect and conserve aquatic habitat, with fish being of critical importance.
- Carefully and respectfully manage culturally significant places and resources.
- Understand the cultural, historical, and archaeological significance of the Nimpkish Valley.
- Manage resources sustainably, across generations.
- Protect lands from degradation and maintain natural ecosystems.

- Maintain healthy terrestrial wildlife populations (especially elk, deer, and bear).
- Promote ‘Na̲mg̲is use of the territory, especially opportunities and access for youth.
- Have a greater proportion of protected and reserved areas.
- Access cedar and other plant resources for cultural uses.

Managing the values placed on forest ecosystems by local communities.

- The opportunity to undertake the TFL 37 pilot concurrent with the Gwa’ni Project provided many opportunities for coordinating and sharing of engagement. This was complemented by having the same planning team for ‘Na̲mg̲is in both projects, and Western and Provincial representatives as advisors on the respective projects. The TFL 37 pilot was able to incorporate both Gwa’ni Project and supplementary engagement completed as part of the TFL 37 pilot. The Gwa’ni Project produced a “What We Heard Engagement Report” which provided confirmation of the planning values. The TFL 37 pilot completed additional engagement with local government representatives, TFL 37 employees and contractors, as well as with TFL 37 and TFL 6 Public Advisory Groups.
- Through this engagement, key themes emerged around managing the values placed on forest ecosystems by local communities which include:
  - Predictability in the forest sector not only for those employed directly, but also for those who live, work, and recreate in the North Island.
  - Balance among all land uses and between ecological and economic considerations.
  - Local input that prioritizes local perspectives to best serve the people who live and work within the planning area considering the forest economy, employment, and sustainable harvesting.
  - Recognition of ‘Na̲mg̲is Forest Values as a high priority and a commitment to prioritize the rights and interests of ‘Na̲mg̲is and reconciliation efforts more broadly.
  - Desire for communication and information.

Preventing, mitigating, and adapting to impacts caused by significant disturbances to forests and forest health, including wildfire, insects, disease, and drought.

- Connected planning provides a robust approach to climate change adaption because most climate change adaptation strategies are ultimately elements of ecosystem management. Maintaining healthy, diverse, and resilient forests that consist of native species, communities, natural landscapes, and ecological functions, provides the strength and capacity to allow nature to best adapt to a range of future uncertainties. This is not achieved by any single element but is best reflected through the desired future forest condition following the same principle as biodiversity and ecosystem health. The 12 future forest outcomes that function together to help prevent, mitigate, and adapt to impacts are described in the Proactively Advancing Stewardship section of the Companion Document.

- In addition to the 12 future forest outcomes, many of the stewardship strategies in the FOP are also designed to support climate change adaptation through specific mitigation practices. The cumulative impact of these stewardship strategies is reflected in the 12 future forest outcomes.

- In recognition that effective climate change adaptation also requires structured learning, adaptive management indicators as described in the Adaptive Management Framework section of the Companion Document are in place to detect impacts from a changing climate in an effort to enable a timely response. This will allow changes to be made on a real-time basis to help prevent, mitigate, and adapt to impacts.

- Projected changes in climate were carefully considered in establishing the 12 future forest outcomes. This included working with subject matter experts to ensure the latest information available to the technical team was being interpreted correctly, and the limitations of the data, and risks of decisions were well understood.

Establishing Future Forest Outcomes

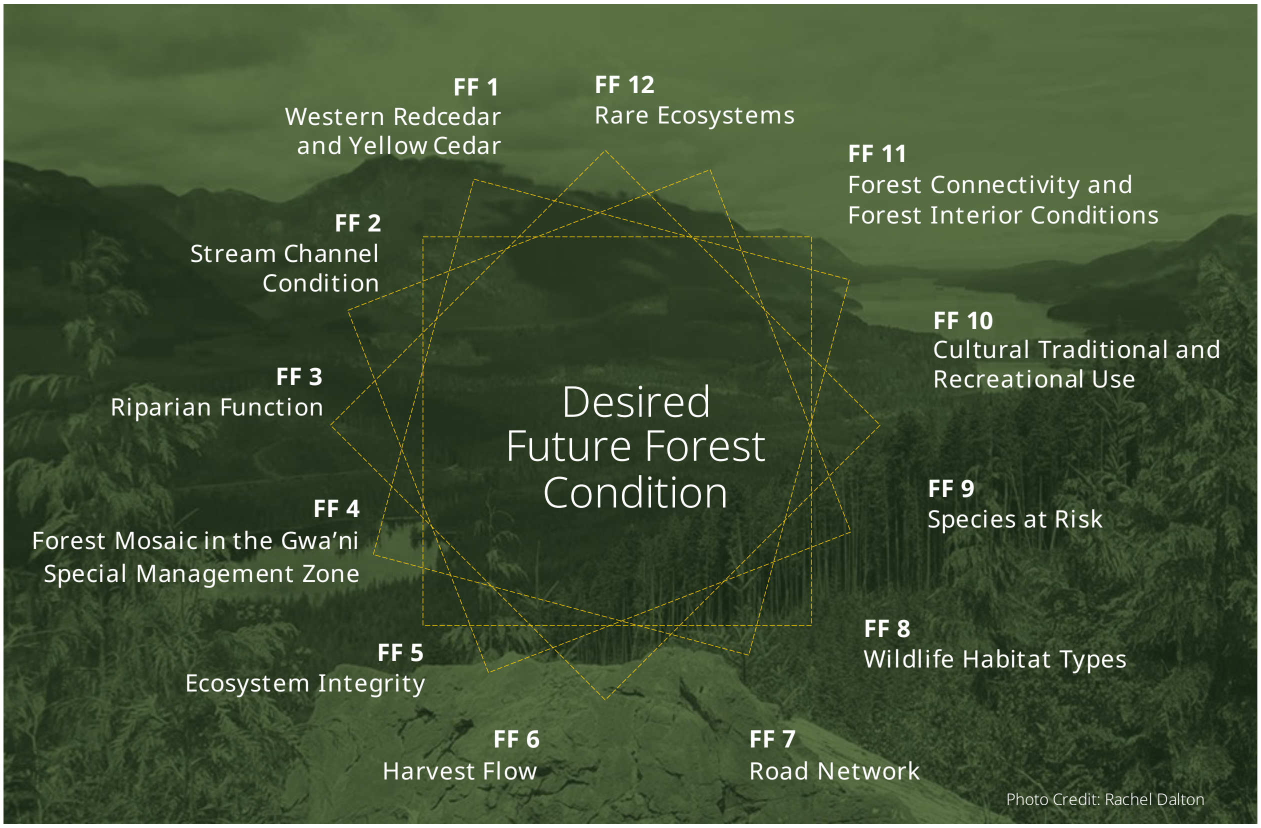
FRPA Section 2.28 (1) (b)

The Forest Landscape Plan includes 12 future forest outcomes for the management of forest resource values for a defined area[1]. The FLP includes a description of how the FRPA Section 2.22 objectives were taken into consideration in establishing the 12 future forest outcomes.

To establish the outcomes, it was necessary to first develop a spatial and temporally explicit desired future forest condition. The desired future forest condition was then described through the 12 individual future forest outcomes which articulate 'Na̲mg̲is territory and TFL 37 over the next 300 years. The concept of how individual future forest outcomes function together to articulate the desired future forest condition is visualized in Figure 1 below.

The 12 future forest outcomes are designed to provide a transparent picture of what the plan area will look like over the next 300 years.

Figure 1: The 12 future forest outcomes that describe 'Na̲mg̲is territory and TFL 37.



[1] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-landscape-plans

Each of the 12 future forest outcome includes supporting information that is structured as follows:

- A table identifies the FRPA Section 2.22 objectives that the future forest outcome supports and whether the future forest outcome also supports biodiversity and ecosystem health and climate change adaptation. This integrated approach to biodiversity and ecosystem health and climate change adaptation is described in additional detail in the Companion Document.

Supports Biodiversity and Ecosystem Health	✦
Supports Climate Change Adaptation	☀

- A table identifies the objective(s) from the Gwa’ni Project that are relevant to the future forest outcome.

Linked Gwa’ni Objective
Description of the objective.

- A table identifies the future forest outcome for the FLP Goal tied to the relevant objective(s) from the Gwa’ni Project. The future forest outcomes function together to provide for an overall description of the desired future forest condition over the next 300 years. The outcome at year 2035 is aligns with the 10-year term of the plan and is an estimate of the interim progress being made towards the desired future forest condition. It is recognized that there will be variability on a 10-year basis of individual future forest outcomes compared to the forecast, given they are all connected in some way. Some future forest outcomes will be more sensitive than others, yet on balance, they will provide an overall basis of comparison to guide our transition to the desired future forest condition.

FLP Goal	FF 1
Description of the goal in the context of the linked Gwa’ni objectives and the desired future forest condition over multiple generations.	The future forest outcome described at the end of 2035, in the context of the 300-year forecast.

- A section titled, **Description of the Outcome and Forecast** includes supporting information for the future forest outcome including a description of the forecast over the next 300 years. The supporting information includes details on the basis for the future forest outcome, why it is important, and the forecast over the next 300 years.

- A section titled, **How the FRPA Section 2.22 Objectives were Considered in Establishing the Outcome** describes how the FRPA Section 2.22 objectives were considered in establishing the outcome as required by FPPR Section 2.28 (1) (c). Each of the relevant Section 2.22 objectives are described in detail.

- A section titled, **Supporting Stewardship Strategies** identifies the stewardship strategies that support achievement of the future forest outcome.

- A section titled, **Adaptive Management Indicators** identifies the adaptive management indicators that are being monitored in support of achieving the future forest outcome.

FF 1 — WESTERN REDCEDAR AND YELLOW CEDAR

Supports FRPA Section 2.22 Objectives	
Supports Biodiversity and Ecosystem Health	✦
Supports Climate Change Adaptation	☀

Linked Gwa’ni Objectives

GO 2 — Maintain a healthy, diverse, and resilient[1] forest that contains native species, communities, natural landscapes, and ecological functions characteristic of the Nimpkish Valley.

[1] Resilience is defined as the ability of an ecosystem to absorb external influences and remain intact (Holling, 1973)

GO 3 — Manage for western redcedar and yellow cedar to ensure a perpetual supply exists supporting cultural and ecological health.

GO 4 — Manage the Gwa’ni project area recognizing the projected changes to the local climate.

FLP Goal

Maintain the long-term presence of western redcedar and yellow cedar trees across a range of sizes supporting cultural and ecological health.

FF 1

More than 25,000 hectares of stands[1] containing k’wa’x̱tłu[2] and 4,700 hectares of stands[3] containing trees for bark harvest are present at the end of 2035[4], with the long-term presence forecast to increase over the next 300 years.

[1]Stands containing k'wa'x̱tłu are defined in the forest cover as > 250 years old, containing a minimum of 10% Cw and Yc by volume (m^3), and include all patches of trees.

[2]K'wa'x̱tłu includes both western redcedar (wilkw) and yellow cedar (dixw) and includes trees > 100cm in diameter that meet specific quality criteria of a minimum of 6m in length, round, sound, straight, surface relatively clear of knots on all 3 sides.

[3]Stands containing trees for bark harvest are defined in the forest cover as ≥ 61 years old and ≤ 120 years old, containing a minimum of 10% Cw and Yc by volume (m^3), and include all patches of trees.

[4]Natural disturbance events may affect the outcome.

Description of the Outcome and Forecast

Western redcedar and yellow cedar are integral to 'Na̱mg̱is health, culture, and local ecosystems and provide a wide variety of uses including textiles, canoes, totem poles, and other types of wood carvings. These uses require trees across a diverse range of diameters. Sustaining a diversity of western redcedar and yellow cedar across a range of sizes and ecology types enhances biodiversity, ecological integrity, habitat structures, contributing to increased resilience across the landscape. Western redcedar and yellow cedar also provide habitat for a range of species including cavity nesting birds, bats, and those that require relatively large trees for denning such as black bears.

To help verify the long-term presence of western redcedar and yellow cedar across a range of sizes, a forecast of species by diameter category has been developed for the next 300 years. To produce this forecast, diameter growth equations were developed for each species based on the statistically significant variables of site index and biogeoclimatic ecosystem classification. Existing and future stands were then grown into the future reflecting the reforestation and stand tending strategy which includes prioritizing reforestation with western redcedar and yellow cedar where it is ecologically suited and expected to be a long-term species, with consideration of climate change. This forecast does not include the full complexity of uneven-aged stand structures that develop with older seral stages given the challenges of modelling to this level of detail.

The climate change implications associated with these species was considered with the help of subject matter experts and climate and ecology modelling projections provided by the BC Ministry of Forests.

The model ensemble of forecasted climate change from the web tool is shown in Figure 2 and indicates a trend towards warmer summers with less precipitation. By 2030, summers are projected to be 1.8°C (1.3-2.3°C) warmer and 10% (0-22%) drier than the 1961-1990 average. Winters are anticipated to be warmer and wetter.

These changes in temperature, precipitation, and other climate variables can be interpreted using biogeoclimatic zones as climate analogs as shown in Figure 3. A climate analog is a historical climate type of one location that is similar to the future climate of another location. Climate analogs are a useful technique for interpreting how changes in climate variables could impact ecosystems, however caution is required in interpreting the analogs. The actual future climates will likely be a hybrid of the characteristics of the analog climate combined with enduring features (such as valleys with cold air drainage) of the local historical climate.

The projected climates are equivalent to the displacement of the historical climates of the higher elevation Mountain Hemlock (MH) zone with climates more characteristic of the lower elevation Coastal Western

Hemlock (CWH) zone. This displacement is underway and is projected to continue to become more like CWH climates. Climates of the Nimpkish Valley are projected to become similar to analogs from either Washington or Oregon State as the valley bottoms become warmer and drier in the future.

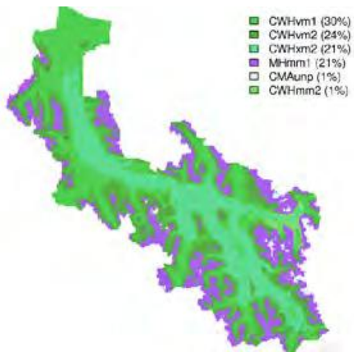
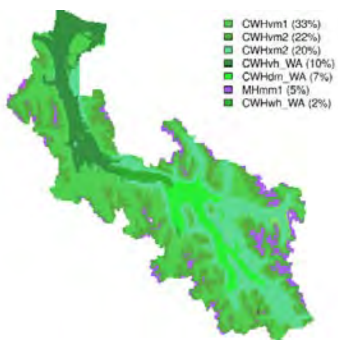
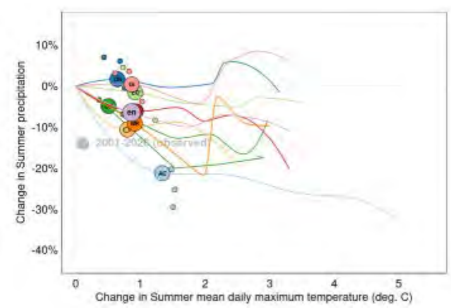
The suitability range for western redcedar and yellow cedar is also forecast to change as identified in Figure 3, but suitability for both species is projected to remain into the future. As the range of yellow cedar decreases, the range of western redcedar increases. The persistence of the climatic suitability for western redcedar in these projections doesn’t, however, rule out challenges for this species. The climate analog approach used for these suitability projections, doesn’t account for likely changes in climate extremes and the potential for changes in insect and pathogen dynamics.

This detailed review led us to conclude that while there are risks to western redcedar and yellow cedar, they are generally low and that prioritizing reforestation with these species aligned with Climate Based Seed Transfer[42] requirements, which matches seedlings to the future (projected) planting site, continues to be an appropriate strategy. Several climate change indicators have also been developed to enable structured monitoring and learning during implementation of the plan over the next 300 years.

The 300-year forecast of the estimated number of western redcedar and yellow cedar trees across a range of diameters, including relatively large trees > 150cm in diameter, is shown graphically in Figures 4 to 9. The forecasts demonstrate that a diverse range of tree sizes are maintained over the long-term. A separate forecast for the ‘Na̱mg̱is Conservation Network is provided for interest given the limited harvesting expected in this area. This forecast is likely conservative as the ‘Na̱mg̱is Conservation Network will have additional diversity given the multilayer complexity of older seral stage forests. To establish a short-term outcome for western redcedar and yellow cedar that aligns with the 10-year term of the plan, the total area of stands that contain k’wa’x̱tłu and stands that contain trees for bark harvest have been forecast at the end of 2035. This outcome includes the forecast of the harvest pattern over the next 10 years.

[2] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/tree-seed/seed-planning-use/climate-based-seed-transfer

Figure 2: Forecast change in biogeoclimatic zones and summer temperature and precipitation.

<table>
<tr><th></th><th>Model Ensemble of Forecast Biogeoclimatic Analogs for Changing Climate Conditions</th><th>Model Ensemble of Forecast Change in Summer Temperature and Precipitation</th></tr>
<tr><td>Baseline 1961-1990 Climate</td><td>
</td><td>Not Applicable</td></tr>
<tr><td>Observed 2001-2020 climate</td><td>
</td><td>
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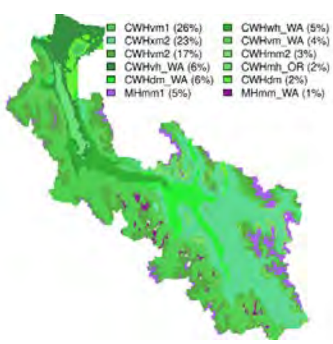
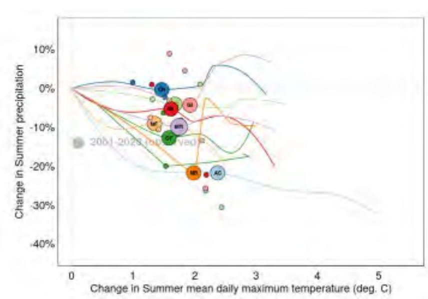
<tr><td>Ensemble Mean 2021-2040 Climate</td><td>
</td><td>
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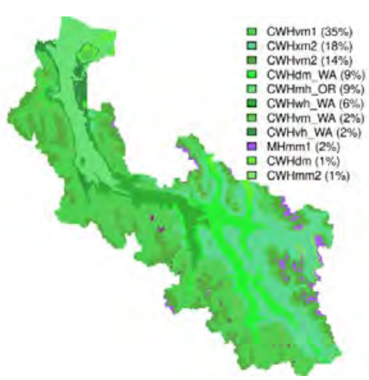
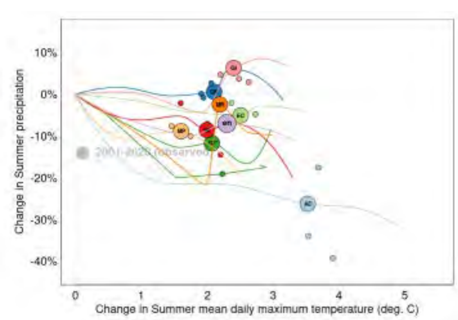
<tr><td>Ensemble Mean 2041-2060 Climate</td><td>
</td><td>
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Figure 3: Model ensemble feasibility loss/gain forecast for western redcedar and yellow cedar.

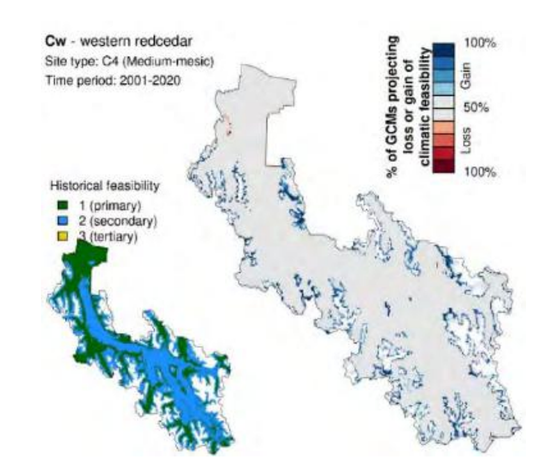
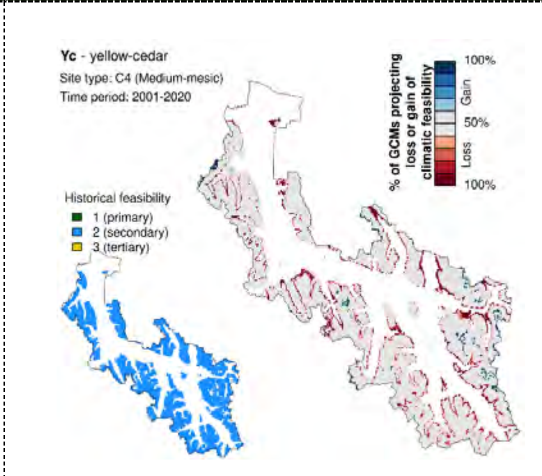
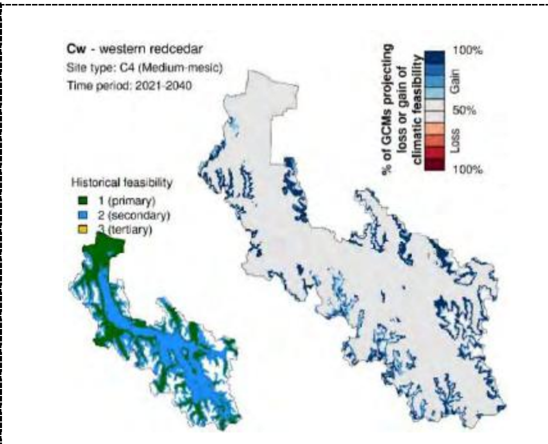
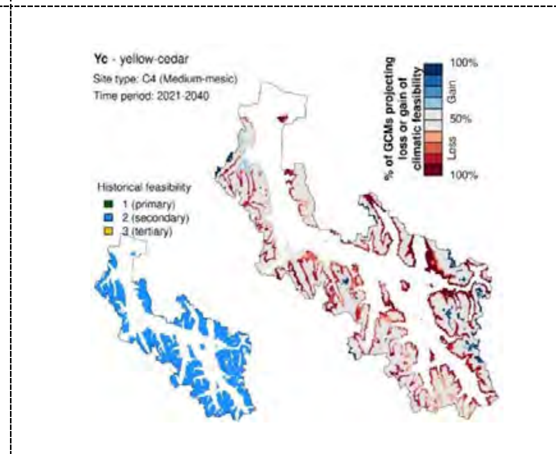
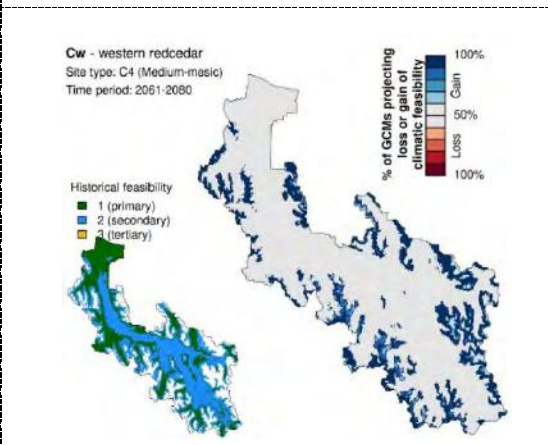
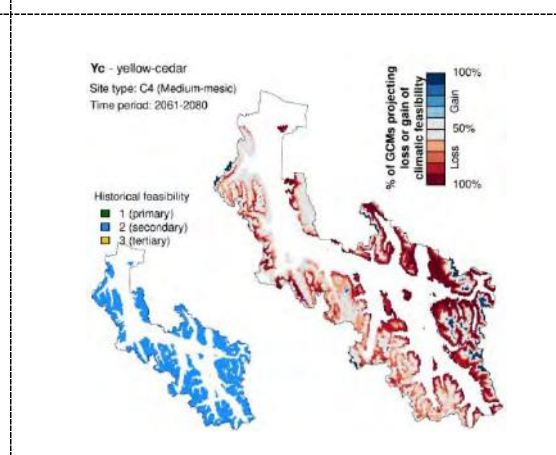
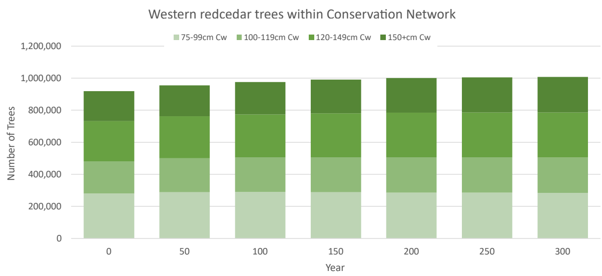
	Model Ensemble Feasibility Loss/Gain Forecast for Western Redcedar	Model Ensemble Feasibility Loss/Gain Forecast for Yellow cedar
Observed 2001-2020 climate		
Ensemble Mean 2021-2040 climate		
Ensemble Mean 2061-2080 Climate		

Figure 4: Forecast of western redcedar and yellow cedar within the ‘Na̱mg̱is Conservation Network.



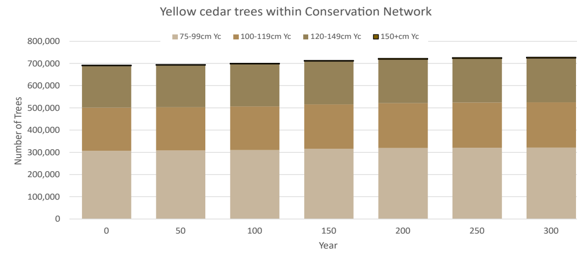
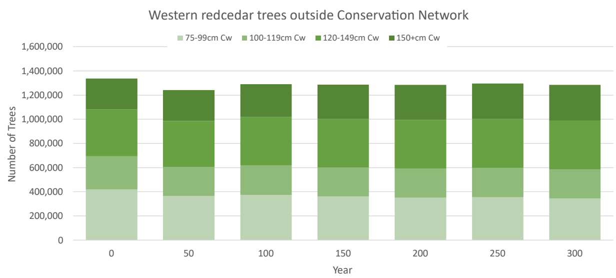


Figure 5: Forecast of western redcedar and yellow cedar outside the ‘Na̱mg̱is Conservation Network.



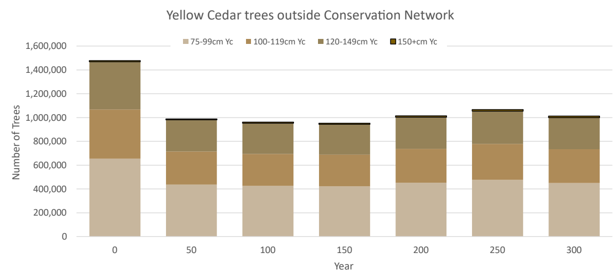
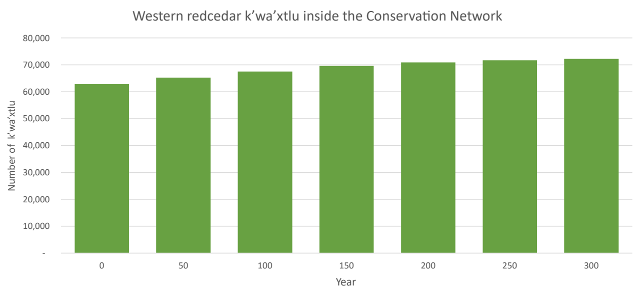


Figure 6: Forecast of k’wa’x̱tłu inside the ‘Na̱mg̱is Conservation Network.



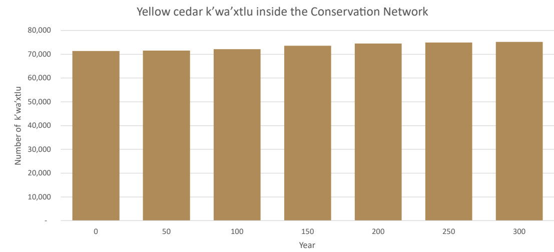
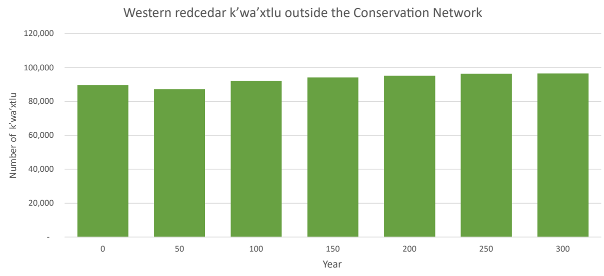


Figure 7: Forecast of k’wa’x̱tłu outside the ‘Na̱mg̱is Conservation Network.



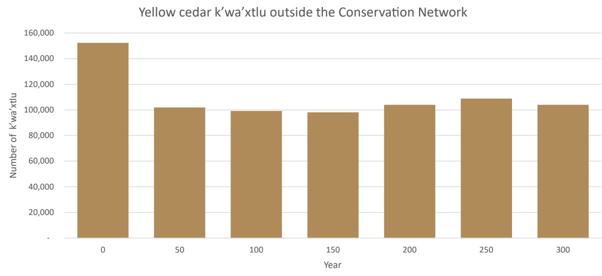
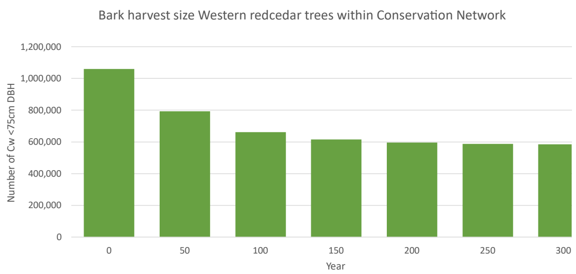


Figure 8: Forecast of western redcedar and yellow cedar < 75cm dbh inside the ‘Na̱mg̱is Conservation Network.



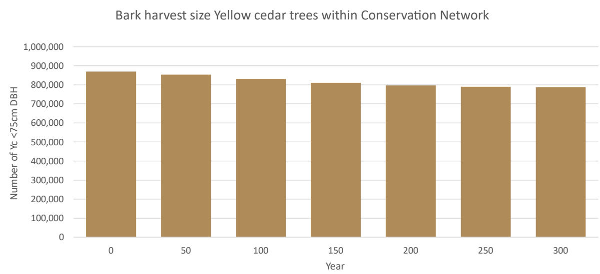
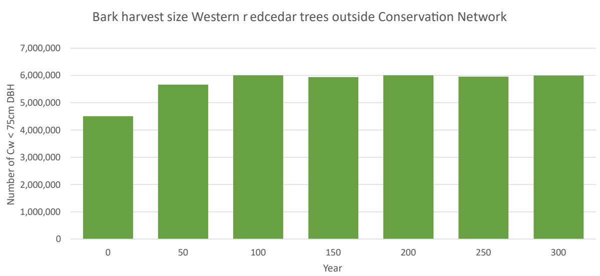
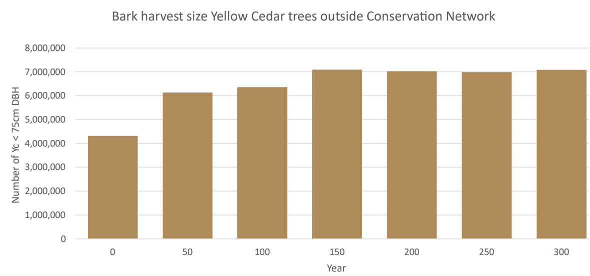


Figure 9: Forecast of western redcedar and yellow cedar < 75cm dbh outside the ‘Na̱mg̱is Conservation Network.





How the FRPA Section 2.22 Objectives were Considered in Establishing the Outcome

The details of how the four relevant FRPA Section 2.22 Objectives were considered in establishing the outcome are as follows:

Supporting the protection and conservation of the environment.

- This is one of the ten outcomes that is an element of biodiversity and ecosystem health.
- The Nimpkish Valley contains five biogeoclimatic subzones which are the CWHvm1, CWHvm2, CWHmm1, CWHxm2, and MHmm1. Western redcedar and yellow cedar are ecologically suited across many of the ecosystem types in these subzones and maintaining western redcedar and yellow cedar is integral to the current and projected future ecology of the area.
- It is understood that large portions of the Nimpkish Valley in the past, likely contained stands that had an uneven-age forest mosaic with a range of tree sizes, as represented by the classic inverse-J distribution of diameter classes. Fostering a diverse range of western redcedar and yellow cedar diameters more closely reflects this diversity, increasing the integrity and resilience of the valley into the future.
- The diverse range of diameters reflects the prioritized reforestation of western redcedar and yellow cedar aligned with climate based seed transfer requirements, harvesting using the retention silvicultural system, the 'Na̱mg̱is conservation network, and increased rotation ages in the maɫ̱ik portion of the Gwa'ni Special Management Zone.

Managing the values placed on forest ecosystems by Indigenous peoples.

- Western redcedar and yellow cedar is a keystone Indigenous cultural element of the greater Pacific Northwest region. Borrowing from the Kwak'wala language, we broadly refer to the larger sizes of such cedars as k'wa'x̱tłu. This outcome supports the continued presence of k'wa'x̱tłu in the Nimpkish Valley.
- Western redcedar gathering in the territory was the most frequent activity identified during 'Na̱mg̱is community engagement. As one artist described

in ‘Namgis member engagement, “cedar is more valuable than gold.” This outcome supports the continued gathering of western red cedar in the Nimpkish Valley.

- Traditionally, and continuing into the present, western redcedar and yellow cedar of various sizes supply materials to produce a wide diversity of cedar products. Ensuring an abundance of western redcedar and yellow cedar across a range of ages and sizes increases the certainty that the needs of ‘Namgis will be sustained across generations.

Managing the values placed on forest ecosystems by local communities.

- Gwa’ni and FLP engagement with local communities supported adding western redcedar and yellow cedar as a separate value. Local communities also recognized the importance of these tree species, and that additional emphasis is required, separate from both timber and biodiversity values. This outcome supports the continued presence of western redcedar and yellow cedar in the Nimpkish Valley

- Local community engagement also emphasized managing for a balance between economic and environmental values. FF 1 and FF 6 reflect this balance forecast over the next 300 years. While FF 1 focuses on the long-term diversity of western redcedar and yellow cedar with an emphasis on ‘Namgis culture and health, the long-term harvest flow in FF 6 also includes western redcedar and yellow cedar.

- Healthy forests that include very large trees are valued by all peoples, especially as society in general moves towards renewed expectations for more holistic forest management. Healthy and diverse forests support recreational opportunities which have also been identified as an important value by the local communities.

Preventing, mitigating, and adapting to impacts caused by significant disturbances to forests and forest health, including wildlife, insects, disease, and drought.

- Maintaining western redcedar and yellow cedar in a range of sizes, ages, and conditions across the landscape provides the resilience and diversity nature requires to adapt to significant disturbances. If a natural disturbance event was to impact a particular age class of either tree species more heavily, maintaining a diversity of ages provides the option and flexibility to recruit into the impacted age class more readily.
- Climate change modelling predicts that western redcedar is likely to increase in range at higher elevations and decrease in range at lower elevations, with yellow cedar correspondingly decreasing at higher elevations. Continuing to maintain a diversity of western redcedar and yellow cedar across a range of elevations, ages, and conditions reduces the risk associated with uncertainties regarding the extent and magnitude of these changes.
- Increasing landscape scale species diversity and structure across elevation gradients, contributes to a diverse mosaic through patch dynamics providing increased resilience to forecast changes in climate.

Supporting Stewardship Strategies

- SS 1: ‘Na̱mg̱is Conservation Network
- SS 2: Carbon Reserve
- SS 5: Retention of Riparian Forest – Streams
- SS 6: Retention of Riparian Forest – Wetlands
- SS 7: Retention of Riparian Forest – Lakes
- SS 8: Variable Retention
- SS 9: Harvest Criteria
- SS 11: K’wa’x̱tłu Retention Criteria
- SS 12: Reforestation and Stand Tending
- SS 18: Karst Features
- SS 20: Habitat Features (Bears, Raptors, Great Blue Heron)

Adaptive Management Indicators

- AMI 1: Area (ha) of stands containing k’wa’x̱tłu and area (ha) of stands containing trees for bark harvest.
- AMI 13: The five-year rolling average of the total number (stems/ha) of western redcedar and yellow cedar at the time of free growing where these species were planted as defined by the inventory label.
- AMI 14: The five-year rolling average of the change (%) in the density (stems/ha) of western redcedar and yellow cedar at the time of free growing compared to the density at planting.
- AMI 15: The five-year rolling average of the change (%) in the density (stems/ha) of western redcedar and yellow cedar at the next harvest compared to the density at free growing.
- AMI 33: The total inventory (#) of k’wa’x̱tłu by diameter category.
- AMI 38: The total number of potential operating days at Mount Cain in December of each year, based on opening day. The depth of snowpack (cm) on April 1 of each year.

FF 2 — STREAM CHANNEL CONDITION

Supports FRPA Section 2.22 Objectives	⬡ ⛾ ◎ ⊕
Supports Biodiversity and Ecosystem Health	✦
Supports Climate Change Adaptation	☀

Linked Gwa'ni Objectives

GO 1 – Maintain or improve aquatic ecosystems with a functioning and resilient riparian forest supporting healthy fish populations.

GO 4 — Manage the Gwa'ni Project area recognizing the projected changes to the local climate.

GO 7 – Maintain the hydrological function of the Nimpkish Valley as a source of abundant and clean water.

FLP Goal

Stable or improving stream channel conditions supporting healthy fish populations.

FF 2

The channel condition of the mainstem reach[1] within each local watershed is improving across the majority[2] of the watersheds.

[1]Channel condition of the mainstem reach is monitored through a professional assessment approximately every 10 years. The next professional assessment is planned for the period between 2028 to 2032.

[2]The majority of the watersheds is defined as ≥ 75% of the watersheds have a channel condition that is classified as improving, stable, or consistent with the natural condition.

Description of the Outcome and Forecast

Most of TFL 37 is in the Nimpkish watershed which is a regional watershed that drains north into the Broughton Strait near Cormorant Island. Major basins within a regional watershed that drain directly into the mainstem of the regional watershed are called local watersheds. For the purposes of this outcome, the channel condition of the mainstem reaches of the local watersheds are monitored to determine if the channel condition is improving, stable, or consistent with the natural condition.

The main Nimpkish Valley, and extending into the upper Oktwanch watershed, has a broad valley floor with floodplains, wetlands, fans, and numerous alluvial streams. Many of the tributary watersheds rise to steep upper valley slopes with alpine areas, rockslides, and avalanche tracks. The Nimpkish Valley floor has fine-textured marine or glaciolacustrine deposits, and extensive alluvial deposits. The lower and mid valley slopes are typically till-blanketed, and the mid and upper slopes have varying colluvial veneers and blankets. Stream channels across these different landforms achieve a form in response to inputs of water, sediment, and large wood debris inputs.

This makes the monitoring of physical indicators of stream channel condition an effective approach. A professional assessment and judgement interpret existing watershed conditions and trends rather than utilizing a more generalized set of watershed level indicators such as road density, stream crossing density, or equivalent clear-cut area. Aspects of recovery that are typically assessed by a specialist include:

- Revegetation of sediment sources including landslide paths, stream escarpments, eroded gullies, road cut slopes, fill slopes, and ditch lines.
- Hydrologic recovery of regenerating forest stands with respect to characteristics affecting streamflow response.
- Riparian vegetation regrowth including on stream banks and bars, its contribution to reducing channel bank erosion, improving channel stability, and supply of large wood.
- Alterations in channel morphology caused by historic logging practices, landslides, wildfires, or extreme floods.

The joint professional practice guidelines for Watershed Assessment and Management of Hydrologic and Geomorphic Risk in the Forest Sector (January 14, 2021) provides additional detail on this approach. While habitat complexity and fish populations are not directly assessed, inferences can be made from stream channel type and riparian condition. For example, an alluvial stream with unlogged riparian forest could be expected to have greater habitat complexity than a nonalluvial stream; or than an alluvial stream where the riparian forest is inadequate to supply large wood inputs or limit channel bank erosion.

Climate change can have implications on rates of watershed disturbance and hydrologic response. For example, increased rainfall intensity may increase landslide occurrence or peak flows which can increase the delivery of sediment to stream networks. This can also delay the recovery of floodplains and forest immediately adjacent to stream channels impacted by historic harvesting. This makes it important to implement FF 2 in the context of adaptive management framework with the flexibility to adjust SS 3 and SS 4 in the FOP as needed aligned with the current stream channel condition trend. Where the stream channel condition is not improving, SS 3 and SS 4 can be adjusted to help sustain a continued improvement aligned with the predicted trend.

Figure 10 identifies the current channel condition trend by local watershed from the latest assessment completed in 2020. The outcome reflects the results of this assessment, which predicts a continued trend of improving stream channel condition.

It is recognized that there may be periods of time where the trend does not improve as the result of intense storm events that can impact the channel condition while the riparian forest continues to recover. The majority of local watersheds with a channel condition that is classified as improving, stable, or consistent with the natural condition is therefore defined as ≥75%.

Figure 10: The current channel condition trend in 2020 by local watershed.

2020 Channel Condition Trend	Local Watershed[3]
High disturbance	Kilpala, Kinman, Sutton
Moderate disturbance, or improving and may have sites that are of concern	Eve-Kunnum, Gold, Kaipit, Kilpala – Karmutzen, Kiyu, Kla'anch Maquilla, Noomas, Surprise Nimpkish Remainder – mid (Nimpkish Lake to Woss) Nimpkish Remainder – upper (upstream of Woss)
Minor disturbance, or improving and may have sites that are still disturbed	Atluck – Wolfe, Remainder Davie – Granite, Schoen North, Remainder Kaipit – Canon, Lukwa, Maquilla – Quilla, Tlakwa, Woss – Clint, Fiddle, Remainder Kokish – Tsulton, Tsitika – Elliott Upper Tsitika, West Tsitika
Stable or consistent with natural condition	Atluck – Marion, Shannon, Welch Davie – Club, Croman, Klaklakama, Hump, Steele, Storey, Woodengle Woss – Torback, Nimpkish Remainder – lower Theimer

[3] See Appendix A for a map of the local watersheds.

How the FRPA Section 2.22 Objectives were Considered in Establishing the Outcome

The details of how the four relevant FRPA Section 2.22 Objectives were considered in establishing the outcome are as follows:

Supporting the protection and conservation of the environment.

- This is one of the ten outcomes that is an element of biodiversity and ecosystem health.
- The cumulative effect of all activities, including natural disturbance events, in the upland forest all influence channel condition. This outcome, supported through adaptive management monitoring, reflects the cumulative effect of all activities proving a point of reference for maintaining healthy aquatic ecosystems.
- Stream channels achieve a form in response to inputs of water, sediment, and large wood inputs. Historic harvesting in the Nimpkish Valley has affected the stability of some streams including floodplains along the Nimpkish River. This outcome reflects the recovery of these floodplains.
- Maintaining trees of an adequate size adjacent to alluvial stream channels resists streambank erosion and provides inputs of functional large wood. This is particularly important during peak flow events which occur in coastal watersheds during high intensity rainstorms and rain-on-snow events.
- Maintaining stream channels that are stable or consistent with natural conditions is part of promoting healthy aquatic ecosystems and fish populations.

Managing the values placed on forest ecosystems by Indigenous peoples.

- Aquatic resources including salmon were identified during engagement as one of the most important values to ‘Na̱mg̱is culture, and restoring salmon habitat is a top priority. The goal of this outcome is to maintain stable or improving stream channel conditions to support healthy fish populations.
- The holder of TFL 37 and ‘Na̱mg̱is have supported and participated in stream restoration projects over the decades, while recognizing the need to allow for the natural recovery of riparian areas. Stream channel condition reflects the

recovery of riparian areas as part of supporting healthy fish populations.

- Areas around aquatic features are identified as important places in terms of spiritual, cultural, and recreational uses. Stream channel condition reflects the retention of riparian areas for a variety of purposes including spiritual, cultural, and recreational uses.

Managing the values placed on forest ecosystems by local communities.

- In targeted stakeholder engagement for the Gwa'ni Project, aquatic habitat and fish and wildlife were the highest ranked values amongst tourism and recreation stakeholders, and the second highest amongst forestry tenure holders and contractors.
- The same engagement showed that impacts to salmon habitat was a top five concern of residents.
- In a public survey delivered as part of Gwa'ni Project engagement, fishing and camping was ranked among the four most popular uses within the Nimpkish Valley, by both residents and visitors. Within this survey, day use activities such as fishing and harvesting of non-timber forest products were among other high ranking popular activities. Many of these activities are associated with aquatic areas and the riparian forest. Stream channel condition reflects the retention of riparian areas for a variety of purposes including spiritual, cultural, and recreational uses.

Preventing, mitigating, and adapting to impacts caused by significant disturbances to forests and forest health, including wildlife, insects, disease, and drought.

- Maintaining stable channels helps to reduce the effects that may be caused by intense rain and wind, and rain-on-snow events.
- Stable channels have inputs of large wood that cannot be transported by the stream, leading to a more resilient channel in both high and low flows, with improved habitat opportunities.
- Rivers and adjacent riparian forests can be more resistant to fire. These sites generally contain more moisture and a higher proportion of deciduous tree species which are more fire resistant. They can, however, also have higher fuel loads, and after prolonged drying can serve as a fuel wick.

Supporting Stewardship Strategies

- SS 1: ʼNa̱mg̱is Conservation Network
- SS 2: Carbon Reserve
- SS 3: Rate of Harvest in Areas of Sensitivity
- SS 4: Acceptable Level of Landslide Risk
- SS 5: Retention of Riparian Forest - Streams
- SS 8: Variable Retention
- SS 15: Invasive Plants
- SS 16: Erosion Control Treatments
- SS 18: Karst Features

Adaptive Management Indicators

- AMI 2: The proportion of local watersheds that have a channel condition of the mainstem reach classified as improving, stable, or consistent with the natural condition, as identified through a professional assessment.
- AMI 35: The average number of annual rainfall events over 75mm in 12 hours or 100mm in 24 hours.

FF 3 — RIPARIAN FUNCTION

Supports FRPA Section 2.22 Objectives	⬡ ♜ ◎ ⊕
Supports Biodiversity and Ecosystem Health	✦
Supports Climate Change Adaptation	☀

Linked Gwa'ni Objectives

GO 1 — Maintain or improve aquatic ecosystems with a functioning and resilient riparian forest supporting healthy fish populations.

GO 4 — Manage the Gwa'ni Project area recognizing the projected changes to the local climate.

GO 7 — Maintain the hydrological function of the Nimpkish Valley as a source of abundant and clean water.

FLP Goal

Riparian forest that provides channel bank stability and functional large wood inputs that resist erosion supporting healthy fish populations.

FF 3

The proportion of riparian forest[1] that contains trees large enough to provide channel bank stability and functional large wood inputs by stream class at the end of 2035[2] is identified in Figure 11, with riparian forest along the largest rivers forecast to be fully recovered in 150 years.

Figure 11: Proportion of riparian forest with trees large enough to provide bank stability and functional large wood inputs.

Riparian Class	Bank Stability (%)	Functional Large Wood Inputs (%)
Nimpkish, Davie, Woss, Sebahall	~13%	~13%
S1	~62%	~62%
S2	~82%	~65%
S3	~93%	~64%

[1]Defined in Figure 12 through the age of riparian forest. The width of riparian forest used in the forecast is defined by SS 5 in the FOP, which is conservative, as approximately 80-90% of large wood inputs comes from within 10m of the channel.

Description of the Outcome and Forecast

The riparian area along streams is the transition from the aquatic environment to the upland terrestrial ecosystems. An integral aspect of the riparian area are the trees within the first 10m of the stream channel. These trees directly help to maintain channel bank stability through their root structures and provide greater than 90% of the large wood inputs to the stream channel. These functions are particularly important along alluvial and semi alluvial stream channels where the banks are more susceptible to erosion with a heightened importance during peak flow events associated with periods of heavy rainfall or rain-on-snow. The size of trees required to maintain channel bank stability and provide functional large wood inputs that won't be washed away varies by the size and transport potential of the stream. We have chosen to focus on the larger S1 to S3 streams recognizing the significance of fish habitat and that recovery from historic harvesting will take longer to achieve. Figure 12 identifies the age of riparian forest, as a surrogate for tree size, that has been developed specific to the Nimpkish Valley, with the help of a specialist with experience in the area. The parameters in this table were used to produce a quantifiable forecast for the recovery of riparian forest along S1 to S3 streams. We recognize that this approach is conservative because the full width of riparian forest has been used which will take longer to achieve the minimum forest age than just the first 10m of trees immediately adjacent to the stream channel. The Nimpkish, Davie, Woss, and Sebahall rivers are grouped separately given their size and significant length of alluvial stream channel reaches. The forecast in Figure 13 identifies that recovery of the riparian forest along these rivers is already underway with a period of significant change forecast between 30 and 150 years into the future. For the other S1, S2, and S3 streams, recovery is also well underway and is forecast to be complete in approximately 50 years.

Figure 12: Age of riparian forest required to support channel bank stability and functional large wood inputs by stream class.

Stream Class	Channel Bank Stability		Functional Large Wood Inputs	
	Riparian Forest Width (m)	Minimum Forest Age (Years)	Tree Size (DBH)	Minimum Forest Age (Years)
Nimpkish, Davie, Woss, Sebahall	70m or floodplain	≥ 150	50cm[4]	150
All other S1	70m or floodplain	≥ 60	30cm	60
S2	50m or floodplain	≥ 30	30cm	60
S3	30m or floodplain	≥ 15	30cm	60

Climate change can have implications on channel bank stability and the transport of large wood debris inputs. For example, increased rainfall intensity can lead to higher peak flows which can cause bank erosion while also flushing large wood inputs downstream contributing to debris jams or wedges that can exacerbate stream channel and bank erosion. This can also delay the recovery of floodplains that have been impacted by historic harvesting. The minimum forest ages used in this outcome include consideration of the potential for higher peak flows that may occur because of climate change. To establish a short-term outcome that aligns with the 10-year term of the plan, the proportion riparian forest that contains trees large enough to provide channel bank stability and functional large wood inputs at the end of 2035 is identified as part of the future forest outcome in Figure 11. The outcome evaluates the total length of streams by stream class to determine the proportion.

[4] Large wood functions in alluvial reaches up to about 50m channel width. In large rivers like the Nimpkish floodplain reaches, large wood debris aggregates in jams which influence channel morphology and create habitat features.

Figure 13: Forecast of the proportion of riparian forest area with an age adequate to maintain channel bank stability and functional large wood inputs.

<table>
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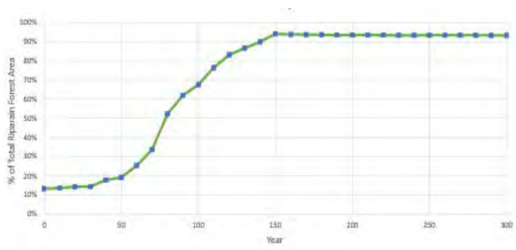
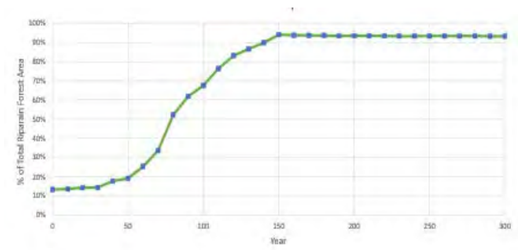
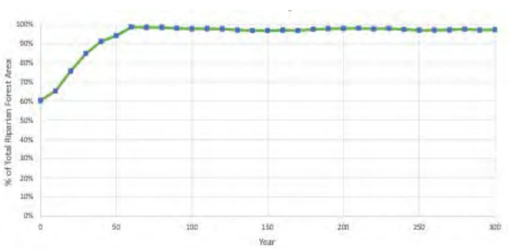
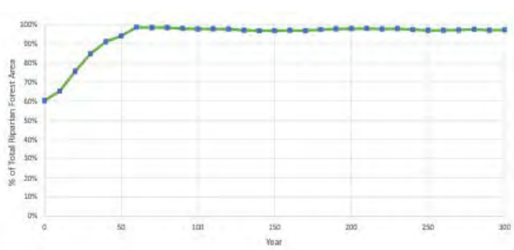
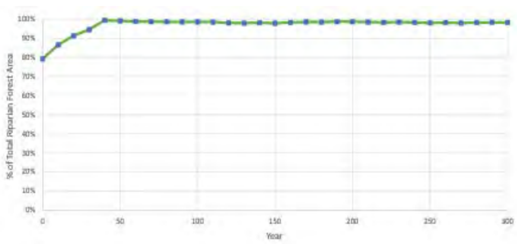
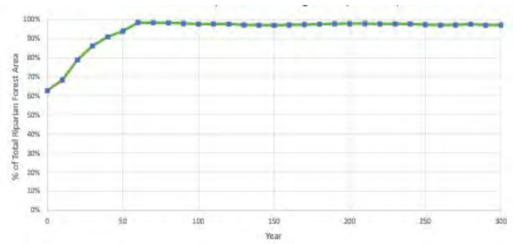
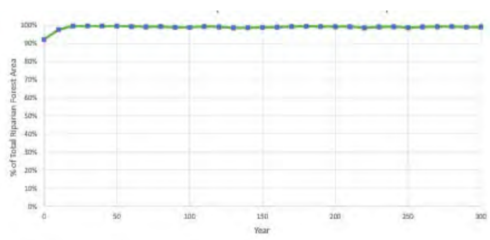
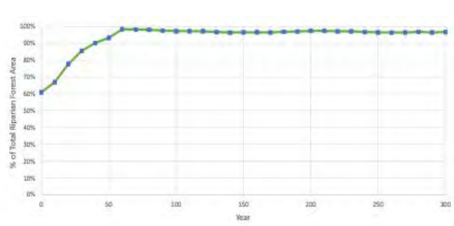
<tr><td>Nimpkish, Davie, Woss, Sebahall</td><td></td><td></td></tr>
<tr><td>All other S1</td><td></td><td></td></tr>
<tr><td>S2</td><td></td><td></td></tr>
<tr><td>S3</td><td></td><td></td></tr>
</table>

How the FRPA Section 2.22 Objectives were Considered in Establishing the Outcome

The details of how the four relevant FRPA Section 2.22 Objectives were considered in establishing the outcome are as follows:

Supporting the protection and conservation of the environment.

- This is one of the ten outcomes that is an element of biodiversity and ecosystem health.
- The first 10m of trees immediately adjacent to the stream channel are integral to channel bank stability through their root structures and provide greater than 90% of the large wood inputs to the stream channel.
- Historic harvesting has created instability along sections of the larger streams where the riparian forest continues to recover as it ages. This is providing more robust root structures adjacent to the stream channels, along with larger diameter wood inputs.
- Maintaining stable stream channels reduces erosion and large wood inputs help to promote healthy aquatic ecosystems supporting fish populations.

Managing the values placed on forest ecosystems by Indigenous peoples.

- Aquatic resources including salmon were identified during engagement as one of the most important values to ‘Na̲mg̲is culture, and restoring salmon habitat is a top priority. The recovery of riparian forest helps to support healthy salmon habitat.
- ‘Na̲mg̲is and the holder of TFL 37 have supported and participated in many stream restoration projects over the decades, while recognizing the need to allow for the natural recovery of riparian areas.
- Areas around aquatic features are identified as important places in terms of spiritual, cultural, and recreational uses. Riparian forests support a wide range of uses.

Managing the values placed on forest ecosystems by local communities.

- In targeted stakeholder engagement for the Gwa'ni Project, aquatic habitat and fish and wildlife were the highest ranked values amongst tourism and recreation stakeholders, and the second highest amongst forestry tenure holders and contractors. The recovery of riparian forest helps to support healthy salmon habitat.
- The same engagement showed that impacts to salmon habitat was a top five concern of residents. The recovery of riparian forest helps to support healthy salmon habitat.
- In a public survey delivered as part of Gwa'ni Project engagement, fishing and camping was ranked among the four most popular uses within the Nimpkish Valley, by both residents and visitors. Within this survey, day use activities such as fishing and harvesting of non-timber forest products were among other high ranking popular activities. Many of these activities are associated with aquatic areas and the riparian forest.

Preventing, mitigating, and adapting to impacts caused by significant disturbances to forests and forest health, including wildlife, insects, disease, and drought.

- Managing for channel bank stability and large wood inputs helps to reduce the effects that may be caused by intense rain and wind, and rain-on-snow events.
- Large wood inputs that are unable to be transported by a stream create a more resilient channel in both high and low flows and provide habitat opportunities.
- Healthy streams and adjacent riparian plant communities can serve as a fuel break as they are more resistant to fire. The fuel load of the riparian area does influence though, how well it serves as a fuel break.
- These sites generally contain more moisture and a higher proportion of deciduous tree species which are more fire resistant. The majority of the S1 to S3 streams are at lower elevations and contain a significant component of Douglas-fir. As these trees age, the bark will continue to thicken and enable them to withstand low to medium intensity fires.

Supporting Stewardship Strategies

- SS 1: ‘Na̲mg̱is Conservation Network
- SS 2: Carbon Reserve
- SS 3: Rate of Harvest in Areas of Sensitivity
- SS 4: Acceptable Level of Landslide Risk
- SS 5: Retention of Riparian Forest – Streams
- SS 15: Invasive Plants
- SS 18: Karst Features

Adaptive Management Indicators

AMI 3: The proportion (%) of the area of riparian forest of S1, S2, and S3 streams that have trees large enough to maintain channel bank stability and provide functional large wood inputs.

FF 4 — FOREST MOSAIC IN THE GWA'NI SPECIAL MANAGEMENT ZONE

Supports FRPA Section 2.22 Objectives	△ ⬡ ♜ ◎ ⊕
Supports Biodiversity and Ecosystem Health	✦
Supports Climate Change Adaptation	☀

Linked Gwa'ni Objectives

GO 2 — Maintain a healthy, diverse and resilient[1] forest that contains native species, communities, natural landscapes, and ecological functions characteristic of the Nimpkish Valley.

[1] Resilience is defined as the ability of an ecosystem to absorb external influences and remain intact (Holling 1973)

Gwa'ni Special Management Zone Objective — Increase the proportion of mature forest within an un-even aged mosaic that is reasonably consistent with the attributes of the natural ecosystem supporting connectivity to fish habitat in the Nimpkish River and its primary tributaries.

FLP Goal

A forest mosaic in the Gwa'ni Special Management Zone[1] that increases ecological integrity, connectivity, and wildfire resilience while providing a diverse mix of log grades for manufacturing.

[1]Refer to Appendix A for a map of the Gwa'ni Special Management Zone

FF 4

More than 20% of Gwa'ni Special Management Zone has forest ≥ 120 years old at the end of 2035[1] with a long-term forecast of more than 50% by 2140.

[1]Natural disturbance events may affect the outcome.

Description of the Outcome and Forecast

Forest ecosystems and associated species evolve in response to climate, other biophysical attributes, and range of natural disturbances at various temporal and spatial scales[5]. The Gwa'ni Special Management Zone is being managed in a way that will more closely mimic natural disturbance with forests being reasonably consistent with the attributes of the original forests and forest landscapes aligned with the definition of the 'consistent zone' in the Old Growth Strategic Review[6]. The Gwa'ni Special Management Zone increases ecological diversity and resilience by increasing the complexity of

[5] Beese, W.J., Deal, J., Dunsworth, B.G.,Mitchell, S.J., & Philpott, T.J. (2019). Two decades of variable retention in British Columbia: A review of its implementation and effectiveness for biodiversity conservation. Ecological Processes, 8, 1-22. DOI: 10.1186/s13717-019-0181-9

[6] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/stewardship/old-growth-forests/strategic-review-20200430.pdf

forests associated with the full range of ecosystems as outlined in FF 9 while also increasing the resilience of the landscape to potential future wildfires. All of this is achieved while providing for a diverse mix of log grades supporting manufacturing facilities on Vancouver Island.

Variable Retention harvesting is an important element of this outcome as it maintains elements of the pre-harvest stand enhancing structural complexity including live and dead trees of varying sizes and canopy layers. This is complemented by a longer rotation age within the ma̱łik portion of the Gwa’ni Special Management Zone utilizing a range of cutblock sizes that collectively lead to smaller areas of contiguous stands as described and forecast in Figure 17. Together these strategies contribute to a diversity of forest structures, tree ages, and patch sizes which increase ecosystem integrity as described and forecast in FF 5. Connectivity is also enhanced across the Nimpkish Valley including the Gwa’ni Special Management Zone creating linkages between fish habitat in the Nimpkish River and its primary tributaries to the upland forest as described in FF 10.

The forest mosaic being developed in the Gwa’ni Special Management Zone supports landscape fire management by improving the resilience of the landscape and the ability of the landscape to resist changes and recover from wildfire. While the Nimpkish Valley currently has limited fire activity, it is recognized that there is the potential for more extensive and intense fires in the future given the prediction of warmer and drier summers with decreased winter snowpacks. This may or may not lead to more severe wildfires depending on fire behavior and factors such as the soil types and stand types where the fires occur.

With the Gwa’ni Special Management Zone located along the primary riparian corridors of the Nimpkish Valley, a landscape web of more fire-resistant areas, comprised of smaller areas of contiguous stands increases the range of wildfire control options available. The stands in this area are predominantly Douglas-fir and by increasing the average age of the forest in this area, the ability of these trees to survive low to moderate intensity fires improves as their bark thickens. The reforestation strategy associated with the Gwa’ni Special Management Zone also promotes an increase in deciduous tree species, contributing to the overall fire resilience of this area. The spatial pattern of harvest across the Gwa’ni Special Management Zone will help to maintain an accessible road network in support of firefighting while also enabling incidences of laminated root rot (*Phellinus weirii*) in Douglas-fir to be addressed as part of harvesting and reforestation efforts further reducing the risk of wildfire. The location of the Gwa’ni Special Management Zone around the community of Woss helps to decrease the risk of future wildfires impacting the community.

To establish a short-term outcome that aligns with the 10-year term of the plan, the proportion of the forest that contains trees older than 120 years is identified at the end of 2035 in the context of the 300-year forecast in Figure 14 which projects more than 50% of the forest being older than 120 years by 2140 across the Gwa’ni Special Management Zone. Figure 15 forecasts the age class distribution of the mała̱ik and Figure 16 forecasts the age class distribution of the dza̱’wa̱n.

Figure 17 indicates the trend towards smaller patches of contiguous stands < 21 years old (i.e., recent harvest) within the mała̱ik portion of the Gwa’ni Special Management Zone. In the long-term, the forecast indicates 80% of these young patches will be ≤ 10 hectares in size, a significant increase from the current 13%. This patch size distribution increases ecological diversity and resilience by increasing the complexity of forests within the SMZ.

Figure 14: Forecast of area (ha) by age-classes in the Gwa’ni Special Management Zone.

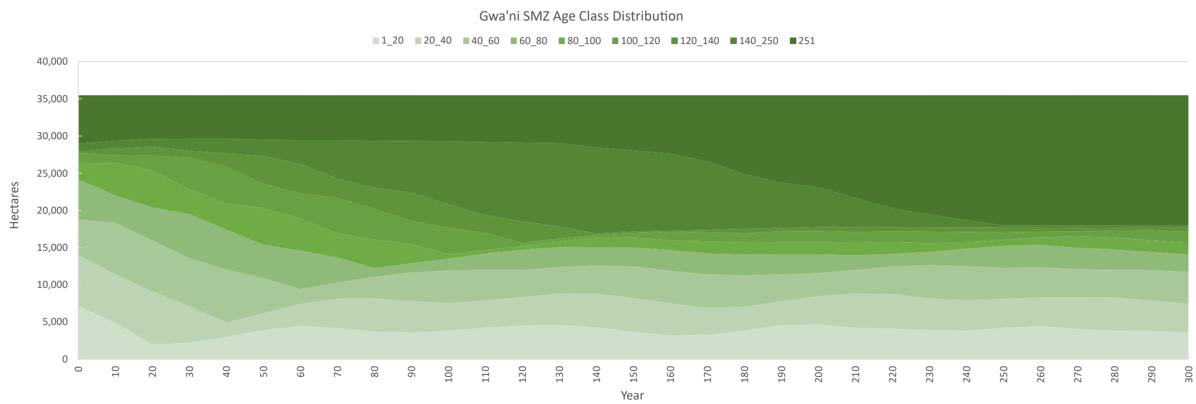


Figure 15: Forecast of area (ha) by age-class in the mała̱ik subzone.

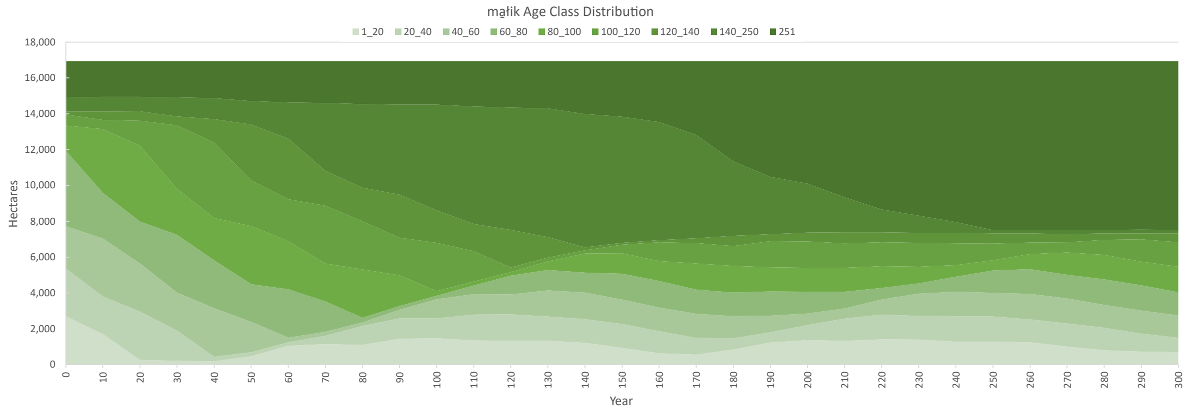


Figure 16: Forecast of area (ha) by age-class in the dza'wan subzone.

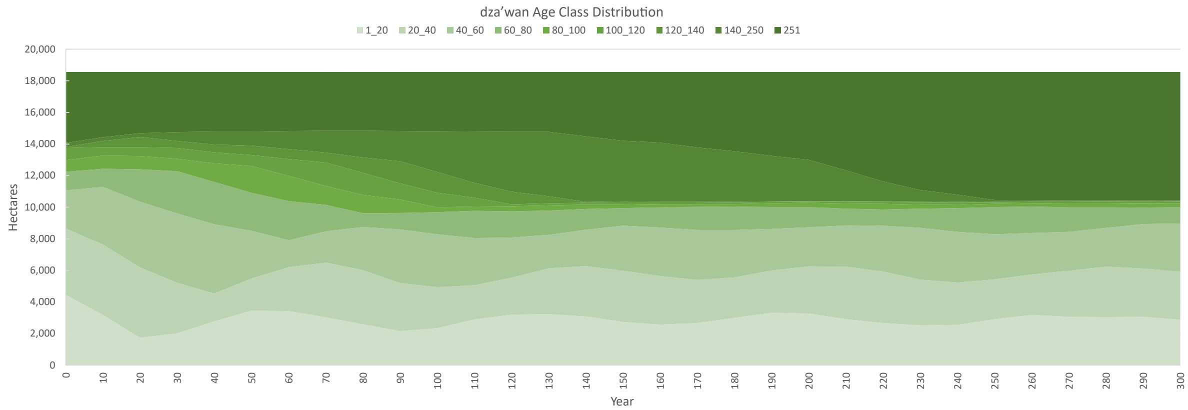


Figure 17: Forecast proportion (%) of contiguous stands <21 years old by size category in the małik.

Area of Contiguous Stands (ha)	Forecast Proportion (Years)		
	2024	2124	2324
≤ 5	4%	19%	45%
> 5 to ≤ 10	9%	16%	35%
> 10 to ≤ 15	6%	9%	14%
> 15 to ≤ 20	13%	8%	5%
≥ 20	68%	47%	2%

How the FRPA Section 2.22 Objectives were Considered in Establishing the Outcome

The details of how all five of the FRPA Section 2.22 Objectives were considered in establishing the outcome are as follows:

Supporting the production and supply of timber in the forest landscape area.

- A diverse mix of log grades aligned with manufacturing facilities on Vancouver Island maintains a vertically integrated supply chain enabling the optimized use of each log.
- Full rotation management that includes the spatial and temporal pattern of the future harvest maintains the critical connections needed to future seed supply planning at the Saanich Forestry Centre aligned with climate-based seed transfer, log profile and fibre mix to Western's and Aṫłi's manufacturing and processing facilities on Vancouver Island, and associated harvest equipment needs.

Supporting the protection and conservation of the environment.

- This is one of the ten outcomes that is an element of biodiversity and ecosystem health.
- Important elements of landscape level biodiversity and an ecosystem approach to biodiversity management are the seral stage distribution of ecosystems, the temporal and spatial pattern of harvest areas, forest interior habitat, landscape connectivity, stand structure, and species composition. The diversity and pattern of forest stands in the Gwa'ni Special Management Zones is intended to promote conditions which are reasonably consistent with the patterns of natural disturbance for the Nimpkish Valley.
- Reducing the total extent and proportion of contiguous area in stands < 21 years of age on a portion of the landscape, increases overall landscape complexity and resilience.
- Increasing the proportion of the forest with older seral stages of plant communities on a portion of the landscape, increases overall landscape diversity and resilience.
- Enhancing structural complexity at the landscape and stand level including live and dead trees of various sizes and canopy layers more closely mimics natural disturbance patterns.

Managing the values placed on forest ecosystems by Indigenous peoples.

- When ‘Na̱mg̱is members were asked what the most important things were to consider when making planning decisions in the Nimpkish Valley, sustainability for all generations was communicated as being extremely important. This outcome recognizes that we are implementing a spatial and temporal management regime today, in order to develop the desired forest mosaic of the future.

- By 2140, mature and old forest stands are expected to cover over half of the Special Management Zone, addressing a top concern of ‘Na̱mg̱is members, regarding impacts to old growth forests.

- The Nimpkish River is the soul of the Nimpkish Valley and lower intensity of harvest across smaller cutblocks, combined with the increased use of the retention silvicultural system within the ma̱łik, reflects the significance of this area.

- While understanding the framework of BC forest policy would like all outcomes to be measurable and verifiable over a 10-year period, ‘Na̱mg̱is members made it clear there is an expectation for a multi-generational perspective to be applied to ecosystem health. An outcome that focuses on the next 10 years is not meaningful and what is required is a transformational shift over the long-term, that moves away from continuing the harvest pattern of the past. This includes the harvesting of stands at older ages to enable the development of more complex forest structures across the landscape.

Managing the values place of forest ecosystems by local communities.

- Respondents to a public engagement survey delivered via the Gwa’ni Project, indicated that old growth forest is a value to prioritize within land use planning. This outcome supports an increase of old-growth forests over the long-term.

  Public engagement also identified the importance of a stable forest sector, and this outcome maintains a diverse log profile mix over the long-term helping to support a stable forest sector.

- The retired Englewood railway grade is largely located within the Gwa’ni Special Management Zone. A diverse forest matrix within this zone will add quality to the recreational experience should the railway grade be available for hiking in the future.

Preventing, mitigating, and adapting to impacts caused by significant disturbances to forests and forest health, including wildfire, insects, disease, and drought.

- A variety of forest structures, tree ages and patch sizes all contribute to healthy, diverse, and resilient forests.
- The Gwa’ni Special Management Zone is anchored along the primary riparian network of the Nimpkish Valley and the forest mosaic being developed will provide a landscape web of natural fire breaks, which include a component of Douglas-fir providing increased resilience to low and moderate intensity fires.
- Full rotation management that includes the spatial and temporal pattern of the future harvest maintains the critical connection to future seed supply planning at the Saanich Forestry Centre aligned with climate-based seed transfer.

The draft Wildfire Risk Reduction areas around the residential communities of Woss, Beaver Cove, and Hyde Creek are located within or adjacent to the Gwa’ni Special Management Zone. As such, the increased wildfire resilience of this zone helps to protect the communities along with good road access providing opportunities for timely wildfire response. At the time of completing the FLP, the field assessments for the Wildfire Risk Reduction areas are in progress of being completed to determine if treatments or further monitoring is required in these areas.

Supporting Stewardship Strategies

SS 1: ʼNa̱mg̱is Conservation Network
SS 2: Carbon Reserve
SS 5: Retention of Riparian Forest – Streams
SS 6: Retention of Riparian Forest – Wetlands
SS 7: Retention of Riparian Forest – Lakes
SS 8: Variable Retention
SS 9: Harvest Criteria
SS 10: Cutblock Size and Green-Up Criteria
SS 11: K’wa’x̱tłu Retention Criteria
SS 18: Karst Features
SS 20: Habitat Features (Bears, Raptors, Great Blue Heron)

Adaptive Management Indicators

AMI 4: The proportion (%) of productive forest in the Gwa’ni Special Management Zone that is > 120 years old.

FF 5 — ECOSYSTEM INTEGRITY

	△	⬡		◎	⌖
Supports Biodiversity and Ecosystem Health	✦				
Supports Climate Change Adaptation	☀				

Linked Gwa'ni Objectives

GO 2 — Maintain a healthy, diverse and resilient forest that contains native species, communities, natural landscapes, and ecological functions characteristic of the Nimpkish Valley.

GO 4 — Manage the Gwa'ni Project area recognizing the projected changes to the local climate.

FLP Goal

A diverse and resilient[1] managed forest landscape with an emphasis on the Gwa'ni Special Management Zone.

[1]Resilience is defined as the ability of an ecosystem to absorb external influences and remain intact (Holling 1973).

FF 5

The proportion of area in each ecosystem integrity class at the end of 2035[1] is identified in Figure 18 with an increase in the highest integrity classes (I and II) in the Gwa'ni Special Management Zone forecast over the next 300 years.

Figure 18: Proportion of area in each integrity class at the end of 2035 for the GMZ and SMZ.

Integrity Class	Proportion of Area (%)
I	22-28
II	8-14
III	26-32
IV	31-37

[1]Natural disturbance events and the ability to achieve the available harvest volume as forecast, will affect the outcome. The forecast includes the contribution of the helicopter harvest method.

Description of the Outcome and Forecast

As regenerating stands develop along a successional trajectory, they develop attributes of older forests, including height, horizontal and vertical structural diversity, species composition and cover, and forest floor development[7][8][9].

Attributes such as age, stand structure, and species diversity, combined with landscape context, are all appropriate and useful for assessing ecosystem integrity. This approach builds on earlier initiatives developed primarily for assessing individual element occurrences of rare or at-risk ecological communities by NatureServe[10] and the BC Conservation Data Centre[11] which utilize the three factors of condition, size, and landscape context to develop an ecosystem integrity score for individual occurrences.

Significant progress has been made that builds on this approach to now utilize LiDAR[12] technology to assess forest structural complexity, focusing on the metric of rumple, which is a measure of canopy roughness or rugosity. The use of LiDAR is a significant step forward, as it allows us to consider the structural complexity of all stands, moving beyond simplified age-based risk approaches. Canopy roughness is an important forest attribute that correlates with other indicators of ecosystem recovery and integrity, such as understory vegetation development and habitat diversity.

A total of six attributes (mean and standard deviation of rumple, stand age, tree species diversity, polygon size, and landscape context) are used to develop an ecosystem integrity score for each forest cover polygon. The current conditions (year 0) are assessed using recent LiDAR and forest inventory data. Future conditions are modeled based on the Patchworks™ forecast of the forest. Details of the approach are contained in Appendix F in the report titled, 'Assessing, Mapping, and Forecasting Integrity – a Lidar-based GIS Approach' (September 17, 2024).

'Namgis community engagement identified that improving the ecological integrity of the Nimpkish Valley meant that we could not simply repeat the harvest pattern of the past. It was important that the integrity of the valley bottom ecosystems, which had

[7] Gerzon, M., B. Seely, and A. MacKinnon. 2011. The temporal development of old-growth structural attributes in second-growth stands: a chronosequence study in the Coastal Western Hemlock zone in British Columbia. Can. J. For. Res. 41: 1534-1546.

[8] LePage, P. and A. Banner. 2014. Long-term recovery of forest structure and composition after harvesting in the coastal temperate rainforests of northern British Columbia. For. Ecol. Manage. 318: 250–260.

[9] Price, K., E. Lilles, and A. Banner. 2017. Long-term recovery of epiphytic communities in the Great Bear Rainforest of Coastal British Columbia. For. Ecol. Manag. 391: 296–308.

[10] Faber-Langendoen, D., W. Nichols, J. Rocchio, K. Walz, and J. Lemly. 2016. An Introduction to NatureServe's Ecological Integrity Assessment Method. NatureServe, Arlington, VA. 33 p.

[11] British Columbia Ministry of Environment. 2006. Standard for mapping ecosystems at risk in British Columbia. An approach to mapping ecosystems at risk and other sensitive ecosystems. Version 1.0. B.C. Ministry of Environment.

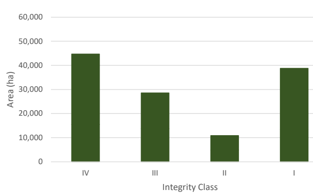
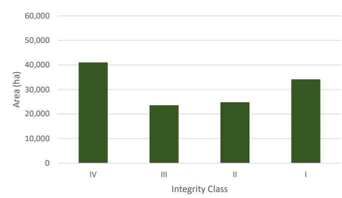
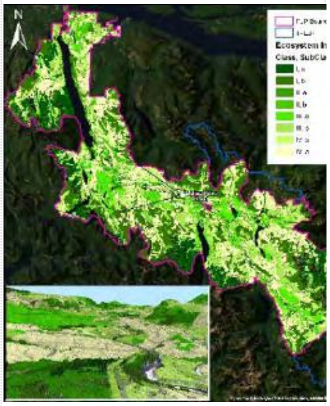
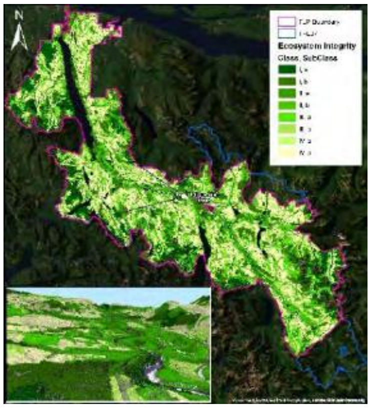
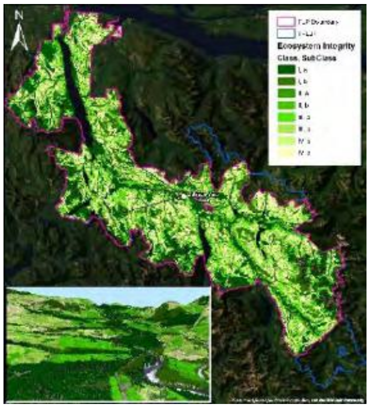
[12] McGaughey, R.J. 2022. FUSION/LDV: Software for lidar data analysis and visualization. January 2022 – FUSION Version 4.30. U.S. Department of Agriculture, Forest Service. Pacific Northwest Research Station.

historically been harvested, be improved and restored into the future. This meant that the forecast harvest pattern through time, needed to support a spatial shift of improving ecosystem integrity along the Nimpkish River and its primary tributaries. Figure 19 illustrates the shift from the current spatial pattern of ecosystem integrity through to ecosystem integrity forecast at years 2124, and 2324.

The current condition identifies that classes IV and III (yellow and light green respectively) are most prevalent at low to mid elevations and classes II and I (darker greens) at mid to higher elevations. By 2124, there is a significant decrease in the area occupied by the lowest integrity class IV with a slight decrease in class III. By 2324, the area in class I has increased further as areas matured and shifted through classes III and II. As young and mature stands further mature, they not only offset changes due to harvesting, but add additional area of older forest to class I, which by 2324, is forecast to make up 33% of the productive forest. The increase in ecosystem integrity within the Gwa'ni Special Management Zone is also evident with a noticeable shift to classes II and I (darker greens), particularly along the Nimpkish River and its primary tributaries.

To establish a short-term outcome that aligns with the 10-year term of the plan, the proportion of area forecast in each ecosystem integrity class at the end of 2035 is identified as part of the outcome in Figure 18 in the context of a forecast increase in the highest integrity classes (I and II) in the Gwa'ni Special Management Zone over the next 300 years.

Figure 19: Forecast of the change in ecosystem integrity classes and spatial pattern for the SMZ and GMZ.

<table>
<tr><th colspan="4">Forecast Change in Ecosystem Integrity (Years)</th></tr>
<tr><th></th><th>2024</th><th>2124</th><th>2324</th></tr>
<tr><td>Ecosystem Integrity Classes</td><td></td><td></td><td></td></tr>
<tr><td>Ecosystem Integrity Spatial Pattern</td><td></td><td></td><td></td></tr>
</table>

How the FRPA Section 2.22 Objectives were Considered in Establishing the Outcome

The details of how all five of the FRPA Section 2.22 Objectives were considered in establishing the outcome are as follows:

Supporting the production and supply of timber in the forest landscape plan area.

- The forecast harvest pattern over the long-term aligns with an overall improvement in ecosystem integrity across the Nimpkish Valley, while also achieving a shift in the highest integrity classes from the higher elevation ecosystems to the valley bottom ecosystems.
- Diverse and resilient landscapes help to maintain a predictable supply of timber into the future.

Supporting the protection and conservation of the environment.

- This is one of the ten outcomes that is an element of biodiversity and ecosystem health.
- Important elements of a landscape level biodiversity and an ecosystem approach to stewardship, include consideration of the seral stage distribution of ecosystems, the temporal and spatial pattern of harvest areas, forest interior habitat, landscape connectivity, stand structure, and species composition. Ecosystem integrity connects all these elements across the entire landscape. FF 5 is one of 10 outcomes that reflect the biodiversity and ecosystem health of the Nimpkish Valley.
- Improving ecosystem integrity correlates to an increased presence of older seral stage plant communities.
- Ecosystem integrity reflects the implementation of variable retention at the landscape and stand level which enhances structural complexity to support diverse, and resilient forests.
- Increasing ecosystem integrity at lower elevations represents the recovery of areas previously harvested which contain higher productivity forests including riparian areas associated with the Nimpkish River.

Managing the values placed on forest ecosystems by Indigenous peoples.

- When asked about what emphasis to place on land use activities, ‘Na̲mg̲is community engagement indicated an even split between two perspectives: one being the need to balance economic interests with the protection of natural ecosystems, and the other being to protect the health of natural systems, even at the expense of economic activities. The ecosystem integrity forecast reflects both of these interests and ensures that the harvest pattern into the future, along with the contribution of the full diversity of forest stands, support the protection of natural ecosystems and economic opportunity.
- Targeted engagement with ‘Na̲mg̲is artists identified the key theme of supporting and rebuilding all environmental relationships and the resilience of Nimpkish Valley's ecosystems. Ecosystem integrity reflects all stands as they develop along a successional trajectory, including height, horizontal and vertical structural diversity, species composition and cover, and forest floor development, better reflecting the overall diversity and resilience of the Nimpkish Valley.
- A spatial and temporal forecast of ecosystem integrity proved to be an effective communication tool providing assurance of outcomes leading toward the desired recovery from past harvest patterns.
- Increasing ecosystem integrity at lower elevations includes areas with high concentrations of cultural values.

Managing the values placed on forest ecosystems by local communities.

- A total of 72% of respondents to a public engagement survey delivered via the Gwa'ni Project indicated the need to balance economic interests with the protection of natural ecosystems, and 24% supported protection of the health of natural systems, even at the expense of economic activities. The ecosystem integrity forecast reflects the harvest pattern into the future and the contribution of the full diversity of stands supporting the protection of natural ecosystems.
- Respondents to a public engagement survey delivered via the Gwa'ni Project indicated that old growth forest is a value to prioritize within land use planning. The ecosystem integrity forecast identifies a noticeable shift to classes II and I (darker greens),

particularly along the Nimpkish River and its primary tributaries.

- Increasing ecosystem integrity at lower elevations includes most of the identified recreation sites.
- A spatial and temporal forecast of ecosystem integrity proved to be an effective communication tool and provided helpful landscape context to the 5-year harvest pattern shared as part of the FOP.

Preventing, mitigating, and adapting to impacts caused by significant disturbances to forests and forest health, including wildfire, insects, disease, and drought.

- Given the unpredictable range of impacts a changing climate could have on the Nimpkish Valley, maintaining a variety of forest structures, tree ages, and diverse species mixes will all contribute to healthy, diverse and resilient forests into the future.
- The pattern of improved ecosystem integrity aligns with improved wildfire resilience associated with the location of the Gwa'ni Special Management Zone.
- Development of a diverse mix of integrity classes provides capacity for increased climate resilience and diversity.

Supporting Stewardship Strategies

SS 1:	'Na̱mg̱is Conservation Network
SS 2:	Carbon Reserve
SS 5:	Retention of Riparian Forest – Streams
SS 6:	Retention of Riparian Forest – Wetlands
SS 7:	Retention of Riparian Forest – Lakes
SS 8:	Variable Retention
SS 9:	Harvest Criteria
SS 10:	Cutblock Size and Green-Up Criteria
SS 11:	K'wa'x̱tłu Retention Criteria
SS 12:	Reforestation and Stand Tending
SS 18:	Karst Features
SS 20:	Habitat Features (Bears, Raptors, Great Blue Heron)

Adaptive Management Indicators

AMI 5:	The proportion (%) of area (ha) in each ecosystem integrity class.
AMI 39:	Average fire size (ha) and the total area (ha) of forest impacted by fire.

FF 6 — HARVEST FLOW

Supports FRPA Section 2.22 Objectives	△			◎	⊕
Supports Biodiversity and Ecosystem Health					
Supports Climate Change Adaptation			☀		

Linked Gwa'ni Objectives

GO 15 — Maintain a predictable flow of commercially viable timber to sustain healthy communities, businesses, employment, and the Provincial economy.

FLP Goal

A predictable flow of commercially viable timber that is relatively stable through time.

FF 6

An average available harvest volume of 589,000 m^3 annually until the end of 2035 with a long-term forecast of 630,000 m^3.

Description of the Outcome and Forecast

The harvest flow reflects the comprehensive Patchworks™ modelling completed that integrates the full complement of stewardship strategies including critical operational criteria such as economics, seasonality of operations, harvest methods, road construction, and road reconstruction requirements. This includes the spatial and temporal implementation of full rotation management inclusive of silviculture strategies, silvicultural systems, rotation ages, and the resulting log grades. This integrated approach maintains the critical connections between the future seed supply at the Saanich Forestry Centre, harvest equipment needs, and associated linkages to manufacturing and processing facilities. The full details of the Patchworks™ modelling are in Appendix C.

With connected planning, the harvest flow is now spatially shown as blocks and roads in the FOP for the first 5 years, concurrent with the FLP outcomes, improving public transparency. This spatial pattern is included in the 10 future forest outcomes that are elements of biodiversity and ecosystem health providing increased confidence that the cumulative effects of current activities are sustaining healthy and resilient ecosystems over the long-term. This is helpful in the context of a changing climate as it provides a foundation to ensure a predictable flow of commercially viable timber into the future.

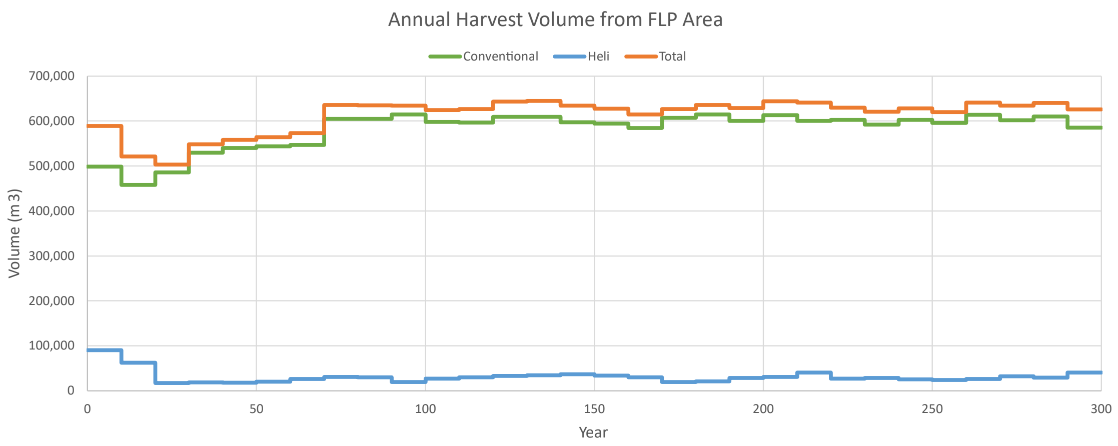
The selected harvest flow maintains the maximum mid-term harvest level providing for a relatively stable yield over the next 300 years, as identified in Figure 20. In the first 10 years, the harvest level is 589,000 m^3/year comprised of 499,000 m^3 of conventional volume and 90,000 m^3 of helicopter volume. The long-term harvest level then trends up to an average of 630,000 m^3 per year. Updated modelling will be completed on a regular basis as a foundation for implementation in an adaptive management framework. Modelling will forecast the available harvest volume into the future based on the latest forest inventory information. This ensures that the harvest level on a go forward basis is aligned with the current inventory and stewardship.

The harvest flow in Figure 20 only reflects the area of the TFL 37 pilot and the total available harvest volume for the TFL is therefore higher. The overall harvest flow for TFL 37 provides for a more stable pattern than shown in Figure 20 recognizing that the overall age class distribution of the TFL supports harvesting in different time periods.

The helicopter portion of the total available harvest volume is being tracked as a separate contribution.

The harvest flow reflects random losses of timber due to natural disturbance events including fire, insects, and windthrow. If losses increase into the future because of climate change, the Patchworks™ model will be updated as part of adaptive management.

Figure 20: Forecast of available harvest volume by helicopter and conventional.



How the FRPA Section 2.22 Objectives were Considered in Establishing the Outcome

The details of how the three relevant FRPA Section 2.22 Objectives were considered in establishing the outcome are as follows:

Supporting the production and supply of timber in the forest landscape plan area.

- Spatial and temporal modelling was completed including consideration of economics, seasonality of operations, harvest methods, road construction and reconstruction, and the full suite of stewardship strategies. This is reflected in an operationally feasible harvest flow that maintains the maximum mid-term harvest level to maintain a relatively smooth flow over the 300-year period.

- The mix of log grades expected from the harvest flow are connected to manufacturing and processing facilities on Vancouver Island maintaining a vertically integrated supply chain that maximizes the value from each log and residual fibre.

- The temporal and spatial pattern of harvest areas associated with the harvest flow are identified in the FOP and are reflected in the 10 future forest outcomes that sustain the biodiversity and ecosystem health of the Nimpkish Valley. Important elements of landscape level biodiversity and an ecosystem approach to biodiversity management is the seral stage distribution of ecosystems, the temporal and spatial pattern of harvest areas, forest interior habitat, landscape connectivity, stand structure, and species composition.

Managing the values placed on forest ecosystems by local communities.

- Engagement delivered through the aligned Gwa'ni Project, identified predictability in the forest sector as one of the main themes expressed by local community respondents. The harvest flow and process improvements associated with connected planning will bring improved predictability.

- The 'What We Heard Report' from the Gwa'ni project states that, "the concepts of sustainability, stability, and certainty were consistently emphasized to ensure that forestry would sustain viable employment while also providing balance across land use planning values." The harvest flow is designed to be sustainable over the long-term.

- Concurrently developing the FOP that includes the spatial pattern of cutblocks and roads, aligned with the harvest flow in the FLP, improves public transparency and was one of the most frequently commented on aspects during the public review and comment period of both plans.

Preventing, mitigating, and adapting to impacts caused by significant disturbances to forests and forest health, including wildfire, insects, disease, and drought.

- The future forest outcomes that are elements of biodiversity and ecosystem health include the forecast of the spatial and temporal harvest pattern. This therefore helps to ensure that the long-term harvest flow can be maintained as part of sustaining biodiversity and ecosystem health, reducing the risk of being unable to maintain a predictable flow of commercially viable timber in the context of a changing climate.
- A predictable harvest flow supports the maintenance of an active road network providing the access that may be needed to enable a timely response to natural disturbance events such as wildfire which may increase with a changing climate. Access management is also an important aspect of public safety.

Supporting Stewardship Strategies

SS 1: ‘Na̲mg̲is Conservation Network
SS 2: Carbon Reserve
SS 3: Rate of Harvest in Areas of Sensitivity
SS 4: Acceptable Level of Landslide Risk
SS 5: Retention of Riparian Forest - Streams
SS 6: Retention of Riparian Forest - Wetlands
SS 7: Retention of Riparian Forest - Lakes
SS 8: Variable Retention
SS 9: Harvest Criteria
SS 10: Cutblock Size and Green-Up Criteria
SS 11: K’wa’x̱tłu Retention Criteria
SS 12: Reforestation and Stand Tending
SS 17: Predetermined Salvage Process
SS 18: Karst Features
SS 19: Visual Quality
SS 20: Habitat Features (Bears, Raptors, Great Blue Heron)

Adaptive Management Indicators

AMI 6: The five-year rolling average of volume harvested (m^3) by conventional and helicopter harvest methods.

AMI 39: Average fire size (ha) and the total area (ha) of forest impacted by fire.

AMI 40: The total volume (m^3) salvaged under the blanket salvage permit timbermark.

FF 7 — ROAD NETWORK

Supports FRPA Section 2.22 Objectives	△ ⌷ ◎ ⌖
Supports Biodiversity and Ecosystem Health	
Supports Climate Change Adaptation	☀

Linked Gwa'ni Objectives

GO 8 — Maintain the conditions that support the sustainable harvest of non-timber forest products.

GO 11 — Recognize the importance of access to the features, resources, and natural beauty of the Nimpkish Valley.

GO 15 — Maintain a predictable flow of commercially viable timber to sustain healthy communities, businesses, employment, and the Provincial economy.

GO 4 — Manage the Gwa'ni project area recognizing the projected changes to the local climate.

FLP Goal

A road network providing access for a wide range of values and uses aligned with the long-term harvest level.

FF 7

A road network of more than 2,500 kilometers at the end 2035[1] which is forecast to increase to 4,000 kilometers over the next 300 years.

[1]The ability to achieve the available harvest volume as forecast, will affect the outcome. Roads are defined as those that are in road permit which also changes as roads are removed from permit.

Description of the Outcome and Forecast

TFL 37 has an extensive and valuable road network providing excellent access across the plan area supporting timber harvesting, stewardship, silviculture, and a wide range of activities including harvesting of non-timber forest products and recreation. This outcome is important because roads are critical infrastructure that reflect the cumulative impact of all activities. Connected planning therefore enables informed decision making regarding the future road network early in the planning process as the total length of future roads required to access the forecast harvest flow changes with the suite of stewardship strategies being evaluated.

Integrating the future harvest pattern as part of the future forest outcomes is critical because requiring more roads to achieve the same harvest flow can have unintended consequences such as increasing the risk of erosion from roads, loss of productive forest land base, and reducing long-term economic access.

Connected planning is an effective way to mitigate against these unintended consequences and the total length of the road network corresponding to the harvest flow was carefully monitored during forest modelling. This outcome reflects the careful balance achieved across the stewardship of values on a cumulative basis.

The spatial and temporal pattern of log hauling was also evaluated which informed the refined pattern of cutblocks in the FOP. This pattern attempts to utilize the road network as efficiently as possible to minimize the amount of road required at any given time for hauling. This reduces the risk of erosion by minimizing the cumulative amount of disturbance associated with road maintenance activities on an ongoing basis while also enabling road maintenance activities to be completed as cost effectively as possible. The adaptive management indicators connected to this outcome are designed to support the effective and efficient use of the road network as the forecast of the future harvest pattern is updated on an ongoing basis as part of the adaptive management framework.

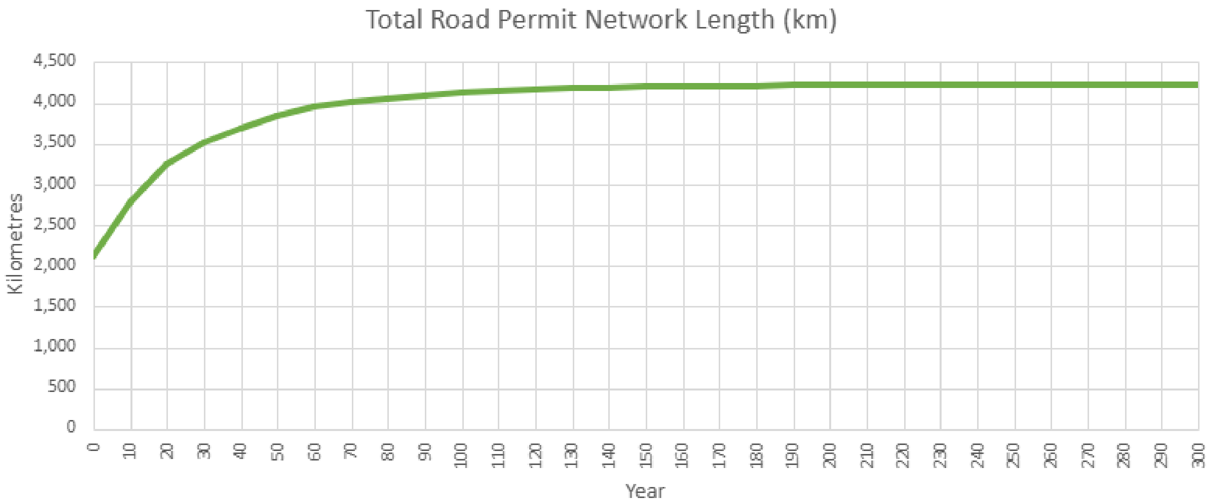
The long-term forecast of cutblocks also enables informed decisions to be made on the appropriate erosion control treatments to apply to roads commensurate with the forecast return period of the next road use. Applying erosion control treatments that are not required, can have the unintended effect of increasing the risk of erosion. Making a conscious decision of when to apply a variety of erosion control treatments, can therefore help to reduce the overall risk of erosion. When roads are deactivated, they have a reduced contribution to cumulative effects. This outcome is therefore based on road permit roads, because as roads are deactivated, they are generally removed from road permit.

The road network is also part of the foundation of the long-term economics of the tenure. Modelling included consideration of new road construction and road reconstruction to develop the long-term forecast of cutblocks and the associated road use.

With the rates of natural disturbance predicted to increase due to climate change, the long-term road network will assist with providing the access needed to respond to wildfires and other natural disturbances including any follow-up salvage activities. If disturbance from wildfires does increase, there may be opportunities to design roads in a way that maximizes their suppression utility in specific areas.

To establish a short-term outcome that aligns with the 10-year term of the plan, the total length of road forecast at the end of 2035 is approximately 2,500 kilometers in the context of long-term network of approximately 4,000 kilometers forecast to be achieved in 100 years as shown in Figure 21. At that point, the road network remains relatively stable into the future.

Figure 21: Forecast of the total length (km) of the road network in road permit.



How the FRPA Section 2.22 Objectives were Considered in Establishing the Outcome

The details of how the four relevant FRPA Section 2.22 Objectives were considered in establishing the outcome are as follows:

Supporting the production and supply of timber in the forest landscape plan area.

- The road network in TFL 37 provides access aligned with the long-term harvest flow in FF 6 and reflects the spatial and temporal forecast of new cutblocks.
- The road network reflects the full cumulative impact of all activities associated with the balanced decisions made considering all values including minimizing the loss of productive forest due to roads. As roads are deactivated with stream crossings removed, they no longer become drivable. At this point, they have a much lower contribution to cumulative effects.
- The efficient maintenance of the road network is foundational to the long-term economics of area-based tenures. The forecast of the long-term road network supports the application of the appropriate erosion control treatments to roads, commensurate with the return period for reusing the road. This helps to minimize road reactivation costs resulting from erosion and maintains the economic viability of the future harvest. This assists with maintaining safe road access for the public which links to managing the values placed on forest ecosystems by local communities.
- The road network assists with minimizing potential timber losses resulting from natural disturbances such as fire and windthrow. For example, the road network enables timely wildfire response while also increasing the amount of damaged timber that can be accessed and economically salvaged.

Managing the values placed on forest ecosystems by Indigenous peoples.

- ‘Na̲mg̱is community engagement confirmed the membership’s desire to access the Nimpkish Valley.
- The road network supports ‘Na̲mg̱is member’s need to access resources for a variety of cultural and

recreational purposes, ranging from supplies for art, food and medicine, knowledge transfer to youth, and for spiritual and ceremonial purposes. In the ‘Na̱mg̱is ‘What we Heard Report’, access is mentioned seven times.

Managing the values placed on forest ecosystems by local communities.

- As part of the Gwa’ni Project community engagement, respondents strongly agreed that they would like the Nimpkish Valley to be accessible and enjoyed, especially by local residents.
- Targeted engagement with local government as part of the Gwa’ni Project, indicated that access was among the top three highest ranked values. This outcome supports continued access to the Nimpkish Valley.
- Targeted engagement with tourism and recreation stakeholders as part of the Gwa’ni Project identified, “improving and expanding access of the territory for recreational use and enjoyment” as one of three key areas to address during land use planning and it was noted that, “continued access is important for both locals and tourists”. This outcome supports continued access to the Nimpkish Valley.
- The forecast of the long-term road network supports the application of the appropriate erosion control treatments to roads, commensurate with the return period for reusing the road. This helps to minimize road reactivation costs due to erosion and maintains the economic viability of the future harvest and assists with maintaining safe road access for the public.

Preventing, mitigating, and adapting to impacts caused by significant disturbances to forests and forest health, including wildfire, insects, disease, and drought.

- The road network provides ready access for responding to natural disturbance events including wildfires, windthrow, and pest infestations which have the potential to increase with a changing climate.

Supporting Stewardship Strategies

SS 1: ‘Namgis Conservation Network
SS 2: Carbon Reserve
SS 3: Rate of Harvest in Areas of Sensitivity
SS 4: Acceptable Level of Landslide Risk
SS 5: Retention of Riparian Forest - Streams
SS 6: Retention of Riparian Forest - Wetlands
SS 7: Retention of Riparian Forest - Lakes
SS 8: Variable Retention
SS 9: Harvest Criteria
SS 10: Cutblock Size and Green-Up Criteria
SS 11: K’wa’xtłu Retention Criteria
SS 12: Reforestation and Stand Tending
SS 13: Cultural Inventory of Plants
SS 14: Coordinated Bark Harvest
SS 15: Invasive Plants
SS 16: Erosion Control Treatments
SS 17: Predetermined Salvage Process
SS 18: Karst Features
SS 19: Visual Quality
SS 20: Habitat Features (Bears, Raptors, Great Blue Heron)

Adaptive Management Indicators

AMI 7: The total length of the road network (km) that is in Road Permit.
AMI 30: The five-year rolling average of the length of road used for hauling logs (km/’000m^3).
AMI 31: The five-year rolling average proportion (%) of the total road network (km) utilized for hauling logs.

FF 8 — WILDLIFE HABITAT TYPES

Supports FRPA Section 2.22 Objectives	⬡ 🗑 ◎ ⌖
Supports Biodiversity and Ecosystem Health	✦
Supports Climate Change Adaptation	☀

Linked Gwa'ni Objectives

GO 2 — Maintain a healthy, diverse and resilient[1] forest that contains native species, communities, natural landscapes, and ecological functions characteristic of the Nimpkish Valley.

[1] Resilience is defined as the ability of an ecosystem to absorb external influences and remain intact (Holling 1973)

GO 10 — Support healthy wildlife populations by promoting a diversity of habitats and enhancing wildlife management practices.

GO 4 — Manage the Gwa'ni project area recognizing the projected changes to the local climate.

FLP Goal

A diversity of forest habitat types and features to support healthy wildlife populations.

FF 8

A diversity of forest habitat types[1] and features are represented at the end of 2035[2] as identified in Figure 22 with the diversity of habitat types forecast to remain over the next 300 years.

Figure 22: Proportion of area in each habitat type at the end of 2035.

Group 2 Habitat Type	Proportion of Area (%)
NT	12
RD	12-16
C1	26-30
C2	8-12
C3	27-31
H	0-2
R[3]	5-9

[1]Defined for Group 2 species in the Description of the Outcome and Forecast.

[2]Natural disturbance events and the ability to achieve the available harvest volume as forecast will affect the outcome.

[3]Riparian takes precedent over the other habitat types for reporting of the proportion of area.

Description of the Outcome and Forecast

Maintaining a diversity of forest habitat types is an effective landscape level approach to increase the likelihood that stewardship practices will sustain vertebrate and non-vertebrate species.

A Species Accounting System[13] has been developed that assigns species into six groups that have similar habitat requirements. Examples of vertebrate species on northern Vancouver Island by each of the species accounting systems groups is included in Appendix B. The six groups are:

- Group 1 contains species that are generalists and inhabit many habitat types or generally respond positively to forest practices.
- Group 2 contains species that can be statistically assigned to broad habitat types defined by the forest cover. This group is the focus of this future forest outcome as it can be forecast across the landscape over the next 300 years.
- Group 3 contains species with strong dependencies on specific habitat elements such as snags or understory vegetation. The habitat elements of this group are reflected in the habitat types associated with group 2. The use of variable retention reflected in FF 5 also retains structural elements of the pre-harvest stand enhancing structural complexity including live and dead trees of varying sizes and canopy layers.
- Group 4 contains species restricted to specialized and highly localized habitats. The focus of this group is Marbled Murrelet which is included in FF 9.
- Group 5 contains species for which patch size and connectivity are important. The focus of this group is northern goshawk which is included in FF 9. Connectivity and forest interior conditions are also the focus of FF 11, and
- Group 6 contains species that are not dependent on forest environments and is included in the list for completeness.

Group 2 species can be assigned into five broad habitat types that can be defined using the forest cover:

- Type NT - Non-treed
- Type RD - Recent disturbance: < 20 years old
- Type C1 - Conifer: 21-60 years old
- Type C2 - Conifer 61-140 years old,
- Type C3 - Conifer > 140 years old
- Type H - Deciduous < 40 years old, ≥ 40 years old
- Type R - Riparian forest along S1, S2, and S3 streams

These seven habitat types are forecast into

[13] Species Accounting System for Western Forest Products, Laurie L. Kremsater, Fred l. Bunnell, and Pierre Vernier, Centre for Applied Conservation Research University of British Columbia, February 2012

the future as part of the desired future forest condition. This is important because the proportion and diversity of habitat types can shift from the cumulative effect of all activities, including natural disturbance.

Maintaining a diversity of habitat types is an effective landscape scale approach and the forecast indicates that a diversity of habitat types is sustained into the future as shown in Figure 23.

The forecast of habitat types indicates a general shift to older Type C3 conifer stands including more Type R riparian forest being older than 140 years. The decrease in younger deciduous forest is likely due to assumptions made regarding deciduous species in regenerating stands. Despite the shift to older conifer forests, a good diversity across the habitat types is maintained over the 300 years.

Roosevelt elk and black-tailed deer are two Group 2 species that are of particular importance to 'Na̲mg̲is. Increasing the proportion of Type C2, C3, and R habitats while maintaining Type RD habitats is expected to benefit the populations of these species. Type C2 and C3 habitats provide winter thermal cover and along with Type C1 provide shelter cover from predators. Type RD and R habitats support increased levels of forage and the spatial pattern of habitat types in Figure 23 confirms that these habitat types are well distributed through the plan area. To establish a short-term outcome that aligns with the 10-year term of the plan, the proportion of area forecast in each habitat type at the end of 2035 is identified Figure 22 in the context of all habitat types continuing to be represented over the next 300 years.

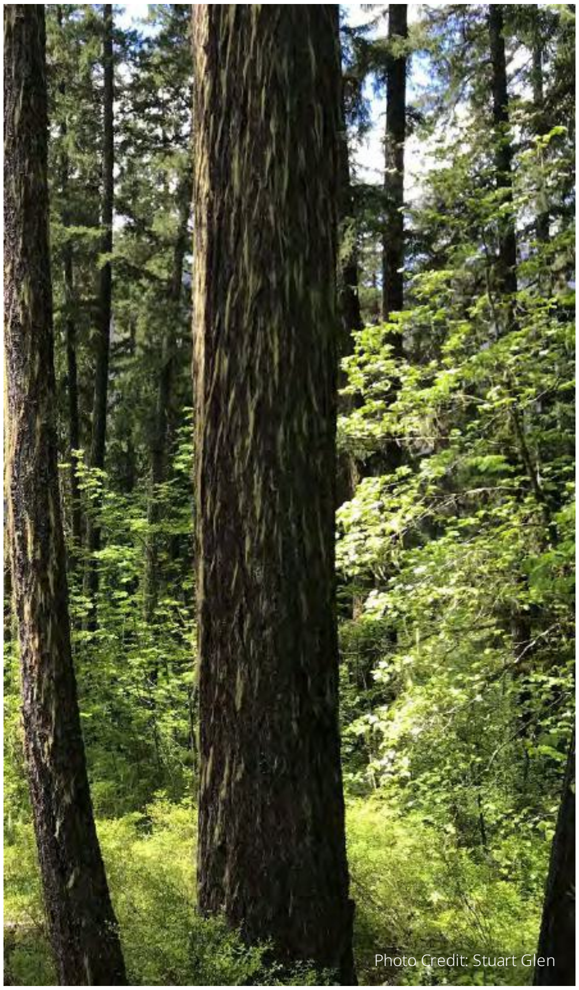


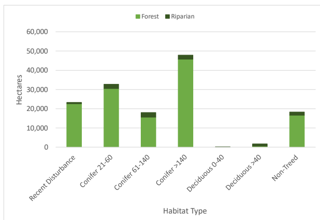
Photo Credit: Stuart Glen

Figure 23: Forecast of forest habitat types by area (ha) and the associated spatial pattern.

Forecast Change in Forest Habitat Types (Years)

Forest Habitat Types Breakdown (ha)

2024



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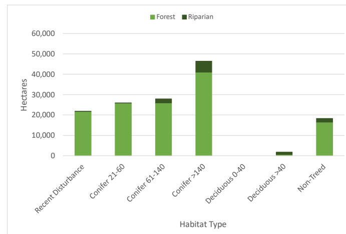

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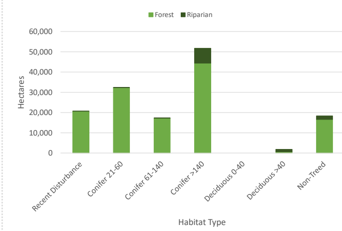
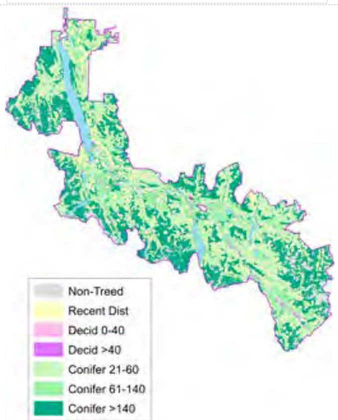


Forest Habitat Types Spatial Pattern

2024



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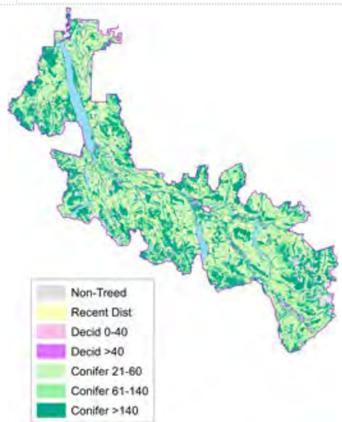

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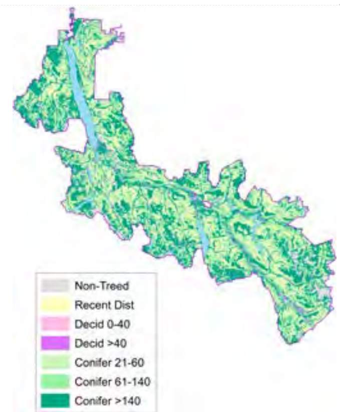


How the FRPA Section 2.22 Objectives were Considered in Establishing the Outcome

The details of how the four relevant FRPA Section 2.22 Objectives were considered in establishing the Outcome are as follows:

Supporting the protection and conservation of the environment.

- This is one of the ten outcomes that is an element of biodiversity and ecosystem health.
- Important elements of landscape level biodiversity and an ecosystem approach to biodiversity management are the seral stage distribution of ecosystems, the temporal and spatial pattern of harvest areas, forest interior habitat, landscape connectivity, stand structure, and species composition. Forest habitat types connect species to many of these elements that can be defined utilizing forest cover inventory data.
- Maintaining a diversity of forest habitat types across the landscape supports the habitat requirements for a broad range of vertebrate and non-vertebrate species.
- This outcome indicates that a diversity of habitat types continues to be sustained over the next 300 years.
- Maintaining a diversity of habitat types helps to sustain the diversity of associated features such as snags and understory vegetation.

Managing the values placed on forest ecosystems by Indigenous peoples.

- During ‘Na̲mg̱is community engagement, members indicated the importance of places recognized as habitat for elk and other wildlife. A diversity of habitat types maintains a range of habitats for elk and other wildlife.
- ‘Na̲mg̱is members identified the harvest of elk and deer as an important seasonal activity. A diversity of habitat types including areas for forage and winter shelter helps to support healthy elk and deer populations.
- Traditional wild food sources continue to have economic and cultural value within ‘Na̲mg̱is community. A diversity of habitat types provides opportunity for a wide range of wild food sources.

- Impacts to wildlife habitat was identified as a top concern of Gwa'ni survey respondents who self-identified as indigenous. Wildlife habitat types provide an effective way to communicate and visualize changes to habitat on a cumulative basis over multiple generations.

Managing the values placed on forest ecosystems by local communities.

- Targeted engagement with tourism and recreation stakeholders, forestry tenure holders, and contractors, as part of the Gwa'ni Project, identified, "aquatic habitat and fish & wildlife" among the three highest ranked values.
- One local stakeholder representative when asked, what are the three most important values in the Nimpkish Valley, replied "jobs, jobs, deer".

Preventing, mitigating, and adapting to impacts caused by significant disturbances to forests and forest health, including wildfire, insects, disease. and drought.

- A diversity of habitat types increases resilience by improving the opportunity for wildlife to shift and adapt to impacts caused by natural disturbances.
- A diversity of habitat types increases resilience by providing the opportunity and space for natural systems to repair themselves after significant disturbance. A diversity of habitat types that includes static and dynamic elements helps mitigate the potential impacts of a changing climate as options are maintained into the future providing the ability to adapt in an informed way.

Supporting Stewardship Strategies

SS 1: ‘Na̱mg̱is Conservation Network

SS 2: Carbon Reserve

SS 5: Retention of Riparian Forest – Streams

SS 6: Retention of Riparian Forest – Wetlands

SS 7: Retention of Riparian Forest – Lakes

SS 8: Variable Retention

SS 9: Harvest Criteria

SS 11: K’wa’x̱tłu Retention Criteria

SS 12: Reforestation and Stand Tending

SS 18: Karst Features

SS 20: Habitat Features (Bears, Raptors, Great Blue Heron)

Adaptive Management Indicators

AMI 8: The proportion (%) of area (ha) in each Group 2 wildlife habitat type.

FF 9 — SPECIES AT RISK

Supports FRPA Section 2.22 Objectives	
Supports Biodiversity and Ecosystem Health	✦
Supports Climate Change Adaptation	☀

Linked Gwa'ni Objectives

GO 2 — Maintain a healthy, diverse and resilient[1] forest that contains native species, communities, natural landscapes, and ecological functions characteristic of the Nimpkish Valley.

GO 10 — Support healthy wildlife populations by promoting a diversity of habitats and enhancing wildlife management practices.

GO 4 — Manage the Gwa'ni project area recognizing the projected changes to the local climate.

[1]Resilience is defined as the ability of an ecosystem to absorb external influences and remain intact.

FLP Goal

Maintain suitable habitats for Species at Risk consistent with British Columbia's implementation Plans[1].

[1]Marbled Murrelet and Northern Goshawk (2018)

FF 9

A total of 833 hectares of suitable habitat for Marbled Murrelet in the Lower Nimpkish Landscape Unit, a total of 1,069 hectares of suitable habitat for marbled murrelet in the Upper Nimpkish Landscape Unit, and a total of 12 Wildlife Habitat Areas[1] for northern goshawk exist at the end of 2035[2] with a forecast increase of Type C2, C3, and R habitat over the next 300 years.

[1]includes a WHA partially located with the FLP area.

[2]natural disturbance events may affect the outcome.

Description of the Outcome and Forecast

Marbled murrelets (*Brachyramphus marmoratus)* are small seabirds that extend along 4,000 kilometers of coastline from California to Alaska. They are members of the same family as auks, puffins, and murres and utilize old-growth forests and rock outcrops such as cliffs for their nests. They usually travel long distances between at-sea locations and nest sites. Most of the known nests in older forests are within 50 km of the ocean and are placed high in trees on large limbs covered with a deep mossy pad. Small gaps in the canopy provide access to the nest. The Province of BC has an Implementation Plan for the recovery of Marbled Murrelet in British Columbia dated February 2018[14]. This plan identifies the terrestrial management actions that are deemed necessary to halt the decline of the Marbled Murrelet population and ensure Marbled Murrelet have a high probability of persistence across their range. Detailed low level aerial reconnaissance and a LiDAR based verification assessment have been completed to identify a total of 833 hectares of suitable habitat for Marbled Murrelet in the Lower Nimpkish Landscape Unit and a total of 1,069 hectares of suitable habitat for Marbled Murrelet in the Upper Nimpkish Landscape Unit consistent with the Implementation Plan and North Island Central Coast District Marbled Murrelet Tenures Tables (updated to 2021 depletions in January 2023). The spatial location of this habitat is identified in Figure 24.

Northern goshawk (*Accipiter gentilis*) is the largest accipiter in British Columbia and has short, rounded wings and a long tail which helps it maneuver through the forest for nesting and foraging. The coastal laingi subspecies range in the BC Implementation Plan[15] is mapped along the northwest coast from Washington to Alaska meaning that the entire Canadian population is found in BC. Nests are most commonly found in forests >60 years old with active nests shifting from year to year within a nesting territory. Detailed ground plots near known


Photo Credit: Deal Photography

[14] https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/species-ecosystems-at-risk/recovery-planning/implementation_plan_for_the_recovery_of_marbled_murrelet.pdf
[15] https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/species-ecosystems-at-risk/recovery-planning/implementation_plan_for_the_recovery_of_northern_goshawk.pdf

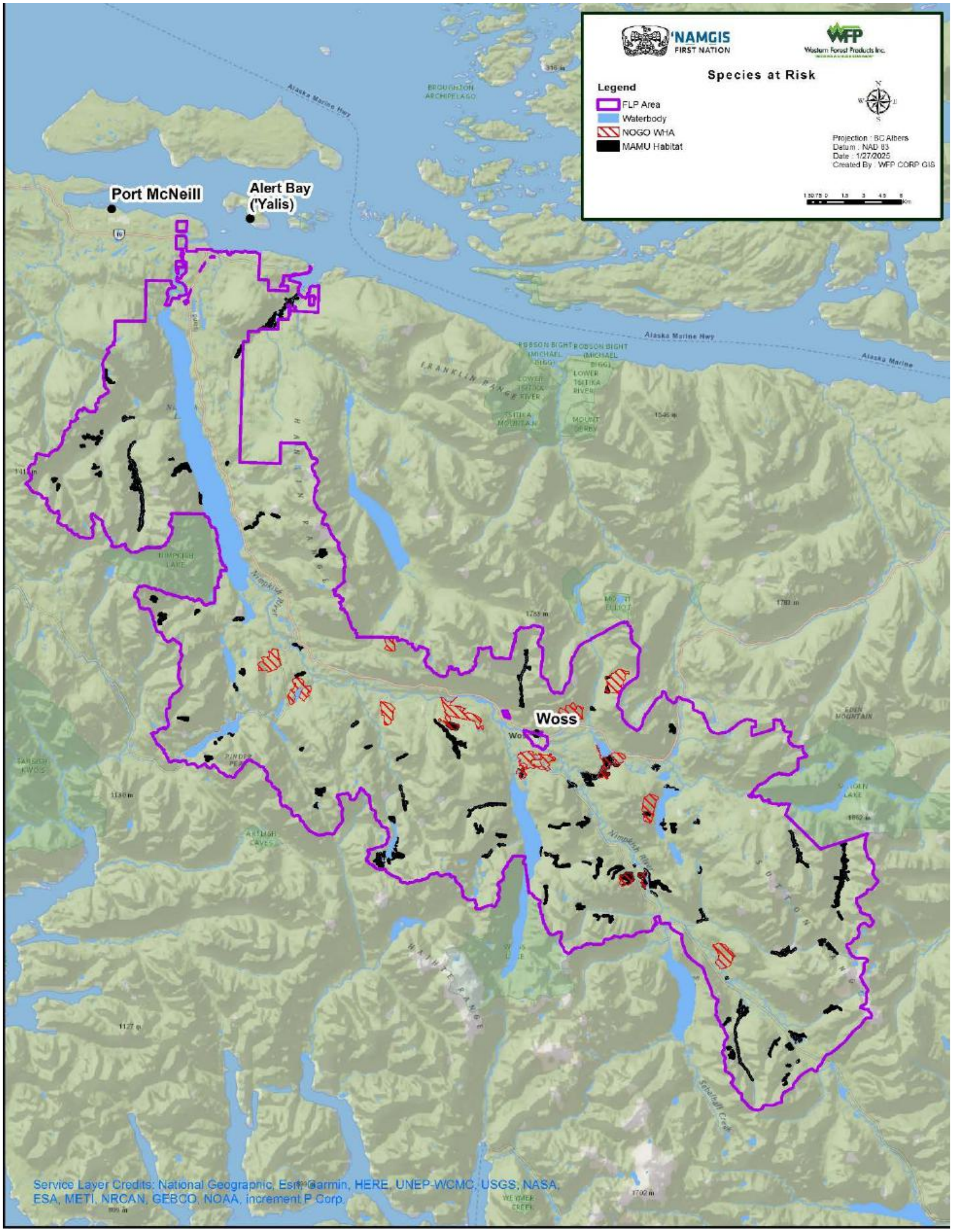
goshawk nests have been completed for six territories and LiDAR based verification for forest cover have been completed to identify a total of 12 Wildlife Habitat Areas[16] for Northern Goshawk consistent with the Implementation Plan. The spatial location of these Wildlife Habitat Areas is identified in Figure 24.

Forests are dynamic and as identified in FF 8, the spatial and temporal distribution of habitat types shifts as activities and natural disturbance occur across the landscape. Marbled Murrelet can generally be associated with Type C3 habitat and Northern Goshawk are generally associated with Type C2 and C3 habitat. As shown in Figure 23 in FF 8, the proportion of Habitat Type C3 increases over the next 300 years, indicating that additional nesting habitat for Marbled Murrelet is likely to exist in the future. The proportion of Type C2 habitat increases significantly over the next 100 years and then declines over the following 200 years as this habitat ages into Type C3. This forecast helps to ensure that the cumulative impact of activities today will sustain habitat for both species over the long-term.

The dynamic consideration of habitat types also helps to support the concept of natural fire refugia. Maintaining a diversity of habitat types across the landscape, increases resilience, and makes it more likely that there will be stability over the long-term. If some portions of the landscape do become more prone to burning in the future, it is more likely that there will be a diversity of habitat types in other areas.

[16] A Wildlife Habitat Area is a mapped area that designates critical habitat which is habitat that is deemed necessary for the survival or recovery of a specific species.

Figure 24: Suitable Marbled Murrelet habitat and Northern Goshawk Wildlife Habitat Areas.



How the FRPA Section 2.22 Objectives were Considered in Establishing the Outcome

The details of how the four relevant FRPA Section 2.22 Objectives were considered in establishing the Outcome are as follows:

Supporting the protection and conservation of the environment.

- This is one of the ten outcomes that is an element of biodiversity and ecosystem health.
- Identifying and retaining the suitable habitat associated with Marbled Murrelet and Northern Goshawk ensures viable populations of these species persist across the range of each conservation region in coastal BC.
- The forecast of Habitat Types in FF 8 indicates that habitat for both species increases over the next 100 years before an increased proportion shifts to Type C3 habitat ensuring that the cumulative impact of activities today sustains habitat for both species over the long-term.

Managing the values placed on forest ecosystems by Indigenous peoples.

- Impacts to wildlife habitat was identified as a top concern of Gwa'ni survey respondents who self-identified as Indigenous.

Managing the values placed on forest ecosystems by local communities.

- Targeted engagement with tourism and recreation, forestry tenure holders, and contractors, as part of the Gwa'ni Project identified, "aquatic habitat and fish & wildlife" among the three highest ranked values.

Preventing, mitigating, and adapting to impacts caused by significant disturbances to forests and forest health, including wildfire, insects, disease and drought.

- A diversity of habitat types increases resilience by improving the opportunity for wildlife to shift and adapt to impacts caused by significant disturbances.
- A diversity of habitat types increases resilience by providing the opportunity and space for natural systems to repair themselves after significant disturbance.

A diversity of habitat types that includes static and dynamic elements helps to mitigate against potential impacts of a changing climate as options are maintained into the future providing the ability to adapt in an informed way.

Supporting Stewardship Strategies

SS 1: ‘Na̱mg̱is Conservation Network
SS 5: Retention of Riparian Forest – Streams
SS 6: Retention of Riparian Forest – Wetlands
SS 7: Retention of Riparian Forest - Lakes
SS 8: Variable Retention
SS 9: Harvest Criteria
SS 11: K’wa’x̱tłu Retention Criteria
SS 12: Reforestation and Stand Tending
SS 18: Karst Features
SS 20: Habitat Features (Bears, Raptors, Great Blue Heron)

Adaptive Management Indicators

AMI 9: The area (ha) of suitable habitat for Marbled Murrelet within the ‘Na̱mg̱is Conservation Network, by Landscape Unit and the number of Wildlife Habitat Areas for Northern Goshawk.

FF 10 — CULTURAL, TRADITIONAL, AND RECREATIONAL USE

Supports FRPA Section 2.22 Objectives	
Supports Biodiversity and Ecosystem Health	✦
Supports Climate Change Adaptation	☀

Linked Gwa'ni Objectives

GO 2 — Maintain a healthy, diverse, and resilient forest that contains native species, communities, natural landscapes, and ecological functions characteristic of the Nimpkish Valley.

GO 4 — Manage the Gwa'ni Project area recognizing the projected changes to the local climate.

GO 8 — Maintain the conditions that support the sustainable harvest of non-timber forest products.

GO 13 — Ensure 'Na̱mg̱is cultural and spiritual values are conserved, managed, or protected within the Gwa'ni Project area.

FLP Goal

A diversity of seral stages across all biogeoclimatic ecosystem variants supporting a wide range of cultural, traditional, and recreational use.

FF 10

A diversity of seral stages is present across all biogeoclimatic variants at the end of 2035[1] as identified in Figure 25 and a diversity of seral stages are forecast to remain over the next 300 years.

Figure 25: Proportion of area in each biogeoclimatic (BEC) variant by age class.

	Proportion (%) of Area (ha) by Seral Stage (Years)			
	Early Seral		Mid Seral	Mature Seral
BEC Variant	≤ 20 Years	21-60 Years	61-140 Years	141+ Years
CWH xm2	14-20	33-39	27-33	15-20
CWH mm1	15-21	32-38	35-41	5-11
CWH vm1	14-20	43-49	12-18	19-25
CWH vm2	16-22	34-40	1-5	38-44
MH mm1	10-16	9-15	1-5	68-74

[1]Natural disturbance events and the ability to achieve the available harvest volume as forecast will affect the outcome. The forecast includes the contribution of the helicopter harvest method.

Description of the Outcome and Forecast

Ecological succession is the process by which the structure of a biological community changes over time. As ecosystems evolve, they support a changing mix of species including plants and animals until a climax or relatively stable state is achieved.

This outcome reflects the goal of maintaining a range of seral stages across each biogeoclimatic (BEC) variant. This ensures a diverse mix of overstory, and understory species are maintained across the landscape. This diverse mix of species function together to support biodiversity and ecosystem health while sustaining a wide variety of cultural[17], traditional[18], and recreational[19] uses.

The stand age associated with each seral stage is identified in Figure 26. The early seral stage has been split into stands ≤ 20 years and 21-60 years as the herbaceous species present in these age classes changes through time providing a different mix of plants for use. The proportion of the forest in each seral stage reflects the harvest pattern forecast in the FOP.

An overall trend of shifting to a greater proportion of each biogeoclimatic ecosystem variant being old seral is identified in Figure 2. This is especially noticeable in the driest ecosystem variants which are the CWH xm2 and CWH mm1. A slight decline in mature seral over the 300 years is present in the CWH vm2 and MH mm1 due to harvesting as both currently have a large proportion of the forest as mature seral. A relatively balanced distribution of seral stages is maintained across all the biogeoclimatic ecosystem variants over the 300 years with only the MH mm1 having a noticeable pattern of a lower proportion of early and mid-seral stages.

To establish a short-term outcome that aligns with the 10-year term of the plan, the proportion of area forecast in each seral stage at the end of 2035 is identified Figure 25 in the context of an overall trend to a greater proportion of the forest being mature seral over the next 300 years.

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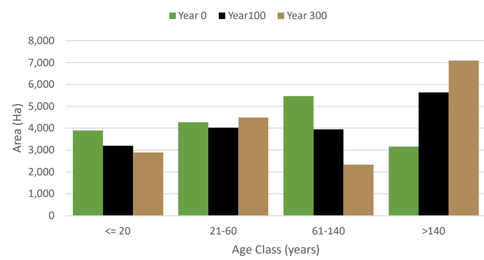
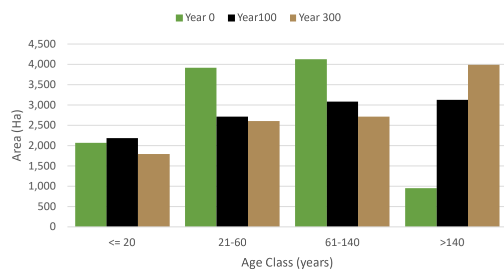
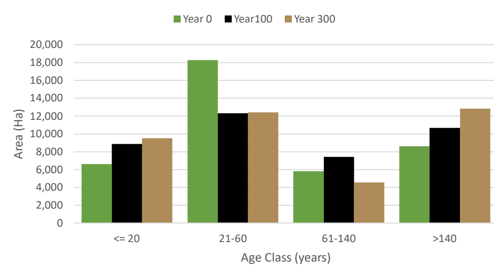
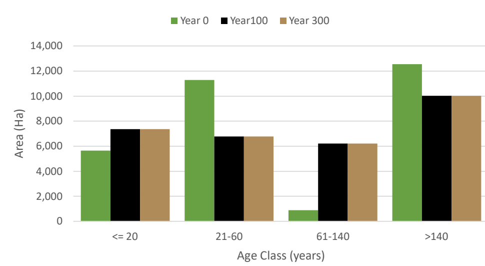
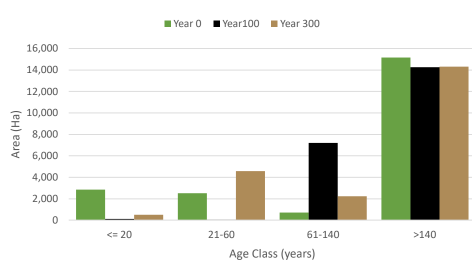
[17] We have defined cultural use as the ability to go and do something.
[18] We have defined traditional use as the ability to go and take something.
[19] We have defined recreational use as the ability to go and enjoy something.

Figure 26: Forecast of the diversity of age classes for each biogeoclimatic ecosystem variant.

<table>
<tr><th>Biogeoclimatic Ecosystem Variant</th><th>Area by Age</th></tr>
<tr><td>CWH xm2</td><td>
</td></tr>
<tr><td>CWH mm1</td><td>
</td></tr>
<tr><td>CWH vm1</td><td>
</td></tr>
<tr><td>CWH vm2</td><td>
</td></tr>
<tr><td>MH mm1</td><td>
</td></tr>
</table>

How the FRPA Section 2.22 Objectives were Considered in Establishing the Outcome

The details of how the four relevant FRPA Section 2.22 Objectives were considered in establishing the Outcome are as follows:

Supporting the protection and conservation of the environment.

- This is one of the ten outcomes that is an element of biodiversity and ecosystem health.
- Important elements of landscape level biodiversity and an ecosystem approach to biodiversity management is the seral stage distribution of ecosystems, the temporal and spatial pattern of harvest areas, forest interior habitat, landscape connectivity, stand structure, and species composition. Maintaining a range of seral stages across all biogeoclimatic ecosystem variants increases overall diversity and resilience reflecting the shifts in species including plants and animals until a climax or relatively stable state is achieved.
- A diverse mix of species is maintained providing for a wide variety of cultural, traditional, and recreational uses.

Managing the values placed on forest ecosystems by Indigenous peoples.

- Through engagement with ‘Na̲mg̲is members, participants identified a range of plant species of interest for gathering for use as food and medicine. Managing for the continued presence of the entire range of plant communities, at all stages of successional development, is a landscape level approach to ensure abundance of plant species to meet the needs of ‘Na̲mg̲is.

Managing the values placed on forest ecosystems by local communities.

- Community engagement delivered through the aligned Gwa’ni Project identified that the majority of part time and full-time residents recreationally harvested non timber forest products from the Nimpkish Valley more than seven times a year. Managing for the continued presence of a wide range of plant communities, at all stages of successional development, is a landscape level approach to ensure that the abundance of non-timber forest products, continues to be available into the future.

Preventing, mitigating, and adapting to impacts caused by significant disturbances to forests and forest health, including wildfire, insects, disease, and drought.

- A variety of plant communities of various ages all contribute to healthy, diverse and resilient forests with the ability to naturally resist and more readily recover from significant disturbances and a changing climate.

Supporting Stewardship Strategies

SS 1: 'Na̱mg̱is Conservation Network
SS 2: Carbon Reserve
SS 5: Retention of Riparian Forest – Streams
SS 6: Retention of Riparian Forest – Wetlands
SS 7: Retention of Riparian Forest – Lakes
SS 8: Variable Retention
SS 9: Harvest Criteria
SS 11: K'wa'x̱tłu Retention Criteria
SS 12: Reforestation and Stand Tending
SS 13: Cultural Inventory of Plants
SS 14: Coordinated Bark Harvest
SS 15: Invasive Plants
SS 18: Karst Features
SS 19: Visual Quality
SS 20: Habitat Features (Bears, Raptors, Great Blue Heron)

Adaptive Management Indicators

AMI 10: The proportion (%) of area (ha) by seral stage in each biogeoclimatic ecosystem variant.

FF 11 — FOREST CONNECTIVITY AND FOREST INTERIOR CONDITIONS

Supports FRPA Section 2.22 Objectives	⬡ ⛉ ◎ ⌖
Supports Biodiversity and Ecosystem Health	✦
Supports Climate Change Adaptation	☀

Linked Gwa'ni Objectives

GO 2 — Maintain a healthy, diverse and resilient[1] forest that contains native species, communities, natural landscapes, and ecological functions characteristic of the Nimpkish Valley.

GO 6 — Recognize the uniqueness of the natural karst features present within the Nimpkish Valley and manage for the inter-connected relationship between karst, fish and water quality at the landscape and site level.

GO 10 — Support healthy wildlife populations by promoting a diversity of habitats and enhancing wildlife management practices.

GO 4 — Manage the Gwa'ni project area recognizing the projected changes to the local climate.

[1]Resilience is defined as the ability of an ecosystem to absorb external influences and remain intact (Holling 1973)

FLP Goal

Connectivity and interior forest conditions support the movement of species across the landscape at multiple scales.

FF 11

More than 36,000 hectares of forest has connectivity[1] and more than 16,000 hectares has forest interior conditions[2] at the end of 2035[3], with connectivity forecast to improve over and forest interior conditions forecast to remain relatively stable after 2035.

[1] Forest connectivity is defined by stands in two age categories located less < 40m apart or natural features such as meadows and wetlands.

- **61-140 years old**
- **> 140 years old**

[2] Forest interior condition is defined by those areas within an old (>250 years) or mature forest stand (>120 years) >100m from an edge of a neighboring stand <30 years old due to anthropogenic activities. If the neighboring stand is ≥ 30 years old, the edge effect is assumed to be negligible.

[3] Natural disturbance events and the ability to achieve the available harvest volume as forecast will affect the outcome. This outcome will be monitored to evaluate how sensitive the connectivity criteria are to the spatial and temporal harvest pattern.

Description of the Outcome and Forecast

Forest connectivity supports the long-term persistence and range shifts of forest-dependent species. Connectivity also factors into a species' ability to shift to suitable climate niches as the climate changes. Figure 27 illustrates connected forest[20] between 61-140 years old and greater than 140 years old across all biogeoclimatic ecosystem variants. Connectivity uses 140 years maintaining consistency with the forest habitat types used in FF 8. This indicates that opportunities are being maintained over the next 300 years to allow species to shift to suitable habitats that are the same or cooler than their current habitat as the climate warms. The connectivity of forests 61 – 140 years old and greater than 140 years old complements FF 8 to provide a more complete picture of connectivity across the variety of habitat types. A spatial pattern that maintains connectivity across habitat types in increasingly older forests anchored on a riparian network where forest conditions are cooler, can reasonably be expected to increase resilience in a warmer and drier climate.

Forest interior conditions[21] provide important habitat for species that are closed canopy specialists which are not typically found near forest edges. For example, the red-breasted nuthatch and brown creeper are area-sensitive forest birds that rely on forest interior habitat. Therefore, forest interior is a measure of quality and an indicator of landscape-level ecosystem diversity. Forest interior condition uses 120 years maintaining consistency with the older rotation age in the małik. Figure 28 illustrates that there is slight decline in forest interior conditions over the next 10 years and then it remains relatively stable over the next 300 years. By year 300, essentially all forest that associated with forest interior conditions is older than 250 years.

To establish a short-term outcome that aligns with the 10-year term of the plan, more than 36,000 hectares of forest has connectivity, and more than 16,000 hectares has forest interior conditions at the end of 2035, with connectivity forecast to improve and forest interior conditions forecast to remain relatively stable after 2035.

[20] Forest connectivity is defined by stands in two age categories (61 to 140 years old and > 140 years old) located less < 40m apart or natural features such as meadows and wetlands.
[21] Forest interior condition is defined by those areas within a old (>250) or mature forest stand (>120) >100m from an edge of a neighboring stand <30 years old due to anthropogenic activities. If the neighboring stand is >30 years old, the edge effect is assumed to be negligible.

Figure 27: Forecast of the spatial pattern of landscape connectivity in forests 61 to 140 years old and forests greater than 140 years old.

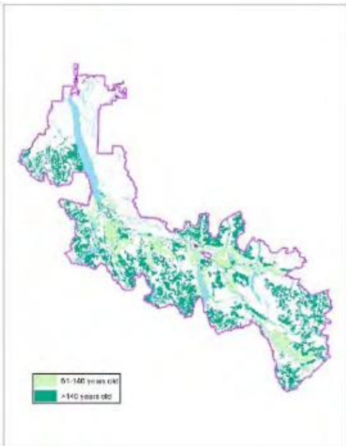
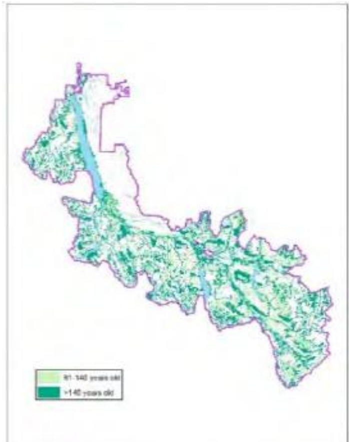
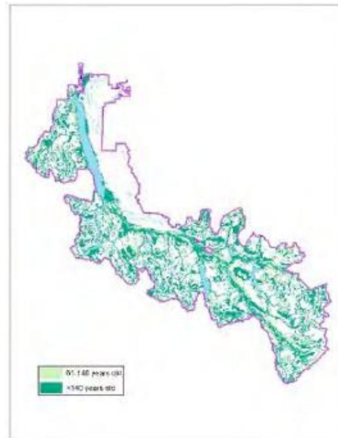
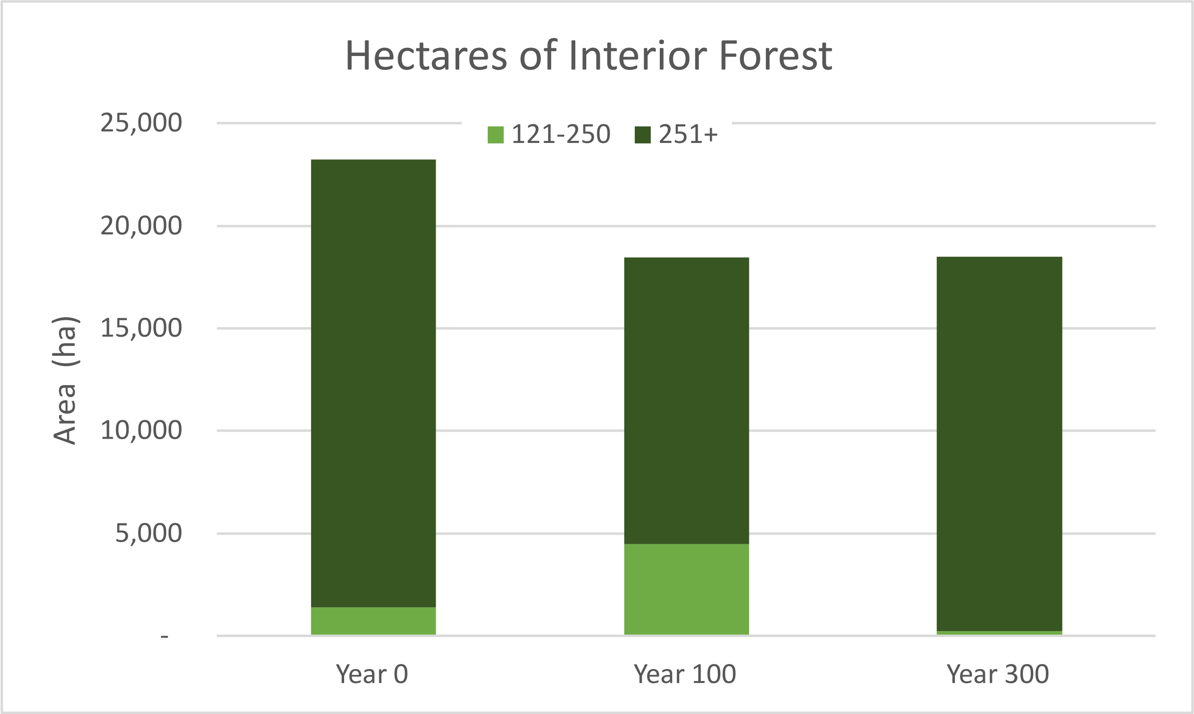
Forecast Change in Landscape Connectivity (Years)			
	2024	2124	2324
Landscape Pattern of Connectivity			

Figure 28: Forecast of the area (ha) with forest interior conditions by age category.



How the FRPA Section 2.22 Objectives were Considered in Establishing the Outcome

The details of how the four relevant FRPA Section 2.22 Objectives were considered in establishing the Outcome are as follows:

Supporting the protection and conservation of the environment.

- This is one of the ten outcomes that is an element of biodiversity and ecosystem health.
- Important elements of landscape level biodiversity and an ecosystem approach to biodiversity management is the seral stage distribution of ecosystems, the temporal and spatial pattern of harvest areas, forest interior habitat, landscape connectivity, stand structure, and species composition.
- Forest connectivity supports the long-term persistence and range shifts of forest-dependent species. Connectivity also factors into a species' ability to shift to suitable climate niches as the climate changes.
- The interior of a forest provides important habitat conditions for a number of species (closed canopy specialists) that are not typically found near forest edges. Forest interior is a measure of quality and an indicator of landscape-level ecosystem diversity.

Managing the values placed on forest ecosystems by Indigenous peoples.

- Maintenance of forest connectivity and interior forest conditions helps to ensure appropriate habitat conditions, and resiliency, for a range of species identified as important by 'Na̱mg̱is, including desired food and medicine plants, and animals such as ungulates and bear.
- Impacts to wildlife habitat was identified as a top concern of Gwa'ni survey respondents who self-identified as Indigenous.

Managing the values placed on forest ecosystems by local communities.

- Maintenance of forest connectivity and interior forest conditions helps to ensure appropriate habitat and supports resiliency for a range of species. Targeted engagement with tourism and recreation, forestry tenure holders, and contractors, as part of the Gwa'ni Project identified, "aquatic habitat and fish and wildlife" among the three highest ranked values.

Preventing, mitigating, and adapting to impacts caused by significant disturbances to forests and forest health, including wildfire, insects, disease, and drought.

- Maintaining forest connectivity and forest with interior conditions increases diversity and complexity providing increased resilience for adapting to potential impacts caused by significant disturbances to forests and forest health, including wildfire, insects, disease, and drought as it promotes pathways for species to migrate to more suitable habitat.

Supporting Stewardship Strategies

SS 1: 'Namgis Conservation Network
SS 2: Carbon Reserve
SS 5: Retention of Riparian Forest – Streams
SS 6: Retention of Riparian Forest – Wetlands
SS 7: Retention of Riparian Forest – Lakes
SS 8: Variable Retention
SS 9: Harvest Criteria
SS 10: Cutblock Size and Green-Up Criteria
SS 11: K'wa'xtłu Retention Criteria
SS 18: Karst Features
SS 20: Habitat Features (Bears, Raptors, Great Blue Heron)

Adaptive Management Indicators

AMI 11: The area (ha) of forest with connectivity and area (ha) of forest with forest interior conditions.

FF 12 — RARE ECOSYSTEMS

Supports FRPA Section 2.22 Objectives	
Supports Biodiversity and Ecosystem Health	✦
Supports Climate Change Adaptation	☀

Linked Gwa'ni Objectives

GO 2 — Maintain a healthy, diverse and resilient forest that contains native species, communities, natural landscapes, and ecological functions characteristic of the Nimpkish Valley.

GO 4 — Manage the Gwa'ni project area recognizing the projected changes to the local climate.

FLP Goal

Maintain or improve the integrity of rare ecosystems.

FF 12

The proportion of area in each ecosystem integrity class for rare ecosystems grouped by biogeoclimatic (BEC) variant at the end of 2035[1] is identified in Figure 29 with an increase in the highest integrity classes (I and II) in the drier CWH xm2 and CWH mm1 BEC variants over the next 300 years.

Figure 29: Forecast proportion of area by integrity class at the end of 2035.

BEC Variant	Integrity Class	Proportion of Area (%)
CWH xm2	I	5-9
	II	13-17
	III	38-42
	IV	36-40
CWH mm1	I	3-7
	II	0-4
	III	57-61
	IV	32-36
CWH vm1	I	20-24
	II	10-14
	III	35-39
	IV	27-31
CWH vm2	I	41-45
	II	10-14
	III	14-18
	IV	26-30

[1] Natural disturbance events and the ability to achieve the available harvest volume as forecast will affect the outcome. This outcome will be monitored to evaluate how sensitive it is to the spatial and temporal harvest pattern.

Description of the Outcome and Forecast

We have defined rare ecosystems as those that are provincially red-listed and blue-listed as determined by the BC Conservation Data Center as well as those that are uncommon or less than 2% across the tenures Western manages. It is recognized that the potential for ecosystems to be considered as rare is a function of their late seral stage. As the integrity of these ecosystems improves into the future, an updated assessment will be required to determine if they are still considered rare.

Climate models indicate a displacement of the historical climates of the higher elevation Mountain Hemlock (MH) zone with climates more characteristic of the lower elevation Coastal Western Hemlock (CWH) zone. As the climates change, it is possible that some ecosystems may become rare, while others may no longer be rare, as the abundance of some older seral ecosystems shift with the changing climate.

All ecosystems contribute to healthy, diverse, and resilient forests that contain native species and communities characteristic of the Nimpkish Valley. In recognition that ecosystems are dynamic, the ecosystem integrity approach in FF 5 is an effective way to forecast the integrity of rare ecosystems into the future.

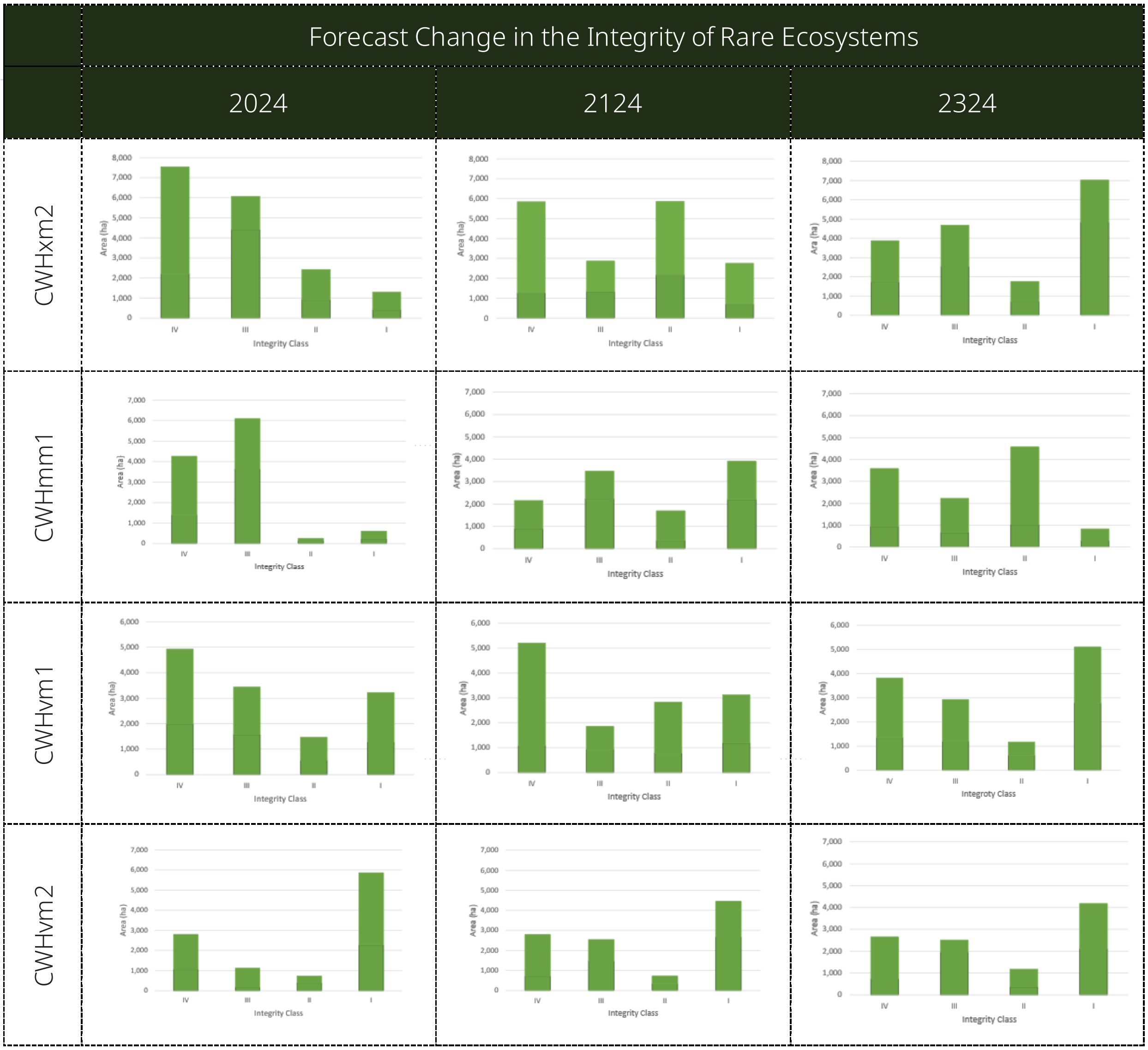
To achieve this, the ecosystem integrity forecast from FF 5 was connected spatially to the rare ecosystems within each biogeoclimatic variant. Figure 30 summarizes the ecosystem integrity classes for the rare ecosystems within the CWHxm2[22], CWHmm1[23], CWHvm1[24], and CWHvm2[25] forecast 300 years into the future. There are currently no rare ecosystems in the MH zone.

Both the CWHxm2 and CWHmm1 have a significant shift in classes from IV and III (lower integrity) to classes II and I (higher integrity). The CWHvm1 and CWHvm2 also shift to a more balanced distribution across all integrity classes.

To establish a short-term outcome that aligns with the 10-year term of the plan, the proportion of area forecast in each ecosystem integrity class at the end of 2035 is identified in the context of an overall trend to a greater proportion of the forest being in higher integrity classes over the next 300 years.

[22] CWHxm2 / 01, 02, 03, 05, 06, 07, 08, 09, 11, 12
[23] CWHmm1 / 01, 02, 03, 05, 06, 07, 09, 12
[24] CWHvm1 / 03, 04, 06, 07, 09, 10, 11, 14
[25] CWHvm2 / 03, 04, 06, 07

Figure 30: Forecast of ecosystem integrity of the rare ecosystems.



How the FRPA Section 2.22 Objectives were Considered in Establishing the Outcome

The details of how the four relevant FRPA Section 2.22 Objectives were considered in establishing the Outcome are as follows:

Supporting the protection and conservation of the environment.

- This is one of the ten outcomes that is an element of biodiversity and ecosystem health.
- Important elements of landscape level biodiversity are the seral stage distribution of ecosystems, the temporal and spatial pattern of harvest areas, forest interior habitat, landscape connectivity, stand structure, and species composition. Ecosystem integrity connects all these elements spatially and temporally across the entire landscape.
- All ecosystems contribute to healthy, diverse, and resilient forests that contain native species and communities characteristic of the Nimpkish valley. In recognition that ecosystems are dynamic, ecosystem integrity provides an effective approach to forecast the change in the condition of rare ecosystems into the future ensuring that the cumulative impact of all activities continues to improve the integrity of rare ecosystems.

Managing the values placed on forest ecosystems by Indigenous peoples.

- ‘Na̲mg̲is community engagement identified supporting and rebuilding environmental relationships and resilience of ecosystems. Also emphasized was the protection of the health of natural systems.
- A spatial and temporal forecast of ecosystem integrity proved to be an effective communication tool providing assurance toward the desired recovery from past harvest patterns. Communicating the forecast change in rare ecosystems helps provide assurance regarding the state of ‘Na̲mg̲is territory and the progress toward the desired recovery from past logging practices.

Managing the values placed on forest ecosystems by local communities.

- A total of 72% of respondents to a public engagement survey delivered via the Gwa'ni Project indicated the need to balance economic interests with the protection of natural ecosystems, and 24% supported protection of the health of natural systems, even at the expense of economic activities. The ecosystem integrity forecast reflects the harvest pattern into the future and the contribution of the full diversity of stands supporting the protection of natural ecosystems.
- Respondents to a public engagement survey delivered via the Gwa'ni Project indicated that old growth forest is a value to prioritize within land use planning. Ecosystem integrity is forecast to improve into the future reflecting the change in the amount of old growth forests.
- A spatial and temporal forecast of ecosystem integrity proved to be an effective communication tool and provided helpful landscape context to the 5-year harvest pattern shared as part of the FOP.

Preventing, mitigating, and adapting to impacts caused by significant disturbances to forests and forest health, including wildfire, insects, disease, and drought.

- Climate models indicate a displacement of the historical climates of the higher elevation Mountain Hemlock (MH) zone with climates more characteristic of the lower elevation Coastal Western Hemlock (CWH) zone. Given the unpredictable range of impacts a changing climate could have on the Nimpkish valley, maintaining a variety of forest structures, tree ages, and diverse species mixes will all contribute to healthy, diverse, and resilient forests into the future.

Supporting Stewardship Strategies

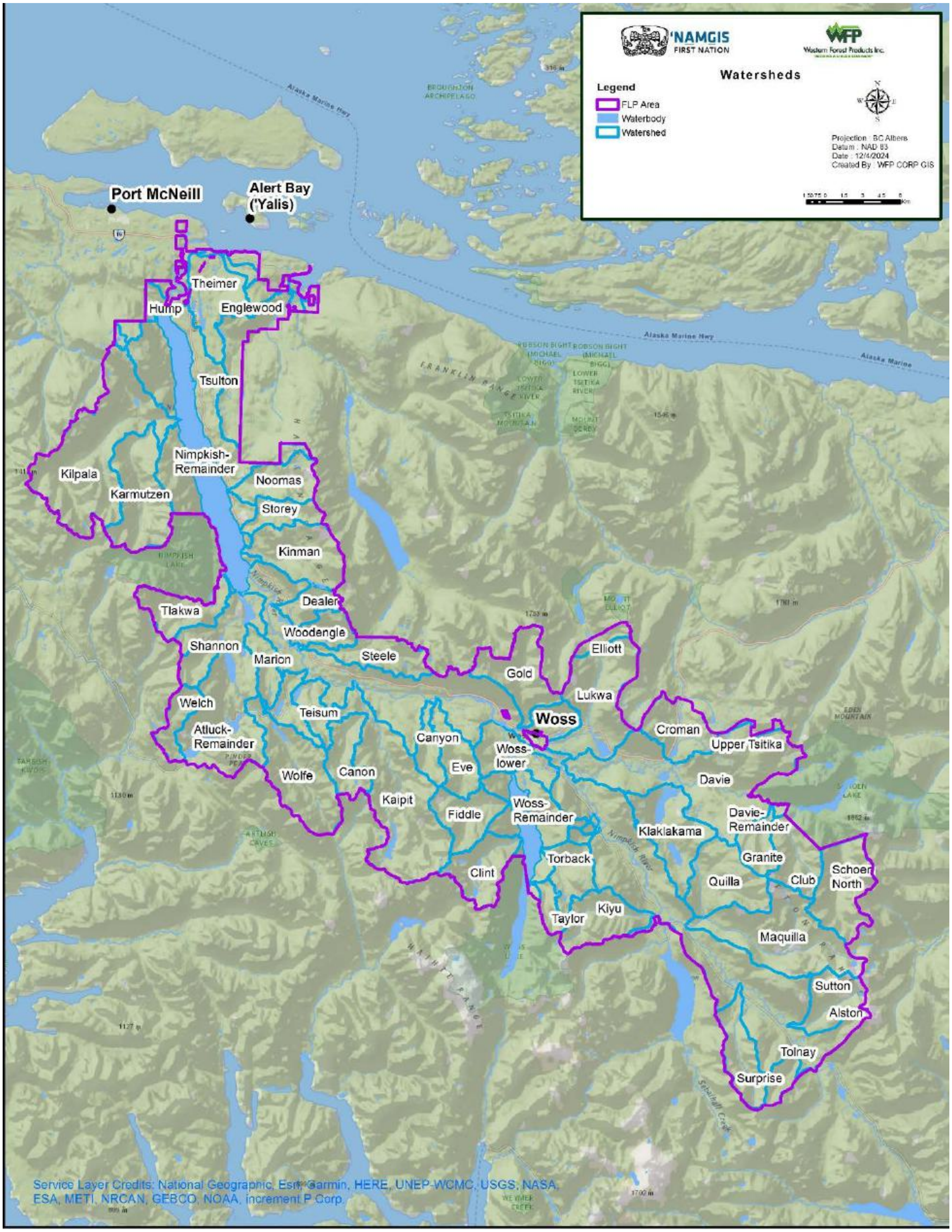
SS 1: 'Na̱mg̱is Conservation Network
SS 2: Carbon Reserve
SS 5: Retention of Riparian Forest – Streams
SS 6: Retention of Riparian Forest – Wetlands
SS 7: Retention of Riparian Forest – Lakes
SS 8: Variable Retention
SS 9: Harvest Criteria
SS 11: K'wa'x̱tłu Retention Criteria
SS 15: Invasive Plants
SS 18: Karst Features
SS 20: Habitat Features (Bears, Eagles, Great Blue Heron)

Adaptive Management Indicators

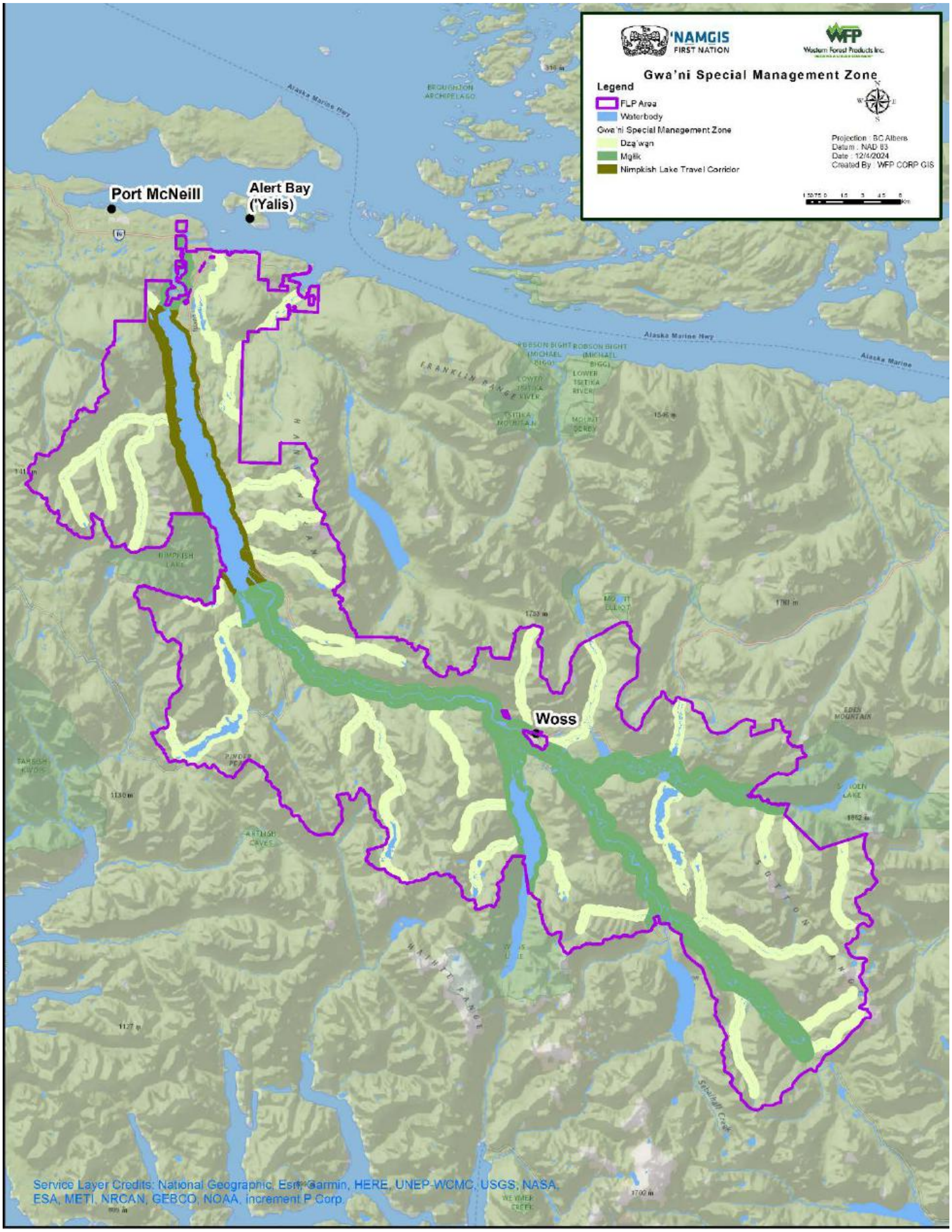
AMI 12: The proportion (%) of area (ha) in each ecosystem integrity class for rare ecosystems grouped by biogeoclimatic variant.

Appendix A

Map A: Watersheds



Map B: Gwa'ni Special Management Zone



Appendix B

Examples of Vertebrate Species of Northern Vancouver Island By Species Accounting System Group

Species Accounting System Group	Species Name[1]
Group 1 Generalists	Band-tailed Pigeon Rufous Hummingbird
Group 2 Forest type	Black-throated Gray Warbler Evening Grosbeak Great Blue Heron[b] Marbled Murrelet Olive-sided Flycatcher Pacific-slope Flycatcher Purple Finch Red Crossbill Sooty (Blue) Grouse Western Wood-Pewee Hoary bat Roosevelt elk
Group 3c Cavity Sites	American Kestrel Barrow's Goldeneye Brown Creeper Chestnut-backed Chickadee Common Goldeneye Northern Pygmy Owl Tree Swallow Vaux's Swift Western Screech Owl American marten Californian myotis Keen's myotis Long-eared myotis Long-legged myotis Silver-haired bat
Group 3d Down Wood	Clouded salamander Ruffed Grouse

Species Accounting System Group	Species Name[1]
Group 3u Shrubs/understory	Red-eyed Vireo Swainson's Thrush Willow Flycatcher Wilson's Warbler Yellow Warbler
Group 3w,r Wetlands/Riparian	Red-legged frog Western (Boreal) Toad Harlequin Duck Pied-billed Grebe Red-throated Loon Virginia Rail American Water Shrew
Group 4 Localized habitat	Ancient Murrelet Black Swift Peregrine Falcon Sandhill Crane
Group 5 Distribution	Northern Goshawk
Group 6 Non-forested	American Goldfinch Barn Owl Barn Swallow Bewick's Wren Brandt's Cormorant Common Nighthawk Killdeer Northern Rough-winged Short-eared Owl[?] Tufted Puffin[?] Western Meadowlark [c] White-tailed Ptarmigan [d]

[1]The American Ornithological Union considers common names of birds as proper names and capitalizes them

[b] *fannini* subspecies

[?]presence uncertain

[c] Georgia Depression Population

[d] *saxatilis* subspecies

Appendix C

Spatial and Temporal Forest Modelling utilizing Patchworks™

Methodology

Patchworks™ forest modelling was integral to development of the FLP and FOP. While forest models have traditionally been viewed as tools supporting the evaluation of future timber supply, they can also be configured to support the spatial and temporal evaluation of a wide range of values.

Patchworks™ was therefore utilized to investigate the interconnected relationships across all stewardship strategies considering a range of scenarios and sensitivities for each of the identified values. Forest modelling and modern datasets was the technology behind connected planning that builds up to the desired future forest condition inclusive of the cumulative effect of all stewardship strategies including the resulting harvesting pattern.

As the interconnectedness of values and relationships between the stewardship strategies became clearer through over 100 modelling runs, each of the stewardship strategies was refined so that they functioned together in a complementary way. This enabled potential unintended consequences to be identified early providing the technical team with the diligence and detailed spatial and temporal data required to align on a well-informed preferred scenario.

This preferred scenario was then described using the Patchworks™ data outputs to create each of the 12 spatially and temporally explicit future forest outcomes in the FLP while concurrently providing the spatial harvest and road pattern for the FOP.

Modelling Inputs – Spatial Data Inputs, Stewardship Strategy Criteria, Growth and Yield criteria, Economics Criteria

The model was configured for the entirety of TFL 37 ensuring coverage across the entire management unit. While the stewardship strategies and future forest outcomes apply only to the FLP area (roughly 89% of TFL 37), the model was constructed with the stewardship strategies applying across the full extent of the TFL. This enables the model to be updated to support collaborative planning with other First Nations as the FLP and FOP is amended to include all TFL 37.

This section summarizes the suite of information integrated into the model:

- Spatial Data Inputs
- Stewardship Strategies
- Growth and Yield

Spatial Data Inputs

A range of spatial data inputs were incorporated into the model. Each of these spatial data layers were brought together into a resultant dataset that formed the spatial basis of the model and are detailed below.

Inventory Data

The inventory data used in the model is summarized in Figure 31.

Figure 31: Spatial inventory data sources.

Data	Source (Vintage)	Comment
Forest Inventory	Western Forest Products (1997)	Updated to December 31, 2021 for age, harvesting, reforestation and growth
LiDAR-based Individual Tree Inventory	Western Forest Products (2018)	Used for determining accurate forest stand heights and volume
LiDAR-based stream network	Western Forest Products (2023)	Combined with field-classified stream data to provide thorough prediction of stream coverage
Alluvial Fans	Western Forest Products (2023)	
Existing Roads	Western Forest Products (2023)	
Future Roads	Western Forest Products (2023)	Projections based on use of LiDAR digital surface model
LiDAR-based operability	Western Forest Products (2023)	Using the future road projections, predicted harvest systems are assigned to physically operable areas.
Archaeological and cultural sites	Province and ‘Na̱mg̱is (2023)	
Recreation sites and trails	Western Forest Products (2000)	
Terrain stability	Western Forest Products (1999)	
Karst Vulnerability	Western Forest Products (2004)	
Terrestrial Ecosystems (TEM)	Western Forest Products (1999)	
‘Na̱mg̱is Conservation Network	FLP (2023)	

Data	Source (Vintage)	Comment
Old Growth Management Areas (OGMAs)	Province and FLP (2023)	Proposed OGMA revisions formally submitted for approval and incorporated into 'Na̲mg̱is Conservation Network
Wildlife Habitat Areas (WHAs)	Province and FLP (2023)	Proposed WHA revisions formally submitted for approval and incorporated into 'Na̲mg̱is Conservation Network
Ungulate Winter Ranges (UWRs)	Province (2022)	Incorporated into 'Na̲mg̱is Conservation Network
Resource Management Zones (Vancouver Island Land Use Plan RMZs)	Province (2000)	
Gwa'ni Zones (including subzones)	Gwa'ni Project (2023)	
Landscape Units	Province (2023)	
Watersheds	Western Forest Products (2022)	
Watershed Areas of Sensitivity	FLP (2023)	
Forest Stewardship Zones	Western Forest Products and FLP (2023)	Modified to reflect Gwa'ni Special and General Management Zones
Established Visual Quality Objectives	Province (2022)	
Additional Visual Quality Polygons	FLP (2023)	
Existing Stand-level Retention (WTP, WTRA, VR, etc.)	Western Forest Products (2021)	
Proposed Conservancy	Gwa'ni Project (2023)	
TFL 37 boundary	Western Forest Products (2022)	
FLP Area	FLP (2022)	
Elk Hazard Zones	Western Forest Products (2023)	Areas where reforestation strategies reflect elk forage
Elevation	Western Forest Products (2023)	LiDAR-derived elevation center of each forest inventory polygon
Fertilized Areas	Western Forest Products (2023)	
Deer Spring Forage Capability	Western Forest Products (2023)	
Harvested and Planned Cutblocks	Western Forest Products (2023)	Cutblocks for 2022, 2023 and 2024
Road network	Western Forest Products (2023)	Includes both existing and future roads with log delivery destinations and physical road barriers

Existing VILUP Zones and Proposed Gwa'ni Zones

The model was configured with both the existing Vancouver Island Land Use Plan (VILUP) zones and proposed Gwa'ni Zones.

The model was configured using the traditional modelling categories of Productive Forest (PF), Timber Harvesting Landbase (THLB), and Non-contributing Landbase (NCLB). The breakdown for each of these categories for the current VILUP Resource Management Zones for the FLP area are listed in Figure 32.

This enabled the model to report out considering both the current and proposed zones and enabled SS9 — Harvest Criteria and SS10 — Cutblock Size and Green-up Criteria to be modelled specific to the applicable Gwa'ni zone.

Figure 32: Modelling categories for the existing VILUP Zones within the FLP area.

VILUP RMZ Type	PF Area (Ha)	THLB Area (Ha)	NCLB Area (Ha)
Agriculture	1,716	353	1,363
Enhanced	49,649	29,652	19,997
General	39,472	24,361	15,111
Settlement	359	72	288
Special	23,998	12,907	11,091
Grand Total	**115,194**	**67,345**	**47,849**

Figure 33 is the breakdown for each of the modelling categories for the proposed Gwa'ni Zones.

Figure 33: Modelling categories for the proposed Gwa'ni Zones within the FLP area.

Gwa'ni Zone	PF Area (Ha)	THLB Area (Ha)	NCLB Area (Ha)
General	78,964	48,954	30,009
Special	36,231	18,391	17,840
dza'wa'n	18,927	10,676	8,251
ma̱łik (including Nimpkish Lk Visual Corridor)	17,303	7,715	9,589
Grand Total	**115,194**	**67,345**	**47,849**

The net effect of the proposed Gwa'ni zone designations is a 100% increase in the area designated as General Management Zone and a 51% increase in the area designated as a Special Management Zone, reflecting the removal of the Enhanced Forestry Zone designation and shift of the Special Management Zone.

‘Namgis Conservation Network

The ‘Namgis Conservation Network which is close to 28,000 ha of productive forest was spatially represented in the model. Figure 34 is the breakdown for each of the modelling categories for ‘Namgis Conservation Network.

This enabled SS 1 – ‘Namgis Conservation Network Including Reserves for Wildlife, Biodiversity, and Carbon to be modelled.

Figure 34: Modelling categories for the ‘Namgis Conservation Network within the FLP area.

Designation	PF Area (Ha)	THLB Area (Ha)	NCLB Area (Ha)
‘Namgis Conservation Network	27,937	0	27,937

Areas of Peak Flow Sensitivity

A total of 13 Areas of Peak Flow Sensitivity have been delineated. These are the spatial areas where the maximum equivalent clearcut area (ECA) limits are applied as specified in SS3 – ECA Limits in Areas of Peak Flow Sensitivity. To calculate ECA values, rain-on snow zone curve R1b[26] with a 4m threshold was applied.

Figure 35 is the breakdown for each of the modelling categories for the Areas of Peak Flow Sensitivity.

This enabled SS 3 – ECA Limits in Areas of Peak Flow Sensitivity to be modelled.

[26] Hudson,R.,and G.Horel. 2007.An operational method of assessing hydrologic recovery for Vancouver Island and South coastal BC. Res. Sec., Coast For.Reg., BC Min. For., Nanaimo, BC. Technical Report TR-032/2007.

Figure 35: Modelling categories for the Areas of Peak Flow Sensitivity.

Area of Peak Flow Sensitivity	PF Area (Ha)	THLB Area (Ha)	NCLB Area (Ha)
Davie	3,778	1,928	1,849
Pink	76	49	27
Kaipit	3,526	2,092	1,434
Kilpala	6,157	3,124	3,033
Karmutzen	1,940	1,068	872
Kilpala	4,217	2,055	2,162
Kiyu	1,022	222	800
Lukwa	2,078	1,136	942
Maquilla	2,782	1,434	1,348
Maquilla	1,997	846	1,151
Quilla	785	588	197
Surprise	1,061	675	386
Sutton	686	359	326
Grand Total	21,165	11,019	10,146

Riparian Forest

To monitor and report on functional and resilient riparian forest, areas of riparian forest were defined for four main rivers (Nimpkish, Davie, Woss and Sebahall), all other S1 streams, S2, and S3 streams. The widths used to define riparian forest are as specified in FF 3.

Figure 36 is the breakdown for each of the modelling categories for the Riparian Classes. The areas do not total as the riparian forest areas overlap, for example, where an S2 stream tributary flows into an S1 stream.

This also enabled SS 5 – Retention of Riparian Forest – Streams to be modelled.

Figure 36: Modelling categories for the Areas of of Riparian Forest.

Riparian Class	PF Area (Ha)	THLB Area (Ha)	NCLB Area (Ha)
Named rivers	3,358	114	3,244
S1	4,247	91	4,156
S2	4,431	98	4,333
S3	5,232	143	5,089

Visual Quality Objectives

Visual Quality Objectives (VQOs) include a combination of those established via the Government Actions Regulation (GAR) and areas identified by ‘Na̲mg̲is as being visually sensitive from significant cultural use sites and lakes where public use has continued to increase. Given the application of the retention silvicultural system, the maximum recommended denudation percentage by VQO class were applied: 15% for Partial Retention and 25% for Modification. Visually Effective Green-up (VEG) heights were determined for each VQO polygon based on the area-weighted average slope calculated using a LiDAR digital elevation model (DEM) and application of Table 6 in Procedures for Factoring Visual Resources into Timber Supply Analyses (BC Ministry of Forests, 1998).

Figure 37 is the breakdown for each of the modelling categories for the Visual Quality Classes.

This enabled SS 19 – Visual Quality to be modelled.

Figure 37: Modelling categories for the Areas of Riparian Forest.

Visual Quality Class	PF Area (Ha)	THLB Area (Ha)	NCLB Area (Ha)
Established via Government Actions Regulation			
Modification	6,264	4,235	2,028
Partial Retention	10,217	5,723	4,494
Forest Operations Plan Stewardship Strategy			
Modification	2,216	1,499	717
Partial Retention	5,442	3,479	1,963
Grand Total	**24,316**	**15,033**	**9,283**

Forest Stewardship Zones

Forest Stewardship Zones identify the spatial areas for applying the appropriate silvicultural system. These zones are based on a combination of resource management zones, biogeoclimatic variant and ecosection mapping.

Given that the Forest Stewardship Zones are linked to resource management zones they have been updated to reflect the proposed Gwa’ni Zones.

Figure 38 is the breakdown for each of the modelling categories for the Forest Stewardship Zones aligned with VILUP and Figure 39 is the breakdown for each of the modelling categories for the Forest Stewardship Zones updated to reflect the proposed Gwa’ni Zones.

This enabled SS 8 – Variable Retention to be modelled.

Figure 38: Modelling categories for the VILUP-based Forest Stewardship Zones.

Stewardship Zone	PF Area (Ha)	THLB Area (Ha)	NCLB Area (Ha)
Enhanced Basic	35,594	21,838	13,756
Enhanced Dry	12,178	6,467	5,711
Enhanced Windy	3,232	1,602	1,630
General Basic	29,563	18,405	11,158
General Dry	10,584	6,097	4,488
Special	24,043	12,936	11,106
Grand Total	**115,194**	**67,345**	**47,849**

Figure 39: Modelling categories for the Gwa'ni-based Forest Stewardship Zones.

Stewardship Zone	PF Area (Ha)	THLB Area (Ha)	NCLB Area (Ha)
General Basic	65,665	40,264	25,401
General Dry	10,793	7,339	3,455
General Windy	2,505	1,351	1,154
Special	36,231	18,391	17,840
Grand Total	**115,194**	**67,345**	**47,849**

Deer Spring Forage

Spring forage modeling was incorporated around each deer winter range based on a procedure developed in 2007 for TFL 64. This procedure quantifies the availability of spring forage adjacent to winter ranges based on:

- Proximity to the winter range (must be within 2 km)
- Aspect (must be between 090^0 and 270^0)
- Slope (≥40% and ≤ 100%)
- Elevation (≤ 800m)
- Stand age

The estimated amount of forage production provided by a hectare of a suitable stand is identified in Figure 40.

Figure 40: Estimated amount of forage provided by a hectare of a suitable stand.

Forage Production Equivalence Factors			
	Age in years (Factor)		
Distance from UWR (Factor)	0 – 10 (90%)	11 – 15 (75%)	16 + (5%)
0m - 400m (100%)	0.9	0.75	0.05
400m - 1000m (75%)	0.675	0.5625	0.0375
1000m - 2000m (50%)	0.45	0.375	0.025

The model was configured to maintain an area of spring forage production equivalent to 10% of the deer winter range area. For example, a 50 ha deer winter range had a target of 5.0 ha of spring forage area.

The results are reflected in the spatial harvest pattern included as part of the FOP.

Stewardship Strategy Modelling Criteria

A total of 20 stewardship strategies were integrated into the model requiring a detailed set of modelling criteria to be applied. Figure 41 lists the criteria used for each of the stewardship strategies and how they were incorporated into modeling where applicable.

Figure 41: Modeling criteria for Stewardship Strategies.

Stewardship Strategy	How Incorporated in Model	Modelling Criteria Applied
1	Spatially	Not available for harvest, except future road crossings
2	Spatially	Part of ‘Na̲mg̲is Conservation Network
3	Spatially and forest cover constraint	Use R1b[27] rain-on snow zone curve with 4m threshold to calculate ECA recovery value for harvested stands within each area of peak flow sensitivity

[27] Hudson,R.,and G.Horel. 2007. An operational method of assessing hydrologic recovery for Vancouver Island and south coastal BC. Res. Sec., Coast For.Reg., BC Min. For., Nanaimo, BC. Technical Report TR-032/2007.

<table>
<tr><th>Stewardship Strategy</th><th>How Incorporated in Model</th><th>Modelling Criteria Applied</th></tr>
<tr><td>4</td><td>Spatially</td><td>In areas of peak flow sensitivity and watersheds with sockeye spawning fans:
• 100% area reduction for Class V terrain stability polygons
• 30% area reduction for Class IV terrain stability polygons
In balance of FLP area:
• 100% area reduction for Class V terrain stability polygons
• 15% area reduction for Class IV terrain stability polygons
Area reductions developed in collaboration with G.Horel based on analysis of past performance.</td></tr>
<tr><td>5</td><td>Spatially</td><td>Buffer equivalent to riparian reserve zone width plus specified minimum retention strategy within riparian management zone. For S6 streams, riparian retention assumed to be addressed by stand level Variable Retention area reductions (refer to SS 8).</td></tr>
<tr><td>6</td><td>Spatially</td><td>Buffer equivalent to riparian reserve zone width plus specified minimum retention strategy within riparian management zone. If no RMZ retention strategy is specified, assumed 50% retention.</td></tr>
<tr><td>7</td><td>Spatially</td><td>Buffer equivalent to riparian reserve zone width plus specified minimum retention strategy within riparian management zone. If no RMZ retention strategy is specified, assumed 50% retention.</td></tr>
<tr><td>8</td><td>Aspatial area reductions</td><td>Within Gwa’ni SMZ, applied a 10.5% area reduction to address incremental area impact of meeting 25% stand level retention within 100% of cutblocks.
Within Gwa’ni GMZ, applied the following area reduction percentages:
<table>
<tr><th>Landscape Unit</th><th>BEC subzone</th><th>Area reduction</th></tr>
<tr><td rowspan="3">Lower Nimpkish</td><td>CWHxm</td><td>7.3%</td></tr>
<tr><td>CWHvm</td><td>5.5%</td></tr>
<tr><td>MHmm</td><td>4.3%</td></tr>
<tr><td rowspan="4">Upper Nimpkish</td><td>CWHxm</td><td>7.5%</td></tr>
<tr><td>CWHmm</td><td>7.6%</td></tr>
<tr><td>CWHvm</td><td>5.5%</td></tr>
<tr><td>MHmm</td><td>4.6%</td></tr>
</table>
Area reductions in GMZ address WTRA requirements plus application of SS 8.
Area reduction percentages are based on a review of the incremental area designated as stand-level retention within recently harvested cutblocks to meet existing retention level targets. Given retention levels will be higher under the FLP, the incremental area impact was increased to address the higher levels of retention.</td></tr>
<tr><td>9</td><td>Specification</td><td>At least 120 years old in mał̱ik portion of SMZ. Elsewhere, age at which 95% of culmination mean annual increment is achieved.</td></tr>
</table>

Stewardship Strategy	How Incorporated in Model	Modelling Criteria Applied
10	Specification	Taking advantage of spatial capabilities of Patchworks™, specified maximum non-greened up areas and green-up heights as detailed in SS 10. To reflect operational realities and discourage harvesting of scattered small cutblocks, specified a maximum of 20 ha harvested annually in cutblocks less than 4 ha in size.
11	Aspatial area reductions	Assumed to be addressed by stand level retention area reductions (refer to SS 8)
12	Growth and yield	Future managed stand yields based on application of SS 12 plus the realized influence of natural ingress and elk. Growth and yield estimates were reduced by 3-5% to reflect stand level retention.
13	Not applicable	
14	Not applicable	
15	Not applicable	
16	Not applicable	
17	Not applicable	
18	Aspatial area reductions	Percentage area reductions for each karst vulnerability polygon such that the recommended netdown from the karst vulnerability inventory is achieved.
19	Spatially and forest cover constraint	Maximum permissible area less than visually effective green-up (VEG) height by VQO polygon based on VQO and average slope.
20	Aspatial area reductions	Assumed to be addressed by stand level retention area reductions (refer to SS 8).

Growth and Yield Criteria

Growth and yield criteria used in the model to enable stands of trees to be grown into the future reflective of the stewardship strategies is detailed below.

Time Periods

Growth and yield criteria varied by stand age, with four time periods defined:

- Natural stands – stands established before 1961. These stands are assumed to be natural regeneration following harvesting or natural disturbances.
- Early managed stands – stands established between 1961 and 1999. These stands are assumed to be the result of planting following harvest with seedlings lacking genetic gain and no shading impacts from stand-level retention.
- Recent managed stands - stands established between 2000 and 2021. These stands are assumed to be the result of planting following harvest with seedlings with average genetic gain for the period and with shading impacts from stand-level retention.
- Future managed stands - stands established after 2021. These stands are assumed to be

the result of planting following harvest with seedlings with current genetic gain and with shading impacts from stand-level retention.

Utilization

The utilization level is 12.5 cm diameter at breast height (DBH) for stands less than 121 years old and for future stands. Stump height for these stands is 30 cm and top diameter inside bark (DIB) is 10 cm. Utilization level for mature stands is 17.5 cm, with stump height of 30 cm and top DIB of 10 cm.

Use of LiDAR

In 2018, Western acquired a light detection and ranging (LiDAR) derived Individual Tree Inventory (ITI) for TFL 37. This inventory used 2016 LiDAR data, ground samples and stereo-imagery to estimate the location, size (height, diameter at breast height, gross volume, net merchantable volume) and species of individual trees.

Stand Height and Site Index

For each forest inventory polygon where LiDAR data was available, stand height was calculated based on this logic:

- Calculate the average height of the top four tree points per 20m x 20m raster;
- Calculate the mean height of all rasters in each inventory polygon;
- Use the mean height unless:
    - Coefficient of Variation > 40%;
    - Roundness index (Length to Area index to indicate long, skinny polygons) < 0.05; or,
    - Less than 20 rasters used to calculate mean height
    - If any of above criteria is met, use 50th percentile of raster heights.

The LiDAR-based stand height and projected age from the forest inventory were input into Site Tools (version 4.2) to generate a LiDAR-based site index value.

ITI Volume

An analysis of cruised cutblocks indicated that ITI-derived volume estimates were more accurate and precise than other inventory estimates available for TFL 37. The raw ITI volumes required an age-related adjustment of 0.625 m^3/ha/year that was assumed to be a result of the LiDAR data failing to identify understory trees, a well-recognized limitation of LiDAR derived inventories.

A similar approach was employed in a set of sensitivity analyses conducted as part of timber supply review conducted for TFL 44 Management Plan #6 and the subsequent AAC determination in June 2023. In his AAC rationale, the Provincial Deputy Chief Forester recommended that the adjusted-ITI inventory be evaluated using a random sample of field plots, as the cruise samples on which the analysis was based were not considered to be representative of the entire productive forest area.

Given the same approach was used in the FLP, a sampling plan was devised with support from the Forest Analysis and Inventory Branch (FAIB). The results of this sampling confirmed that the adjusted-ITI volumes were the most accurate and precise. Furthermore, a separate study using all cruise plots collected since the original study (65 cut blocks representing 1,078 ha) was also conducted. These blocks further support the conclusion that the adjusted-ITI is the most accurate and precise inventory for stand volumes.

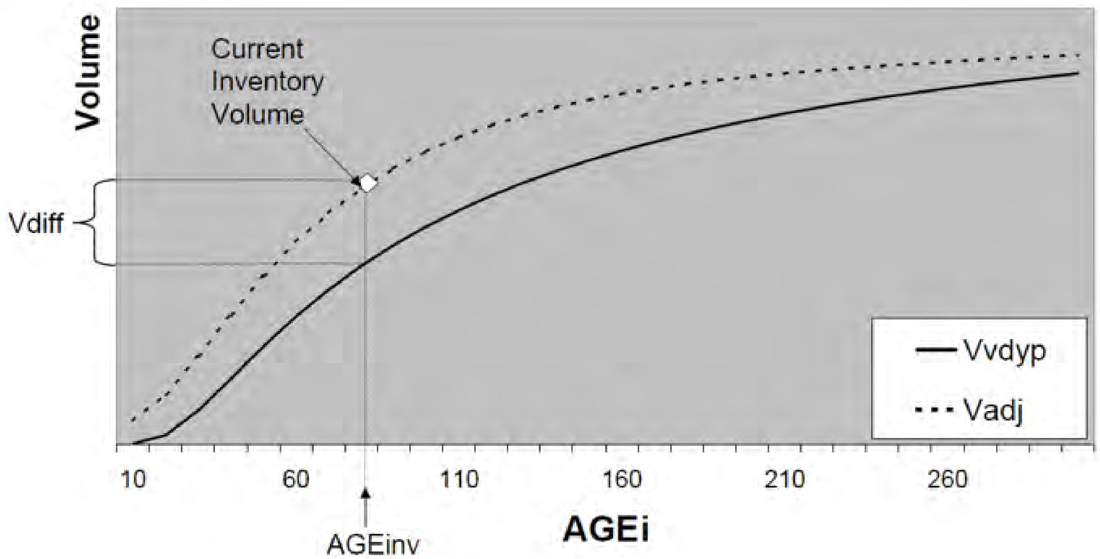
Natural Stands

Yield curves were generated for each individual natural stand utilizing Variable Density Yield Projection[28] (VDYP version 7.33b). Species composition was based on forest inventory data and ages were projected to 2021, including Phase II adjustments. Stand height and site index were LiDAR-derived.

The natural stands VDYP curves were forced through the known adjusted-ITI point (i.e. volume in 2016) using the adjustment formula (Pienaar & Rheney, 1995)[29]. Figure 12 shows an illustration for a generic yield curve adjustment using Pienaar & Rheney's methodology. This approach is more desirable than applying a uniform multiplier because the adjusted yield curve will use the unadjusted curve as a guide for converging on either side of the inventory adjustment. This approach reduces the risk of overestimating volumes in older stands and therefore short-term timber supply.

[28] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-inventory/growth-and-yield-modelling/variable-density-yield-projection-vdyp
[29] Pienaar, L. V., & Rheney, J. W. (1995). Modeling Stand Level Growth and Yield Response to Silvicultural Treatments. Forest Science, 41(3), 629–638.

Figure 42: Generic Yield Curve Adjustment (Pienaar & Rheney, 1995).



$V_{ADJi} = V_{VDYPi} + V_{DIFF} {*} A_1 {*} A_2$

$A_1 = Age_i / Age_{inv}$

$A_2 = e / e \hat{} (Age_i / Age_{inv})$

Where:

V_{ADJi} is the adjusted volume at any age i on the yield curve;

V_{VDYPi} is the unadjusted volume from the VDYP yield curve at any age i;

V_{DIFF} is the difference between the inventory volume and the VDYP yield curve at inventory age, Age_{inv};

Age_{inv} is the inventory age of the polygon, and the age at which V_{DIFF} is measured;

Age_i is the x-axis of the yield curve; and

e is the base of the natural logarithm, with a numerical value of 2.71828.

Managed Stands

Yield curves were generated for managed stands utilizing analysis units and Batch TIPSY (version 4.5). For existing stands, species composition was based on forest inventory data and ages were projected to 2021, including Phase II adjustments. Stand height and site index were LiDAR-derived, where available, otherwise Site Index Estimates by BEC Site Series[30] (SIBEC) values were used.

[30] https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/ecosystems/sibec

Analysis Units

Managed stands were assigned to analysis units for generating yield curves based on the following criteria:

- Age (used to define time period)
- Biogeoclimatic variant (BEC) and site series
- Fertilization (default TIPSY fertilization impacts were applied)

Fertilized analysis units having less than 50 ha were merged into the largest BEC site series within the same BEC and time period. Analysis units not fertilized and smaller than 150 ha were grouped into the largest BEC site series within the same BEC and time period.

Operational Adjustment Factors

Standard provincial operational adjustments factors (OAFs) were applied to TIPSY outputs:

- OAF 1: 15 percent
- OAF 2: 5 percent

Early Managed Stands

Early managed stands (established between 1961 and 1999) are assumed to be planted at 1,000 stems per hectare based on forest inventory species composition with no genetic worth and no yield reduction due to shading from stand-level retention.

Recent Managed Stands

Recent managed stands (established between 2000 and 2021) are assumed to be planted at 1,000 stems per hectare based on forest inventory species composition. Average genetic worth values by species from this period are applied. Site index for the leading species is LiDAR-derived where available. SIBEC values were used for all other species in a stand and for the leading species where a LIDAR-based site index was not available. To account for the impact of shading from stand-level retention, varying yield reductions (3-5%) were applied based on the former stewardship zones linked to VILUP zones.

Future Managed Stands

Future managed stands (established 2022 onwards) are assumed to be planted, after a 1-year regeneration delay, at varying densities such that average free-growing stand densities found in recent years are realized after application of OAF1. Species composition also reflects averages found in recent free-growing stands. Densities and species composition reflect the influence of elk browse on regenerating stands (e.g. lower densities and less redcedar in areas prone to elk damage).

Current (2022) genetic worth values by species are applied. SIBEC values were used for all species in a stand. To account for the impact of shading from stand-level retention, varying yield reductions (3-5%) are applied based on revised stewardship zones linked to Gwa'ni zones and expected higher levels of stand-level retention.

Economic Criteria

To be able to monitor and assess the direct economic implications of the integrated suite of stewardship strategies, harvesting costs and log values were incorporated into the model.

Harvest Costs

Average harvesting costs ($\$/m^3$) were applied based on the modeled harvesting system (cable, ground or helicopter), with allowances for different falling methods (hand, mechanical, tethered mechanical) and different proportions of roadside processing depending on the yarding system and stand age. Helicopter logging costs were based on flight distance to the nearest road and included costs for helicopter support for both falling and yarding phases.

Road-Related Costs

The functionality of Patchworks™ to manage a road network independent of the land base was taken full advantage of. Patchworks™ accounts for the need to have the road nearest to any harvestable land base polygon built prior to, or in the year, a polygon is scheduled to be harvested. For existing roads, it accounts for road maintenance costs every period a road is used to transport logs. It can also apply incremental reactivation costs to account for long periods of inactivity for a given road segment. Finally, Patchworks™ tracks the volume of logs hauled over every road segment and calculates the associated cost.

New Construction

A detailed analysis of all projected future roads was undertaken by breaking the roads into 30 m segments and determining the average uphill and downhill slope for each segment. Based on the average uphill slope (i.e. cut slope), a construction category was assigned to each road segment, ranging from OM (organic material) for slopes less than 20% to XXHR (extra extra heavy rock) for slopes greater than or equal to 80%. A cost matrix of average cost per lineal metre by construction category was applied to calculate the cost to build each segment. A cost additive was incorporated to account for end-hauling of material where the downhill slope (i.e. fill slope) was greater than or equal to 60%. Partial end-haul (i.e. only a portion of excavated material is trucked) was assumed on fill slopes from 60-69%, while full-bench end haul was assumed on fill slopes greater than or equal to 70%.

Reconstruction/Reactivation

For both the initial road network and on-going modeled network, reactivation costs were applied based on the length of time since a road segment was last used for log transport. If the period of inactivity is less than 10 years, no reactivation costs were applied. Different reactivation costs were applied, depending on cut slope gradient, if the period of inactivity was between 10 and 25 years or greater than 25 years. The assumption applied is that inactive roads on steeper slopes will require greater reactivation costs as more cut slope slumping and water management issues are anticipated than roads on gentler terrain.

Maintenance

Road maintenance costs are incurred every period a road segment is used to transport logs. These costs are assumed to address on-going maintenance activities such as grading, ditching, brushing and minor culvert replacement.

Log Hauling

The cost to transport logs was based on the time to travel over each road segment, the hourly cost of operating a log truck, average load size and factoring in time to load and unload at each end of the trip. For the FLP model, it was assumed all log transport is done by "highway trucks" and that the least cost route is always used. "Barriers" were added to the road network to reflect infeasible routes, including limiting access points to Highway 19.

Assumed speeds on public roads was the posted speed limit while speeds on logging roads were based on some GPS-tracking data that was obtained from TFL 44, with speeds varying by road class (mainline or spur) and road grade (steepness). Trip times included both the loaded and empty return travel. Finally, time was added to each trip to account for the time required to load and unload a truck.

The total cost of each load was therefore calculated by summing the travel time (both ways) and the load/unload time and multiplying by the hourly cost. The cost per m^3 was calculated by dividing the total cost by the assumed average load size (m^3).

Log Values

To recognize how log values differ by species and log diameter, log sorts and prices were integrated into the model and an average log sort profile by species by age class was generated. By multiplying the log sort proportions by log sort prices, the average value by species by age class was derived and used as a yield curve in Patchworks™. Given Patchworks™ interpolates between values provided in curves, the resulting log values by species were assigned to the first year of each age class. Then, due to the interpolation between specified points on the curve, log values gradually changed as stands aged, reflecting the gradual change in proportion of volume by species by log sort.

Selecting the Preferred Scenario

A structured approach to modelling was completed enabling the informed data driven development of the preferred scenario. A summary of modeling and selecting the preferred scenario is detailed below.

Model Configuration

Patchworks™ was configured using varying period lengths:

- Annual for the first decade to allow incorporation of harvested and planned cutblocks and ensure short-term timber supply reflects annual harvesting, rather than periodic harvesting. This approach enabled the integrated development of the Forest Operations Plan (FOP).
- 5-year periods for following 40 years to be able to analyze mid-term timber supply in more detail than the long-term.
- 10-year periods for final 350 years for a 400-year total planning period. Only the first 300 years is presented in the FLP, with the additional 100 years ensuring the outcomes will be maintained beyond year 300.

The default minimum harvest age was set at the age a yield curve reached 95% of its culmination mean annual increment (CMAI).

Model Accounts

Numerous accounts were created in Patchworks™ to report indicators of interest and to set appropriate model targets. An integrated modeling dashboard was created where results through time for critical indicators could easily be compared across scenarios, including, but not limited to:

- Age class distribution by Gwa’ni zone
- Age class distribution of Conservation Network
- THLB inventory volume (growing stock)
- ECA by watershed area of sensitivity
- Standing cedar volume
- Area not meeting VEG by VQO polygon
- Patch size distribution by Gwa’ni zone
- Average harvest age by Gwa’ni zone
- Average harvest volume per ha by Gwa’ni zone
- Area and number of cutblocks harvested by Gwa’ni zone
- Cutblock size distribution by Gwa’ni zone
- Road construction/reactivation length

- Age class distribution of riparian forest
- Harvest volume by system
- Harvest volume by species
- Harvest volume by age class
- Harvest volume by seasonality
- Road construction/reactivation cost
- Road maintenance costs
- Total cost
- Total log revenue
- Overall margin ($/m^3)

Within the model, a high weighting was applied to objectives related to maximum cutblock sizes, ECAs for watershed areas of sensitivity, non-declining long-term THLB growing stock and harvest volume. Relatively lower weighting was applied to objectives related to VQOs, road maintenance costs and spring forage.

Multiple Scenarios

A series of model scenarios were run before deciding upon the preferred scenario. This list highlights scenarios run and the stewardship strategies that were varied to test sensitivity:

- Benchmarked to MP #10 Woodstock Base Case to quantify impact of switching to Patchworks™:
  - Patchworks™ was able to replicate the MP #10 Base Case harvest flow
- Introduced new data inputs singly to quantify their impact to timber supply:
  - LiDAR-based operability
  - 'Na̲mg̲is Conservation Network
  - Gwa'ni SMZ and GMZ
  - Initially applying VILUP objectives
  - LiDAR-based streams network
  - LiDAR-based growth and yield
- Applied seasonality for harvest feasibility
- Applied various maximum cutblock size and green-up height combinations:
  - FLP area wide
  - Differing between Gwa'ni SMZ and GMZ
- Applied patch size distribution criteria rather than applying maximum cutblocks sizes
- Applied various minimum harvest ages within the Ma̲łik and Dza'wan portion of the Gwa'ni SMZ
- Applied FLP VQOs and ECA limits in Areas of Peak Flow Sensitivity

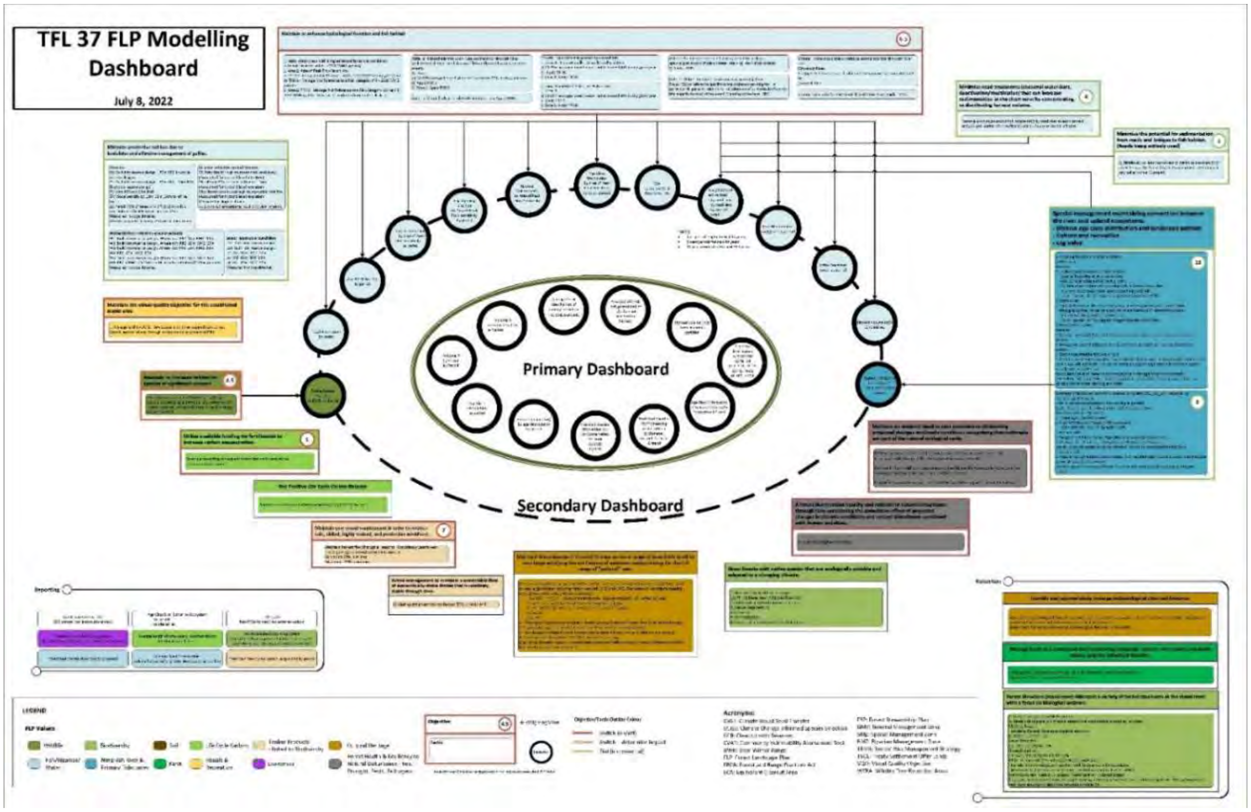
- Applied various retention requirements on S3 and S4 streams (“base” was 30 m for S3s and 10 m for S4s)
- Applied road maintenance cost limits to manage active road network length
- Applied High and Low BEO criteria in the SMZ
- Applied mature seral stage criteria in the SMZ:
    - 141-200 years old and 201-250 years old
- Applied various combinations of all of the above
- Applied spring forage criteria
- Ran even-flow harvest flow to determine the minimum mid-term harvest level to maintain
- Ran Preferred Scenario to generate FLP and FOP outputs

The Preferred Scenario

The preferred scenario was selected based on the detailed evaluation of the spatial and temporal indicators in achieving cultural, biodiversity and ecosystem health goals while also enabling an economically viable timber supply. Therefore, this scenario confirmed the combination of stewardship strategies and resulting harvest pattern will enable the desired future forest condition to be achieved.

Figure 43 is the modelling dashboard that was developed to enable evaluation of different scenarios. It is recognized that the dashboard text is not legible at this scale, but we wanted to include the actual dashboard we utilized, as it is a good visual of the concept of connecting modelling indicators to stewardship strategies. By making these connections, as modelling indicators change, it is possible to trace back to the stewardship strategies affecting the change. This enabled the informed refinement of stewardship strategies to achieve the desired future forest condition.

Figure 43: Dashboard of modeling indicators linked to values and stewardship strategies that supported development of the preferred scenario.



Classifying the Preferred Scenario Landbase

In consideration of the Timber Supply Review (TSR) process, the preferred scenario can be classified and quantified using a traditional hierarchical approach to define the Timber Harvesting Landbase (THLB). The THLB is defined as the subset of the legally harvestable land base where it is economical for timber harvesting to occur based on current forest management practices[31]. The THLB is only a GIS-based estimate of where harvesting will occur given the preferred scenario but does not explicitly define the operational reality of where harvesting will occur. The inclusion or exclusion of a specific site in the THLB does not necessarily relate to how it will be managed which is defined through the stewardship strategies. The hierarchical breakdown of the landbase is summarized in Figure 44.

[31] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/timber-tenures/community-forest-agreements/provincial_guide_for_the_preparation_of_information_packages_and_analysis_reports_for_area-based_tenures_jun_2021.pdf

Figure 44: Landbase classification of the preferred scenario.

Classification Category	Total Area (Ha)	Net Area (Ha)	Total (%)	PFLB[1] (%)
Total Land Base	142,507	142,507	100.0%	-
Less non-forest	16,330	16,330	11.5%	-
Less existing roads	1,780	1,780	1.3%	-
Less powerlines	18	18	0.0%	
Total Forested	123,929	123,929	87.2%	-
Less non-productive	10,487	10,487	7.4%	-
Total Productive	113,442	113,442	79.9%	100.0%
Reductions:				
Archaeological sites	69	69	0.0%	0.1%
Proposed protected area	773	678	0.5%	0.6%
Riparian Management	11,808	10,355	7.3%	9.1%
Wildlife Habitat Areas – legal and proposed	5,397	4,444	3.1%	3.9%
Ungulate Winter Ranges	5,016	2,577	1.8%	2.3%
Recreation	66	29	0.0%	0.0%
Inoperable	42,702	11,274	7.9%	9.9%
Low sites	15,905	1,891	1.3%	1.7%
Deciduous-leading	1,892	384	0.3%	0.3%
Steep terrain	7,814	1,258	0.9%	1.1%
Existing stand-level reserves	4,553	2,304	1.6%	2.0%
‘Na̲mg̲is Conservation Network including OGMAs	33,700	7,332	5.2%	6.5%
Karst	8,571	227	0.2%	0.2%
Future stand-level reserves		3,249	2.3%	2.9%
Total Reductions		46,071	32.4%	40.6%
Current THLB		67,370	47.4%	59.4%

The Productive Forest Landbase (PFLB) is the portion of the forest that is capable of producing a merchantable stand of trees with site index value > than 5m.

The details associated with each hierarchical classification category that are removed from the PFLB to define the THLB is summarized in each section below.

Non-Forest

Non-forest areas are identified in the forest inventory as alpine, rock, water or any other designation indicating no trees are present.

Existing Roads

Existing roads are quantified based on a combination of features represented by polygons within the forest cover and features represented by a line within the GIS. Highway 19 and Beaver Cove Road are the only roads represented by polygons. For the purposes of determining the area of features represented by a line, varying total widths are applied depending on the class:

- Mainlines – 8.0 m
- Railway – 11.0 m
- Spurs – 4.4 m

These widths were determined using LiDAR data and represent the growing space lost to roads within managed stands at rotation age.

Powerlines

Segments of BC Hydro transmission lines supplying power to the north island pass through the FLP area and are kept cleared of trees.

Non-productive Forest

The FLP area includes 10,487 hectares of non-productive forest. These areas are primarily composed of forests situated on poor growing sites and generally do not contribute to timber harvesting.

The non-productive forest area originates from two primary sources:

- Forest cover inventory - These areas are identified based on specific inventory parameters. Mature non-productive stands are defined as those having an inventory volume of less than 200 m^3/ha while immature stands have a site index of less than 5m.
- LiDAR-based process: This process involves the use of various LiDAR-derived data, mainly a crown height model or CHM, to assess the productivity of stands. This identifies non-productive inclusions within forest inventory polygons that are too small to be separately delineated.

Archaeological and Significant Cultural Sites

Archaeological sites registered with the provincial government and other significant cultural sites shared by ‘Na̲mg̲is are protected including through the ‘Na̲mg̲is Conservation Network.

Proposed Conservancy

An outcome of the Gwa’ni modernized land-use planning project is a recommendation to conserve an area at the north end of Nimpkish Lake, surrounding the existing Lower Nimpkish

River Provincial Park.

Riparian Management

The final stream, lake and wetland buffers used to quantify this category are identified in SS 5 – Retention of Riparian Forest – Streams, SS 6 – Retention of Riparian Forest – Wetlands, and SS 7 – Retention of Riparian Forest – Lakes. The estimate is based on a stream network of field-classified streams and projected streams based on accumulation areas to derive the stream inventory. Presence of fish was estimated from field-classified streams and fish-migration barriers developed using elevation, LiDAR stream gradients over 100m sections and breaks (large elevation changes) over 10m sections. Streams below a known fish-bearing lake were assumed to be fish-bearing as well.

Wildlife Habitat Areas

All legally established and proposed Wildlife Habitat Areas (WHAs) are in the ‘Na̲mg̲is Conservation Network. Included in the WHAs are proposed amendments to established WHAs plus new proposed WHAs designed to address the requirements of the November 2021 FPPR Section 7 Marbled Murrelet Notice for both the Upper and Lower Nimpkish Landscape Units (LU), including the Upper Nimpkish LU targets for both the Campbell River and the North Island Central Coast Forest Districts.

Ungulate Winter Range

All legally established Ungulate Winter Ranges from the Ungulate Winter Range (UWR) plan for TFL 37 are included in the ‘Na̲mg̲is Conservation Network. The most recent revisions to the UWR plan were completed in July 2001 and approved by government in September 2001 (U-1-001). The plan identified specific areas of forest where harvesting is reserved to provide cover attributes necessary for the survival of Columbian black-tailed deer and Roosevelt elk.

Recreation

Within the FLP area there are several recreation sites and trails which are essentially included in the ‘Namgis Conservation Network and where located outside, this classification category was quantified using a 10m buffer on each site with the following included in the data set:

Sites	Trails
▪ Atluck Lake	▪ Hoomak Lake
▪ Canyon Lake	▪ Kaipit
▪ Kinman Creek	▪ Kinman Creek (Windsurfer Hookup)
▪ Lower Klaklakama	▪ Klaklakama Lake
▪ Nimpkish Lake	▪ Kokummi Pass
▪ Upper Klaklakama	▪ Rugged Mountain
▪ Woss Lake	▪ Siding 4
	▪ Woss Lookout
	▪ Woss River
	▪ Zeballos Peak

Inoperable

Utilizing the detailed LiDAR data for ground surfaces and canopy heights, forest professionals thoroughly assessed opportunities for timber harvesting and road development. Specifically, non-productive, and low-productive forests, as well as potential areas for future harvesting and road construction, were spatially delineated. Subsequently, appropriate harvesting methods (ground/cable/helicopter) are assigned to these designated areas. This process identifies the physically harvestable areas, with derived polygons and associated roads. Areas assessed as being unsuitable for harvesting are included in this classification category.

Low Sites

Low-productivity sites are currently deemed inoperable due to their limited timber volume, making harvesting economically or practically infeasible. They are identified through either:

- Forest cover inventory - old seral forests with a standing timber volume of less than 300 m^3/ha.
- Operability Assessment - this assessment involves the use of various LiDAR-derived data to enable efficient identification of low-volume stands.

Deciduous-Leading Stands

Over the past 20 years there has been a negligible volume of deciduous species utilized from TFL 37; therefore, these areas are currently excluded from the THLB. However, a small portion of the FLP area has been reforested with red alder which were included in the THLB.

Steep Terrain

This classification category was quantified based on the modelling criteria defined for SS 4 – Acceptable Level of Landslide Risk.

Existing Stand-Level Retention

Existing stand level retention associated with wildlife tree patches (WTP), wildlife tree retention areas (WTRA) and other stand-level retention areas associated with the retention silvicultural system are included.

‘Na̱mg̱is Conservation Network

Western and ‘Na̱mg̱is have developed a multi-value Conservation Network consistent with the Gwa’ni project recommendation. Details of the Conservation Network are identified in SS 1 – ‘Na̱mg̱is Conservation Network Including Reserves for Wildlife, Biodiversity and Carbon.

Karst

The 2004 TFL 37 planning-level karst inventory, that identifies, among other things, the karst vulnerability potential (KVP) of areas within the TFL, was incorporated into the data set. Based on KVP, the features that are likely to exist and best management practices, aspatial netdown reductions were estimated for each karst polygon consistent with SS 18 – Karst Features.

For the FLP model, the area not available for harvesting when all other netdowns had been applied was determined for each karst polygon. If the unavailable area was less than the area that application of the recommended aspatial netdown would result in, an additional netdown was applied to the karst polygon such that the aspatial netdown was achieved. For example, if a 100 ha karst polygon had a recommended netdown of 20%, then at least 20 ha of the karst polygon should be unavailable for harvesting. If all other netdowns only removed 15 ha from the THLB, then an additional 5 ha of THLB area was netted out. If the recommended netdown was equaled or exceeded by the combination of all other netdowns, no additional netdown for karst was applied.

Future Stand-Level Retention

Estimates of future stand-level retention in retention silvicultural system cutblocks and clearcut with reserve cutblocks are quantified based on the retention criteria for the Gwa'ni Special Management Zone and General Management Zone specified in SS 8 - Variable Retention. Given there is no way to predict exactly which cutblocks will be harvested using the retention silvicultural system, the weighted average retention requirements from SS 8 are applied by combination of Gwa'ni zone, landscape unit and biogeoclimatic subzone as listed in Figure 45. These netdowns are not applied to cutblocks harvested since 2000 because this is when application of the retention silvicultural system began. The retention associated with cutblocks from this period was included spatially and excluded from the THLB (refer to Existing Stand-Level Retention).

The netdown percentages were derived based on a review of harvested cutblocks and the incremental area impact of the stand-level retention.

Figure 45: Estimated stand-level retention netdowns by Gwa'ni Zone, landscape Unit and BEC subzone.

Gwa'ni Zone	Landscape Unit	BEC subzone	THLB netdown
SMZ	All	All	10.5%
GMZ	Lower Nimpkish	CWHxm	7.3%
GMZ	Lower Nimpkish	CWHvm	5.5%
GMZ	Lower Nimpkish	MHmm	4.3%
GMZ	Upper Nimpkish	CWHxm	7.5%
GMZ	Upper Nimpkish	CWHmm	7.6%
GMZ	Upper Nimpkish	CWHvm	5.5%
GMZ	Upper Nimpkish	MHmm	4.6%

Appendix D

Comparing the Preferred Scenario to the Base Case

Model Configuration for the Base Case

A base case scenario was completed to enable comparison of the desired future forest condition associated with the Gwa'ni Project, Forest Landscape Plan, and Forest Operations Plan to current practices.

The following changes were made to the preferred scenario model to reflect the base case.

- No netdown for the proposed Lower Nimpkish area for conservation.
- Replaced the 'Na̲mg̲is Conservation Network with the latest reserves for Old Growth Management Areas, Ungulate Winter Ranges, and Wildlife Habitat Areas developed as part of TFL 37 pilot which address the recent Marbled Murrelet Land Use Regulations Order effective December 2021. The establishment of these updated reserves is in progress.
- Maintained the same riparian management area retention except utilized a 40m width on S2 streams and a 30m width on S3 streams.
- Replaced netdowns for harvesting on steep terrain to 95% of class V polygons and maintained the same netdown of 15% on Class IV polygons.
- Replaced netdowns for future stand-level retention to reflect the current implementation of variable retention as summarized in Figure 46. This is associated with the change in existing VILUP zones to the new Gwa'ni General Management Zone and Gwa'ni Special Management Zone and the increased variable retention levels in SS 8.

Figure 46: Netdowns for variable retention by landscape unit and biogeoclimatic ecosystem (BEC) variant.

Landscape Unit	BEC Variant	Netdown (%)
Upper Nimpkish	CHWmm1	7.4% (7.6% in preferred scenario)
Upper Nimpkish	CWHvm1	5.9% (5.5% in preferred scenario)
Upper Nimpkish	CWHvm2	5.6% (5.5% in preferred scenario)
Upper Nimpkish	CHWxm2	7.8% (7.5% in preferred scenario)
Upper Nimpkish	MHmm1	4.6% (4.6% in preferred scenario)
Lower Nimpkish	CHWxm2	5.4% (7.3% in preferred scenario)
Lower Nimpkish	CWHvm1	4.5% (5.5% in preferred scenario)
Lower Nimpkish	CWHvm2	4.6% (5.5% in preferred scenario)
Lower Nimpkish	MHmm1	2.9% (4.3% in preferred scenario)

- Added a 25% mature + old forest requirement in the four VILUP Special Management

Zones.

- Removed the thirty-nine visual polygons added as part of the preferred scenario.
- Applied a 40 ha maximum cutblock size and 3m green-up height to the entire land base. This assumes that cutblocks in the VILUP Special Management Zones are not clearcuts and that cutblocks > 40 ha as permitted within the Enhanced Forestry are not utilized consistent with the current practice.
- No changes were made to growth and yield assumptions.
- Applied a minimum harvest age of 95% culmination mean annual increment to the entire land base.
- Removed deer spring forage considerations.
- Removed road optimization criteria.
- Maintained the same helicopter contribution criteria.

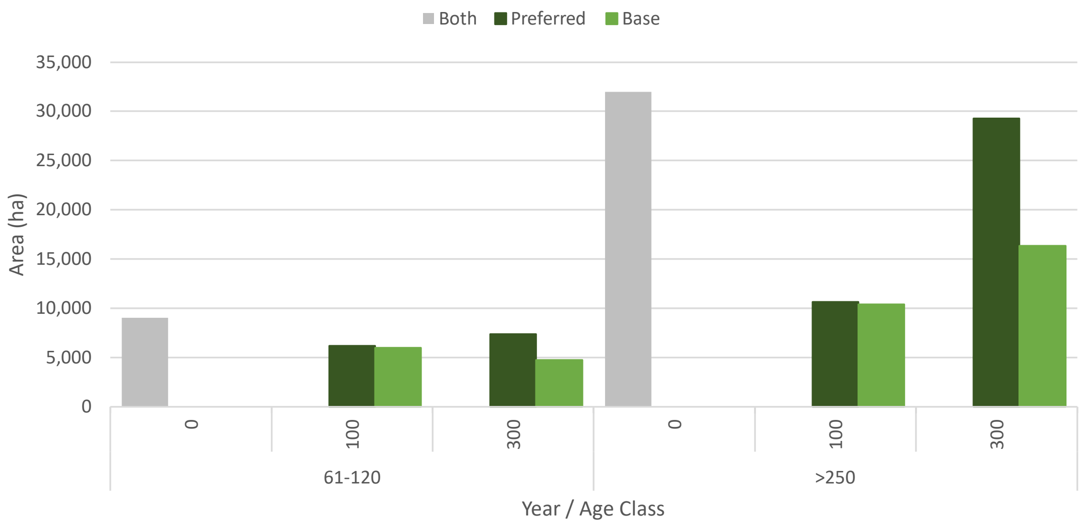
Comparing Future Forest Outcomes for the Base Case and Preferred Scenario

Future forest outcomes were developed for the base case enabling them to be evaluated against the 12 future forest outcomes from the preferred scenario. Each of the future forest outcomes are summarized below.

FF 1 – Western Redcedar and Yellow Cedar

Western redcedar and yellow cedar across the plan area is summarized in Figure 47. Over the 300 years, the preferred scenario results in significantly more area of older seral stands containing western redcedar and yellow cedar and correspondingly more k'wa'x̲tłu, than the base case. Due to the increased conservation of stands with western redcedar and yellow cedar, the preferred scenario does result in less area of stands in the 61-120 age class over the next 300 years as they have grown older than 120 years.

Figure 47: Area of stands[32] containing k'wa'x̲tłu (> 250 years old) and stands containing trees for bark harvest (61-120 years old).



While the 'Na̲mg̲is Conservation Network does not apply to the base case, a comparison is provided in Figure 48 for western redcedar and Figure 49 for yellow cedar to evaluate the difference within the 'Na̲mg̲is Conservation Network.

[32] Stands defined as forest with at least 10% total of western redcedar plus yellow cedar.

Figure 48: Western redcedar trees inside the ‘Namgis Conservation Network.

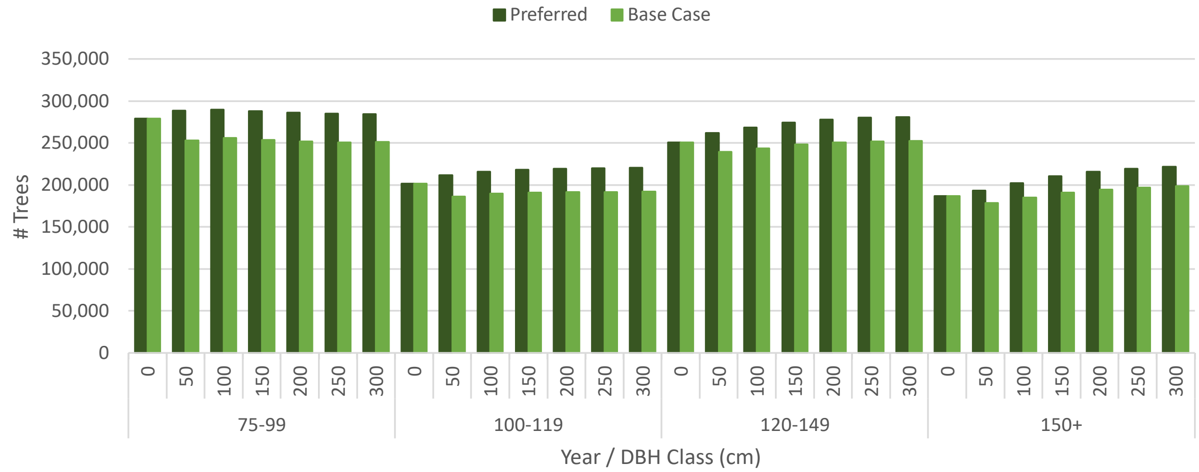
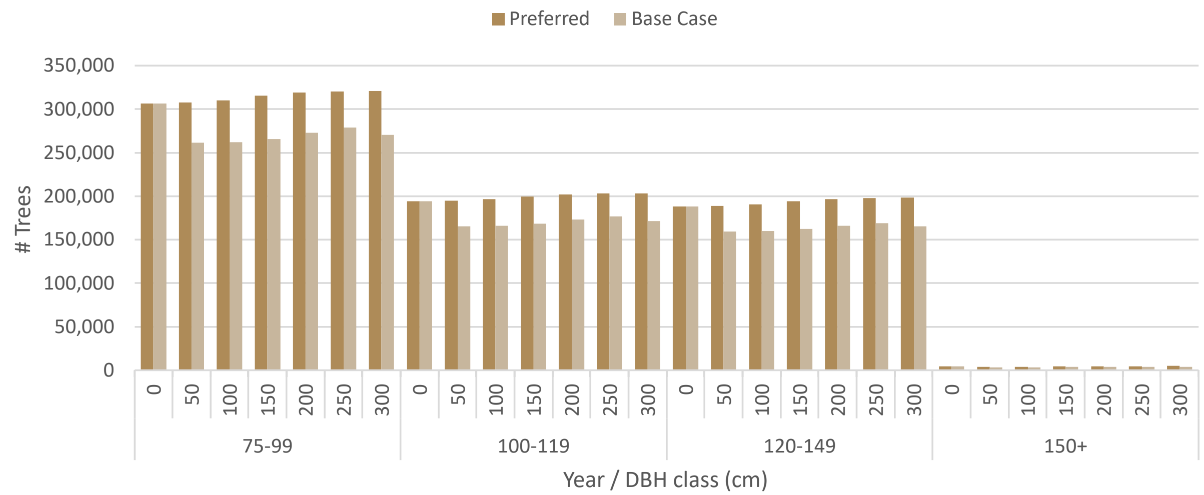


Figure 49: Yellow cedar trees inside the ‘Namgis Conservation Network.



While the ‘Namgis Conservation Network does not apply to the base case, a comparison is provided in Figure 50 for western redcedar and Figure 51 for yellow cedar outside of the ‘Namgis Conservation Network to evaluate the difference for this specific portion of the plan area. The preferred scenario results in more western redcedar and yellow cedar >75cm DBH outside of the ‘Namgis Conservation network due to the increased retention associated with the full suite of stewardship strategies.

Figure 50: Western redcedar trees outside the ʻNa̲mg̲is Conservation Network.

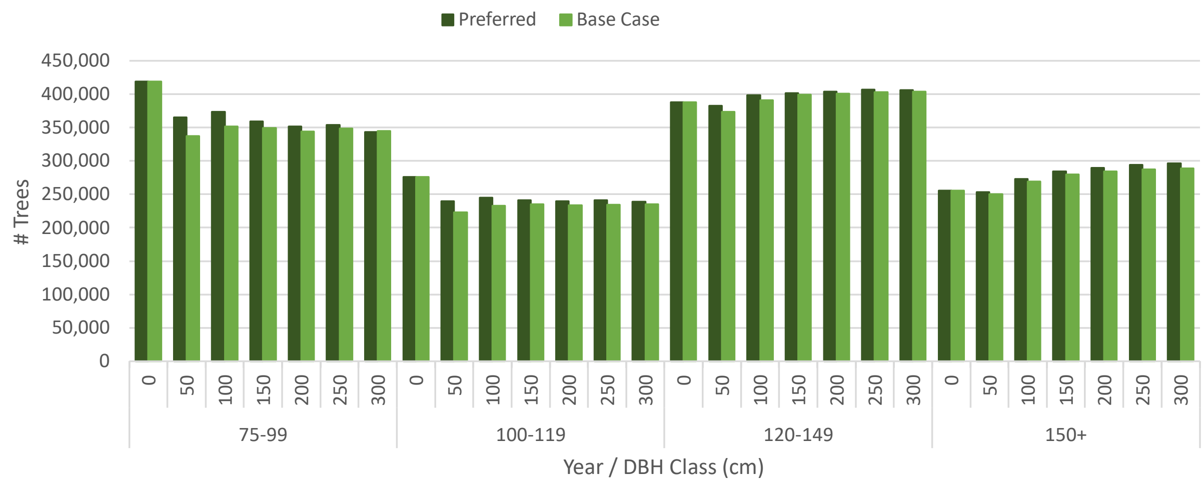
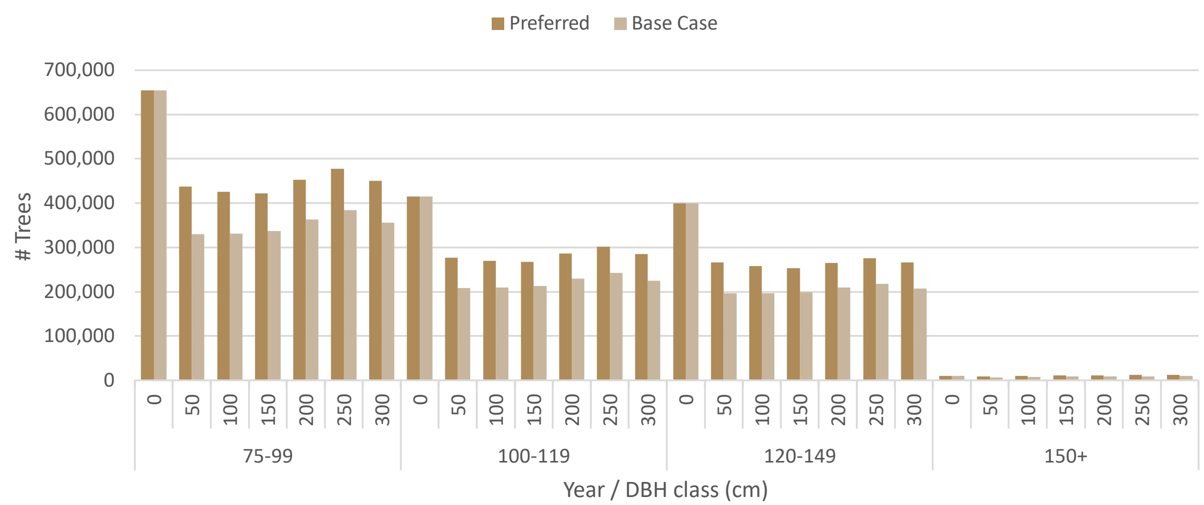


Figure 51: Yellow cedar trees outside the ʻNa̲mg̲is Conservation Network.



A comparison of k'wa'x̲tłu is provided in Figure 52 for western redcedar and Figure 53 for yellow cedar inside the ʻNa̲mg̲is Conservation Network to evaluate the difference for this specific portion of the plan area. The preferred scenario forecasts significantly more k'wa'x̲tłu for both western redcedar and yellow cedar.

Figure 52: Western redcedar k'wa'x̱tłu inside the 'Na̱mg̱is Conservation Network.

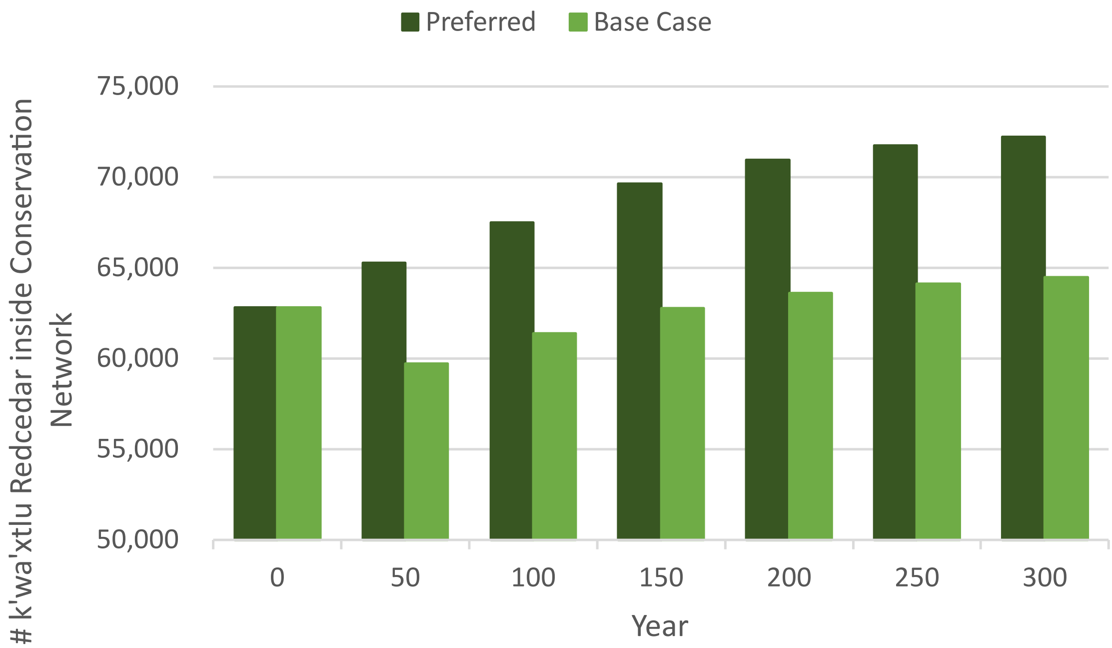
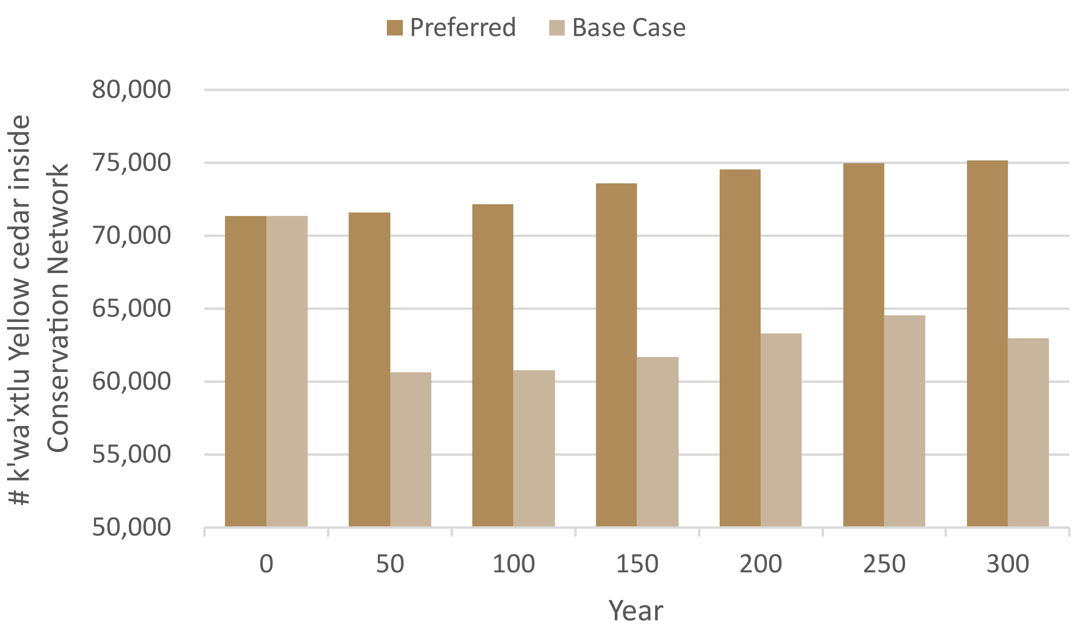


Figure 53: Yellow cedar k'wa'x̱tłu inside the 'Na̱mg̱is Conservation Network.



A comparison of k'wa'x̱tłu is provided in Figure 54 for western redcedar and Figure 55 for yellow cedar outside the 'Na̱mg̱is Conservation Network to evaluate the difference for this specific portion of the plan area. The preferred scenario results in more k'wa'x̱tłu for western redcedar and yellow cedar > 100cm DBH outside of the 'Na̱mg̱is Conservation network due to the increased retention associated with the full suite of stewardship strategies.

Figure 54: Western redcedar k'wa'x̱tłu outside the 'Na̱mg̱is Conservation Network.

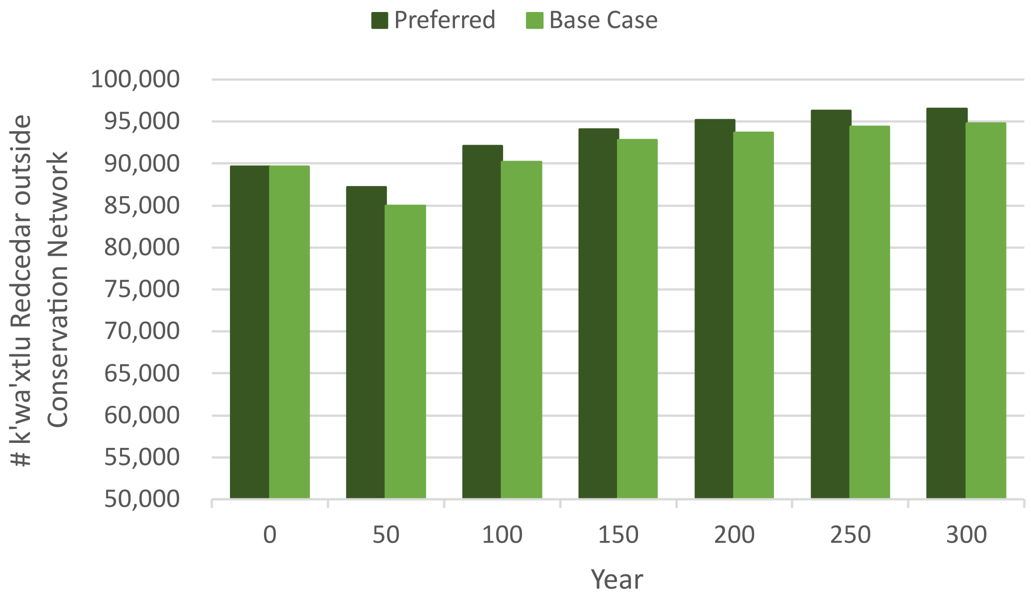
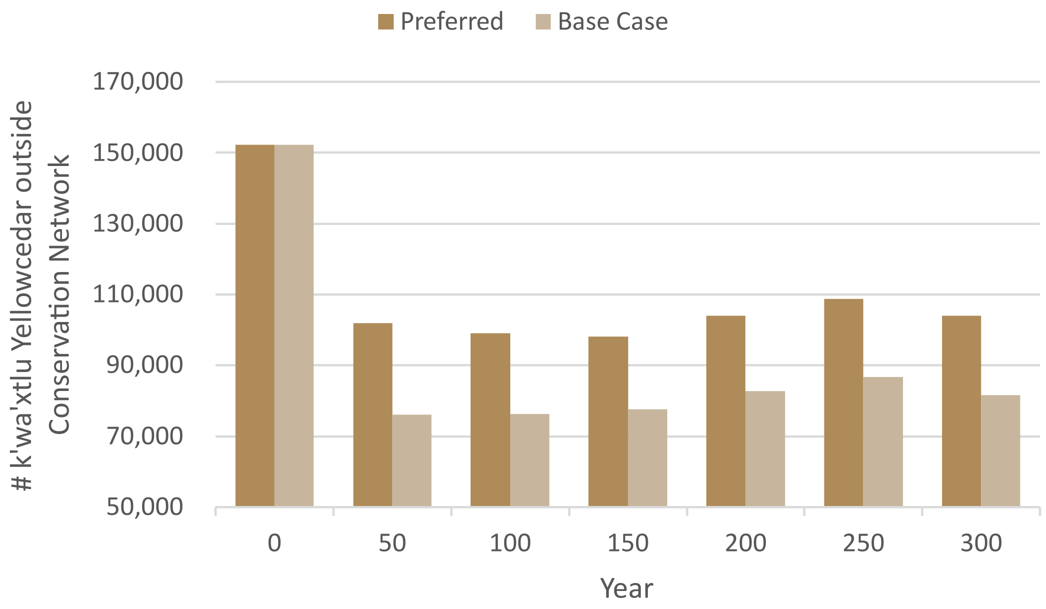


Figure 55: Yellow cedar k'wa'x̱tłu outside the 'Na̱mg̱is Conservation Network.



A comparison of trees suitable for bark harvest is provided in Figure 56 for western redcedar and Figure 57 for yellow cedar inside the 'Na̲mg̲is Conservation Network to evaluate the difference for this specific portion of the plan area. The preferred scenario results in less small western red cedar and yellow cedar <75cm DBH given there is very little harvesting in this area and the existing trees grow into older seral stages. There are however, still significant number of bark-harvest size cedar trees available.

Figure 56: Western red cedar suitable for bark harvest inside the 'Na̲mg̲is Conservation Network.

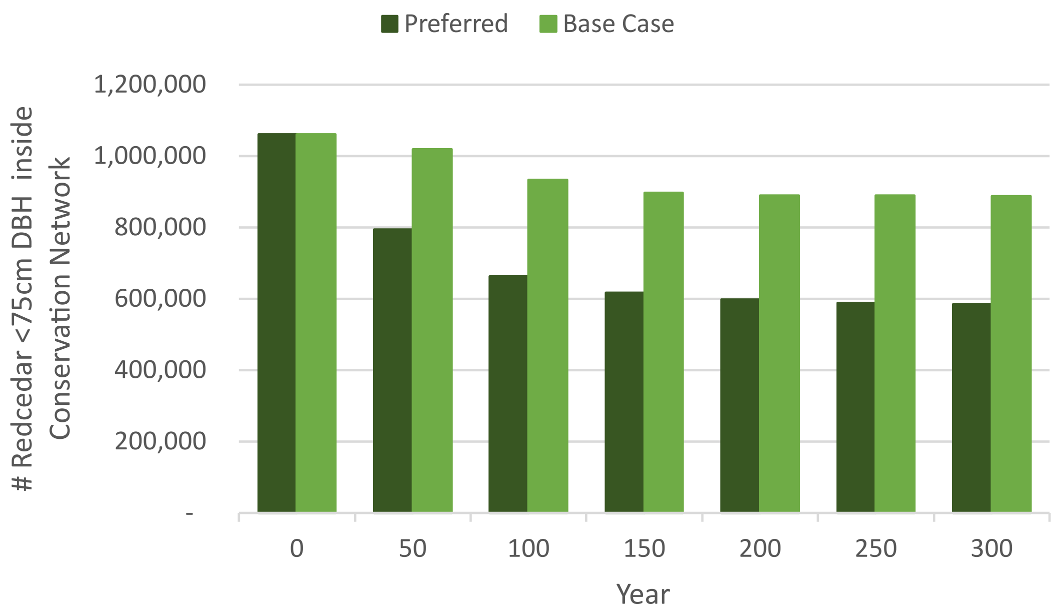
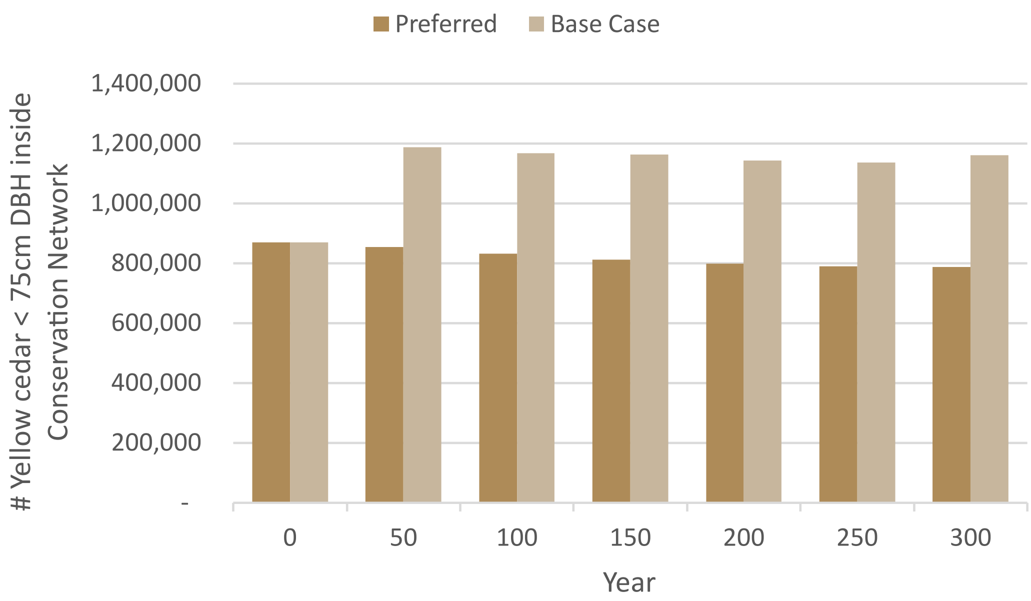


Figure 57: Yellow cedar suitable for bark harvest inside the 'Na̲mg̲is Conservation Network.



A comparison of trees suitable for bark harvest is provided in Figure 58 for western redcedar and Figure 59 for yellow cedar outside the 'Namgis Conservation Network to evaluate the difference for this specific portion of the plan area. The preferred scenario results in less small western red cedar and yellow cedar <75cm DBH due to the increased retention associated with the full suite of stewardship strategies. Overall, the preferred scenario results in significantly more of the larger western redcedar and yellow cedar trees being available for cultural use.

Figure 58: Western red cedar suitable for bark harvest outside the 'Namgis Conservation Network.

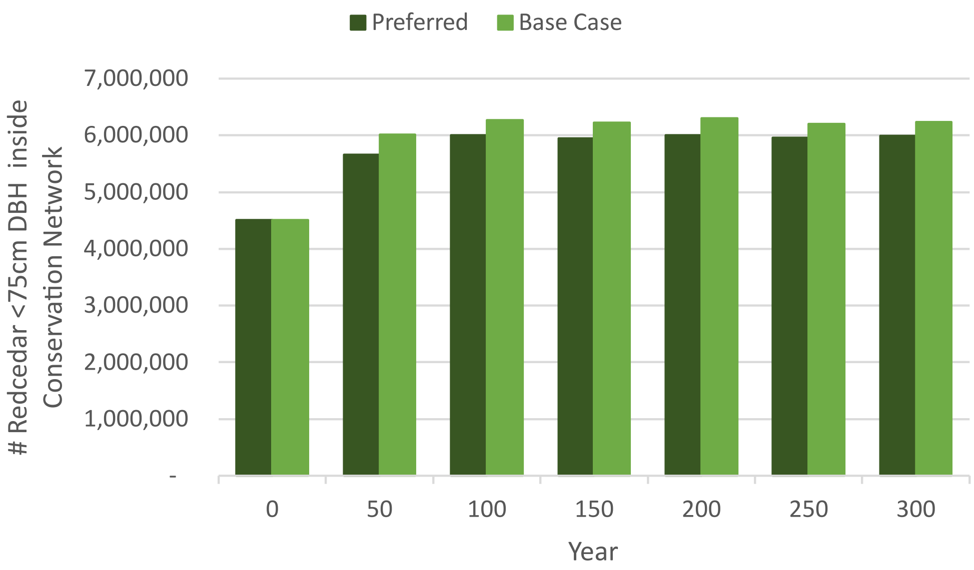
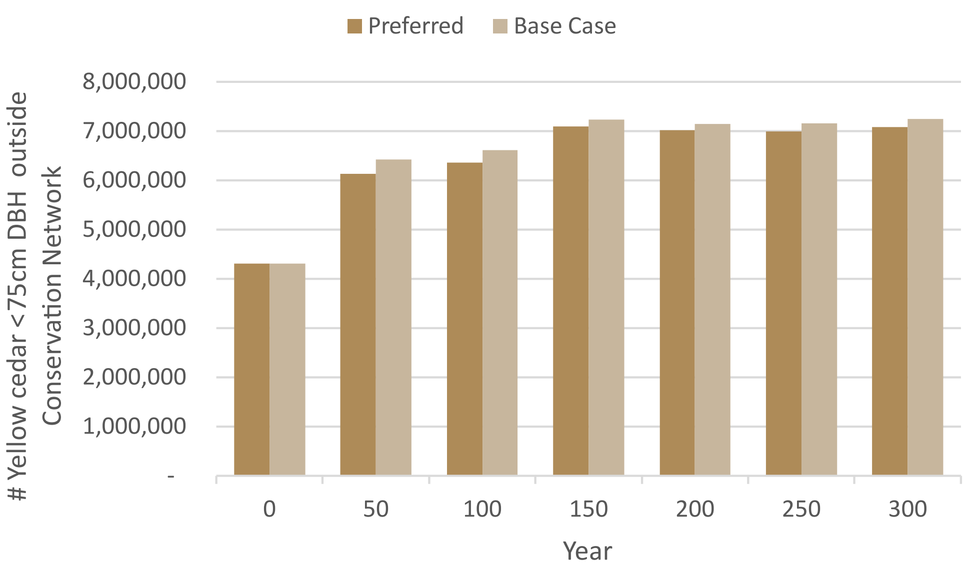


Figure 59: Yellow cedar suitable for bark harvest outside the 'Namgis Conservation Network.



FF 3 – Riparian Function

The proportion of the riparian forest with an age adequate to maintain channel bank stability and large wood inputs is summarized in Figures 60 to 65. Over the 300 years, the preferred scenario results in more riparian forest that is of an adequate size to maintain channel bank stability and large wood inputs due to the increased riparian forest retention. This increased riparian forest retention is harvested under the base case and therefore shows as having less riparian forest of an adequate size. This can overemphasize the degree of change between the base case and preferred scenario given that most large wood inputs come from areas closest to the stream channel.

Figure 60: Forecast of the proportion of riparian forest area with an age adequate to maintain channel bank stability and large wood inputs for the Nimpkish, Davie, Woss, and Sebahall Rivers.

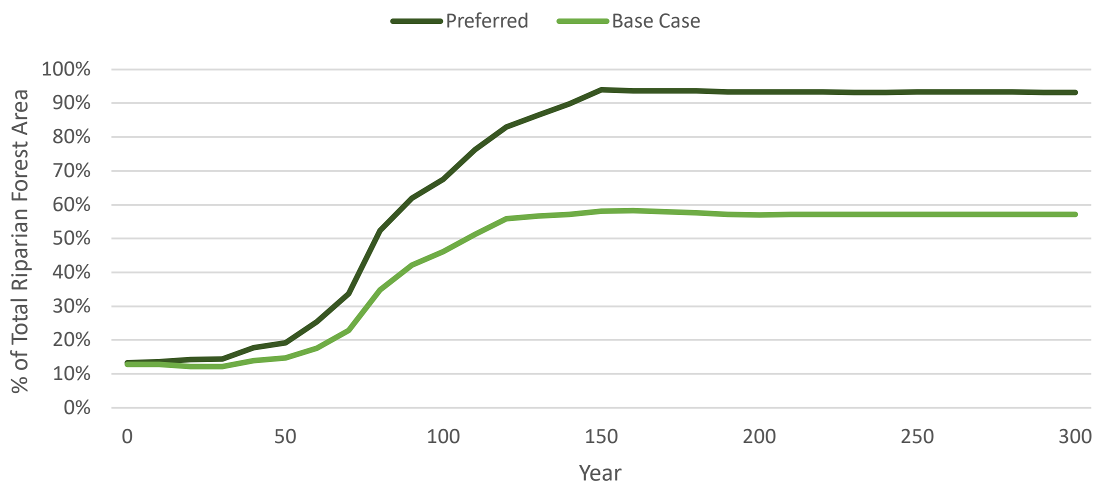


Figure 61: Forecast of the proportion of riparian forest area with an age adequate to maintain channel bank stability and large wood debris inputs for all other S1 streams.

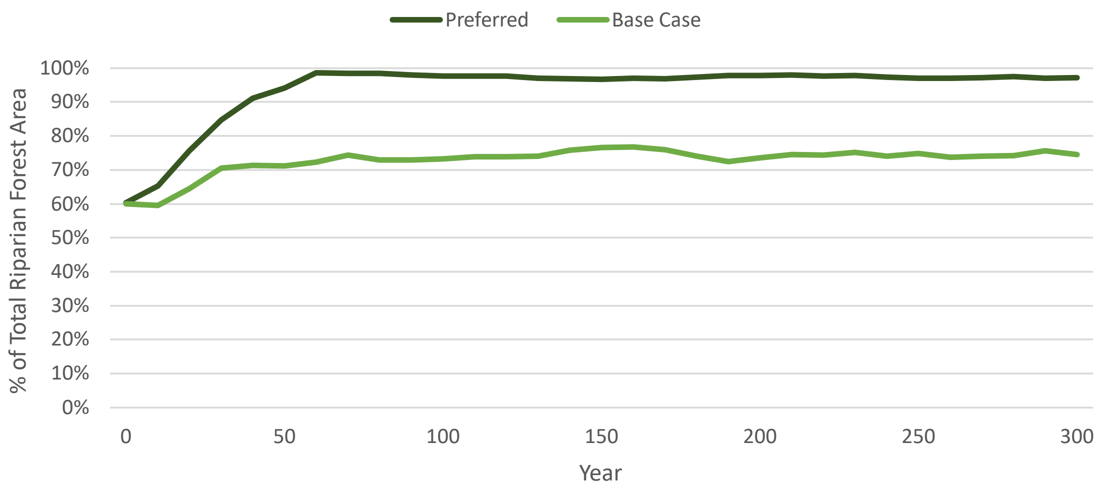


Figure 62: Forecast of the proportion of riparian forest area with an age adequate to maintain channel bank stability for S2 streams.

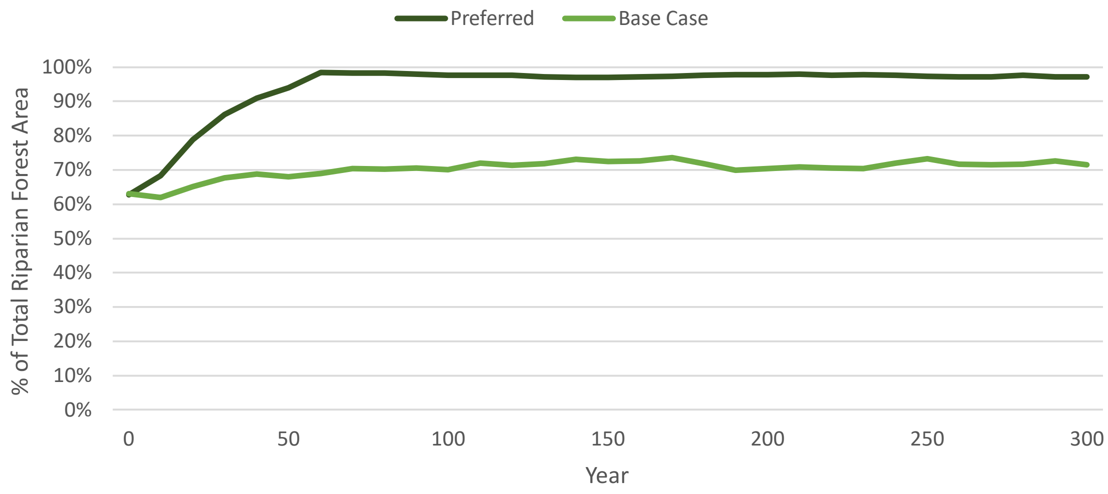


Figure 63: Forecast of the proportion of riparian forest area with an age adequate to maintain functional large wood inputs for S2 streams.

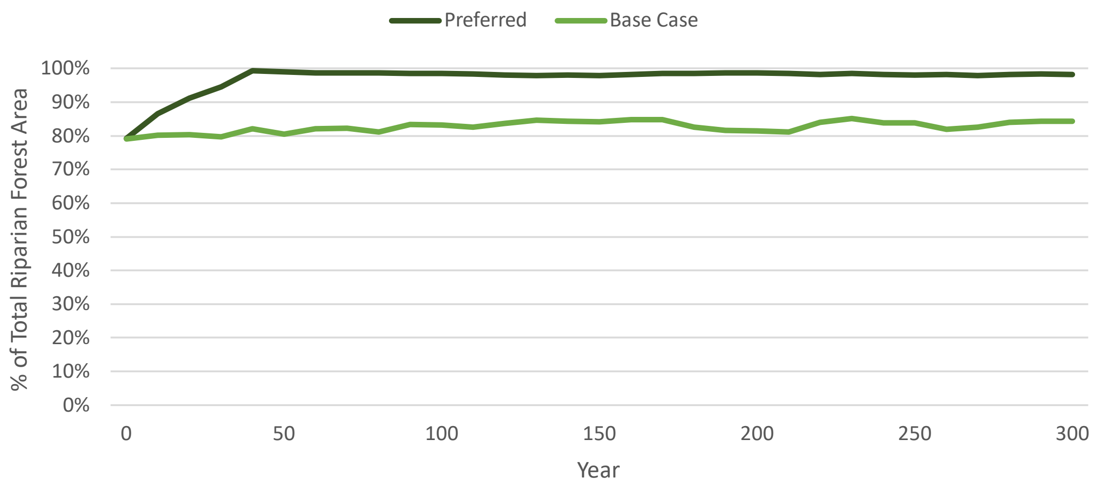


Figure 64: Forecast of the proportion of riparian forest area with an age adequate to maintain channel bank stability for S3 streams.

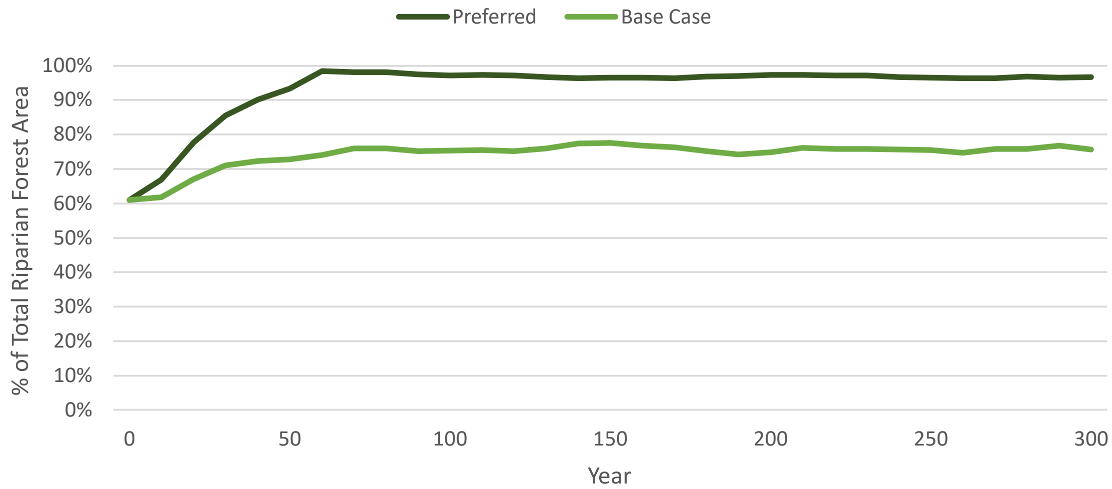
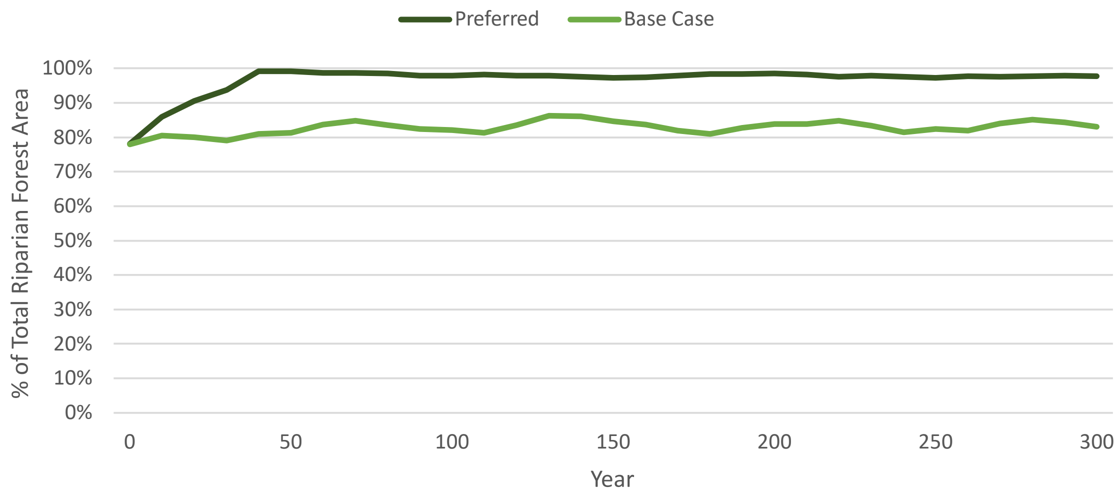


Figure 65: Forecast of the proportion of riparian forest area with an age adequate to maintain functional large wood inputs for S3 streams.



FF 4 – Forest Mosaic in the Gwa'ni Special Management Zone

The age class distribution of the Gwa'ni Special Management Zone is summarized in Figure 66 and the patch size distribution of stands < 21 years old is summarized in Figure 67. The preferred scenario results in significantly less young forest and more mature and old forest within the Gwa'ni Special Management Zone. It also results in the desired outcome of younger forests within the maɫik being in smaller patches and by year 300 the proportion of younger forests in patches > 20 hectares is reduced from 68% to 2% compared the base case at 50%.

Figure 66: Age class distribution within the Gwa'ni Special Management Zone.

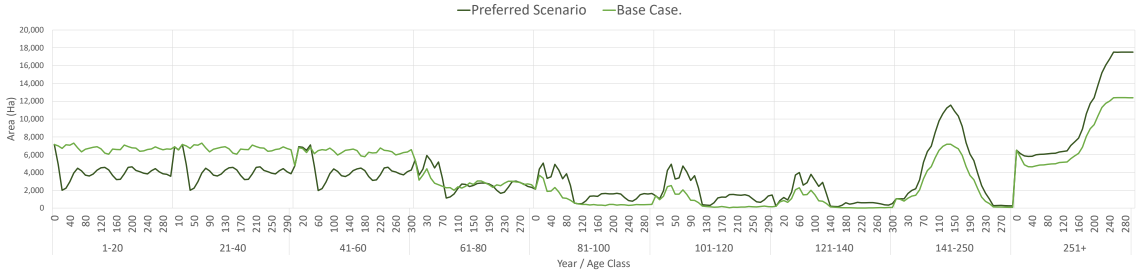
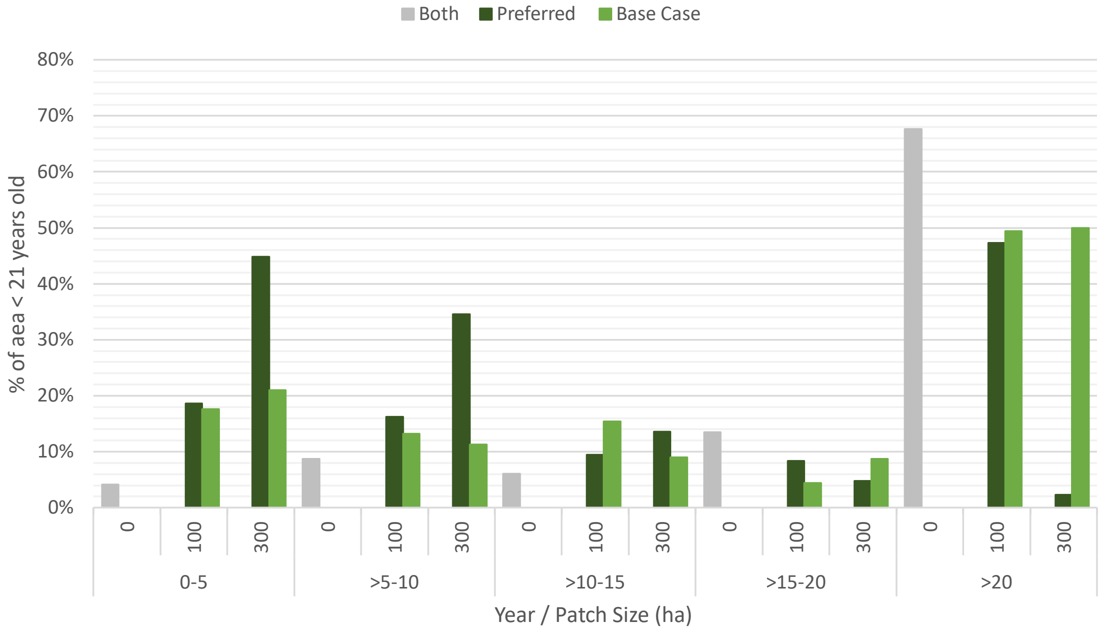


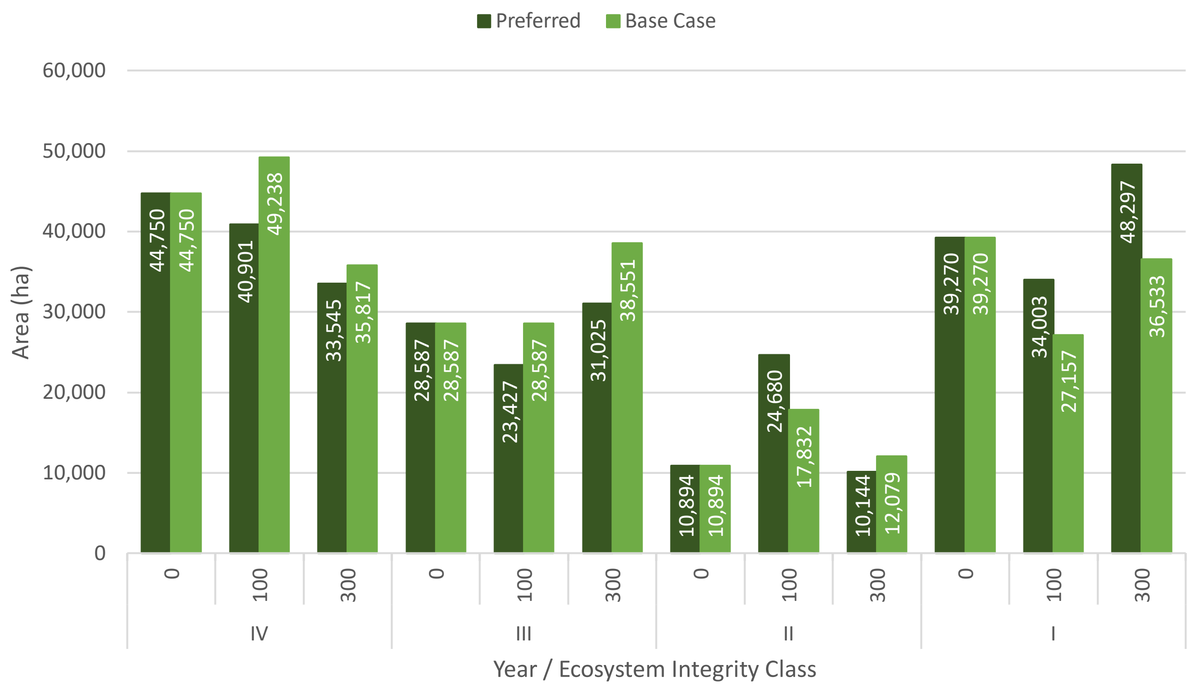
Figure 67: Patch size distribution of stands < 21 years old within maɫik portion of the Gwa'ni Special Management Zone.



FF 5 – Ecosystem Integrity

Ecosystem integrity by ecosystem integrity class is summarized in Figure 68. The preferred scenario results in significantly more area in the higher ecosystem integrity classes of I and II.

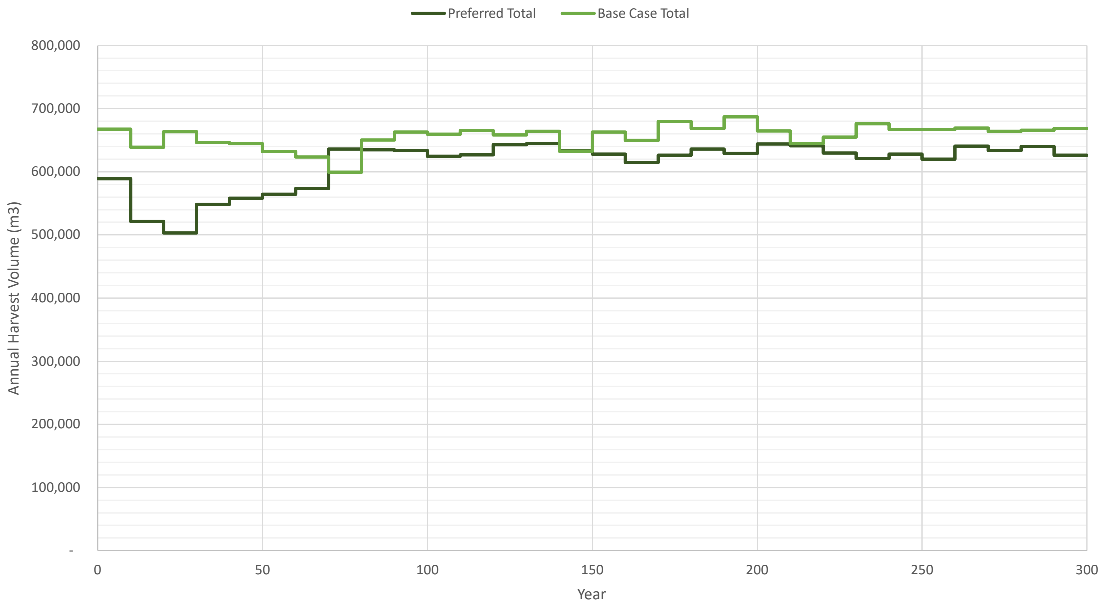
Figure 68: Area of ecosystem integrity classes and subclasses at present and forecast 100 years and 300 years into the future.



FF 6 – Harvest Flow

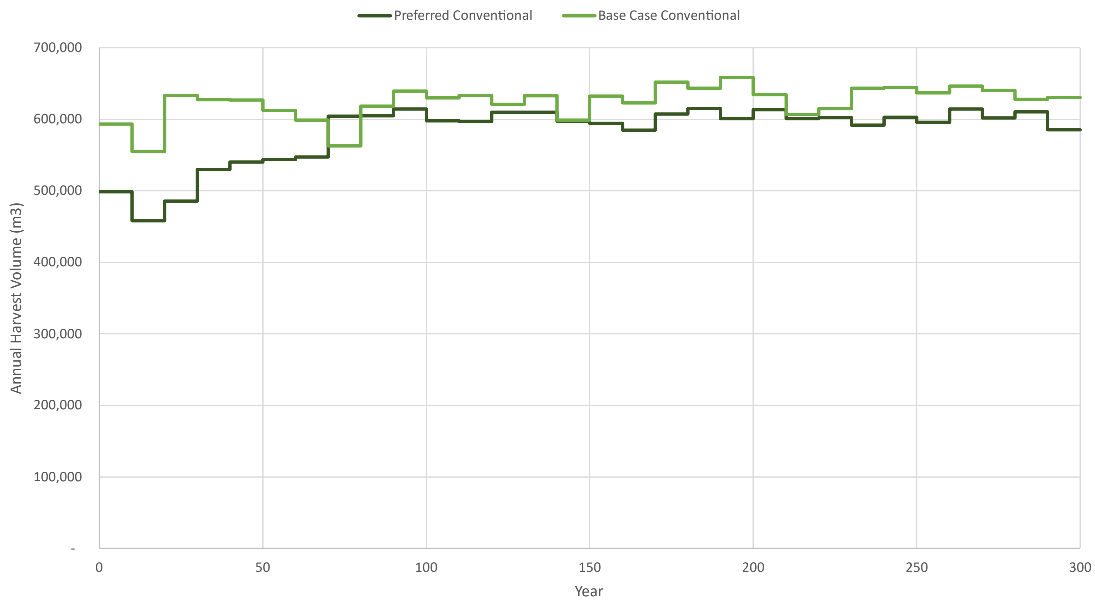
The total harvest flow available for 300 years is summarized in Figure 69. The harvest flow available for the first 10 years is approximately 12% less in the preferred scenario at 588,700 m^3 compared to 667,200 m^3. In the midterm from years 11–70, the available harvest flow averages approximately 16% less at 539,100 m^3 compared to 645,000 m^3. In the long-term from years 71-300, the available harvest flow averages approximately 4% less at 629,500 m^3 compared to 658,500 m^3.

Figure 69: Total harvest flow (m^3) forecast over the next 300 years.



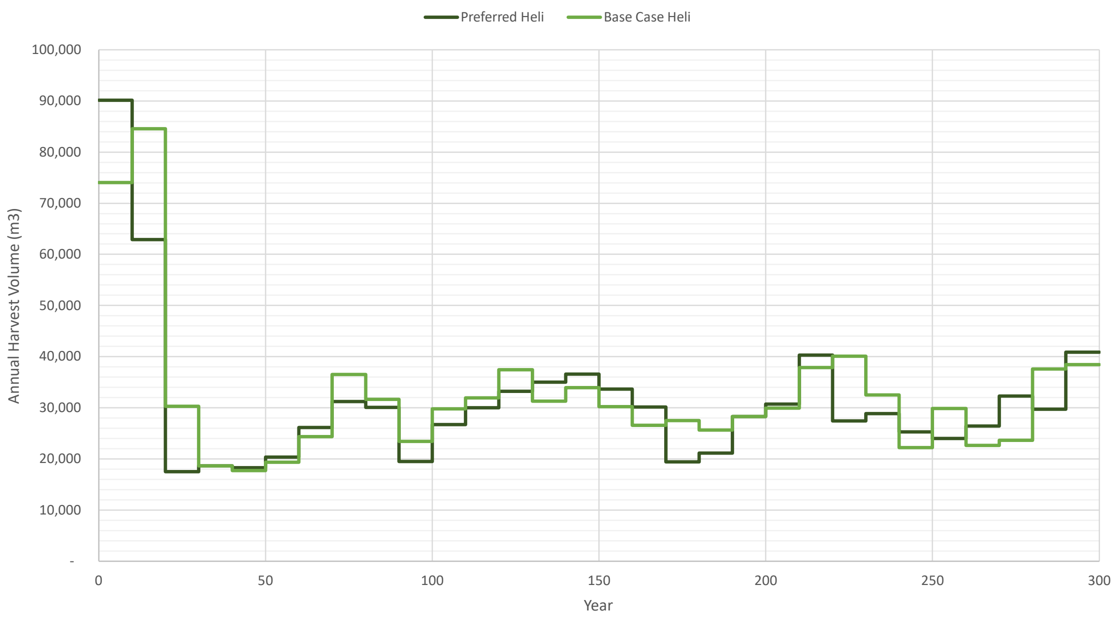
The conventional harvest flow available for 300 years is summarized in Figure 70. The harvest flow available for the first 10 years is approximately 16% less in the preferred scenario at 498,600 m^3 compared to 593,200 m^3. In the midterm from years 11–70, the available harvest flow averages approximately 16% less at 511,500 m^3 compared to 610,900 m^3. In the long-term from years 71-300, the available harvest flow averages approximately 4% less at 600,100 m^3 compared to 627,900 m^3.

Figure 70: Conventional harvest flow (m^3) forecast over the next 300 years.



The helicopter harvest flow available for 300 years is summarized in Figure 71. The harvest flow available for the first 10 years is approximately 22% higher in the preferred scenario at 90,100 m^3 compared to 74,000 m^3. In the midterm from years 11–70, the available harvest flow averages approximately 12% less at 27,500 m3 compared to 34,100 m^3. In the long-term from years 71-300, the available harvest flow averages approximately 4% less at 29,500 m^3 compared to 30,600 m^3.

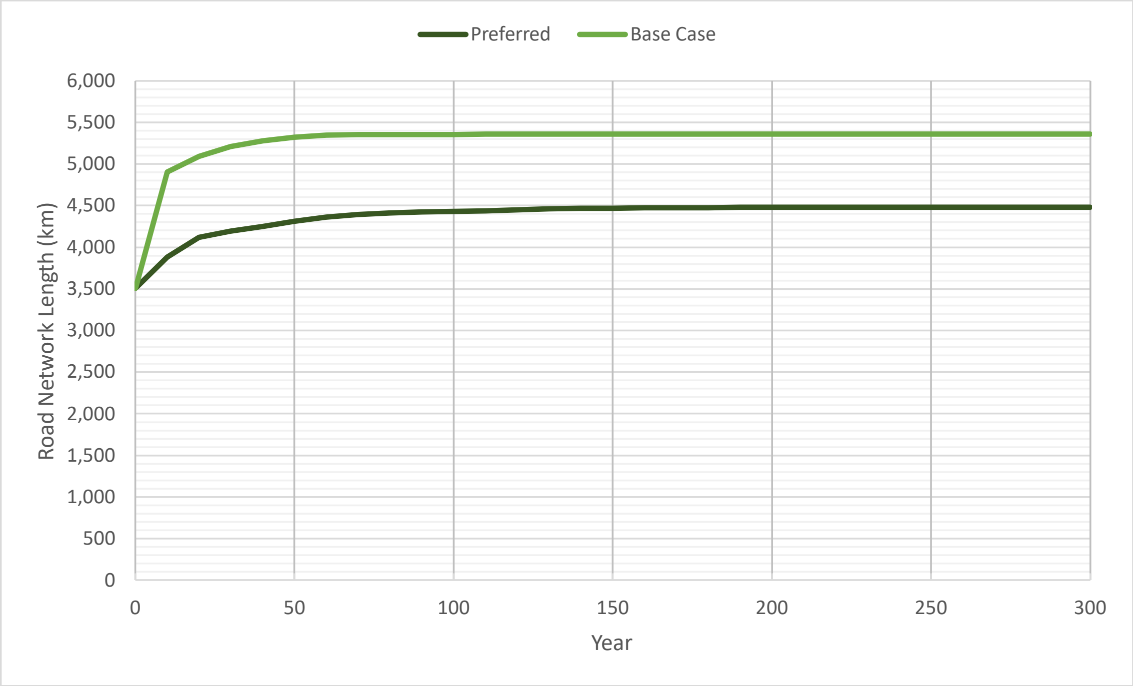
Figure 71: Helicopter harvest flow (m^3) forecast over the next 300 years.



FF 7 – Road Network

The total length of the road network is summarized over the next 300 years is summarized in Figure 72. The preferred scenario reduces the road network by approximately 880 km or 16% at 4,483 km compared to 5,361 km. The reduction in road network is attributed to the lower harvest flow.

Figure 72: Forecast of the road network (km) over the next 300 years.

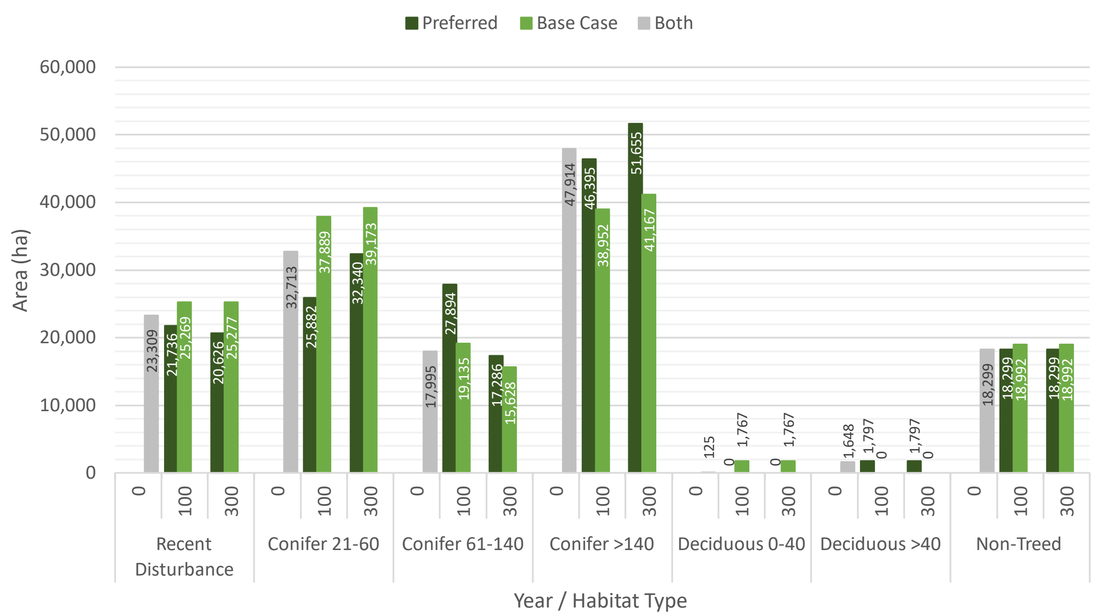


FF 8 – Wildlife Habitat Types

The forecast of wildlife habitat types over the next 300 years is summarized in Figure 73. The wildlife habitat types are the same in the present but over the long-term, the preferred scenario results in approximately 10,000 ha or 25% more Type C3 habitat which is coniferous forest greater than 140 years old and approximately 11,500 ha or 18% less Type C1 habitat which is conifer forest < 61 years old. The wildlife habitat types area:

- Type NT - Non-treed
- Type RD - Recent disturbance: < 20 years old
- Type C1 - Conifer: 21-60 yrs old
- Type C2 - Conifer 61-140 yrs old,
- Type C3 - Conifer > 140 yrs old
- Type H - Deciduous < 40 yrs old, >= 40 yrs old
- Type R - Riparian forest along S1, S2, and S3 streams

Figure 73: Forecast of wildlife habitat types over the next 300 years.



FF 10 – Cultural, Traditional and Recreational Use

The age class distribution of by biogeoclimatic variant are summarized in Figure 74 – 78 at the present and at years 100 and 300 in the future. Every biogeoclimatic ecosystem variant has a greater proportion of forest in stands > 140 years at both 100 and 300 years into the future compared to the base case due to the 'Na̲mg̲is Conservation Network and retention associated with the full suite of stewardship strategies.

Figure 74: Forecast of the diversity of age classes for the CWHxm2 biogeoclimatic ecosystem variant.

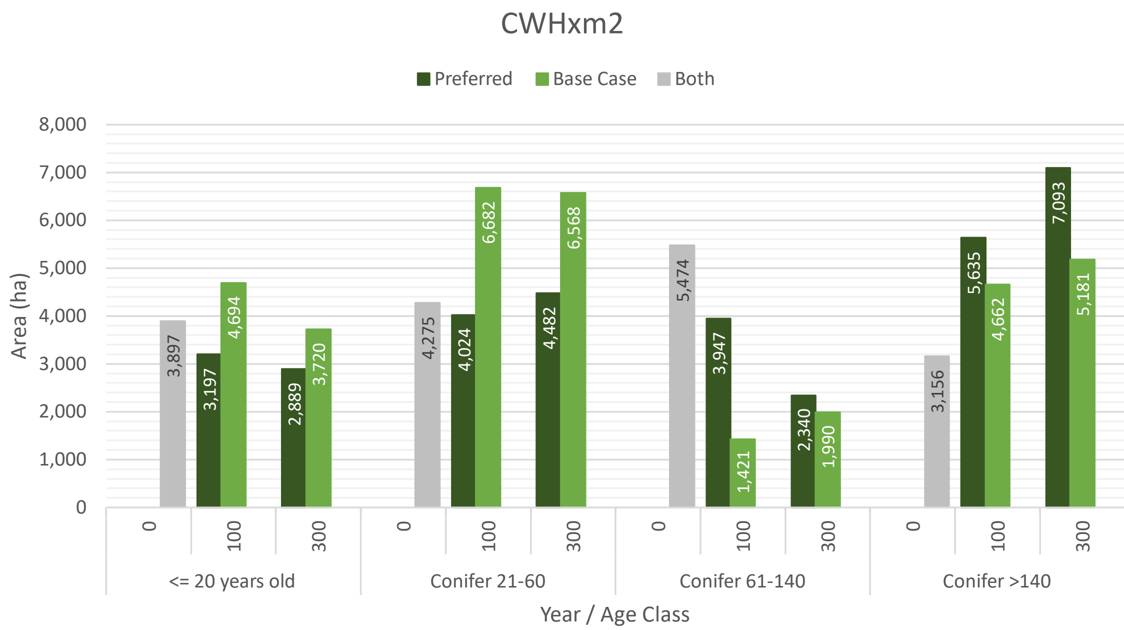


Figure 75: Forecast of the diversity of age classes for the CWHmm1 biogeoclimatic ecosystem variant.

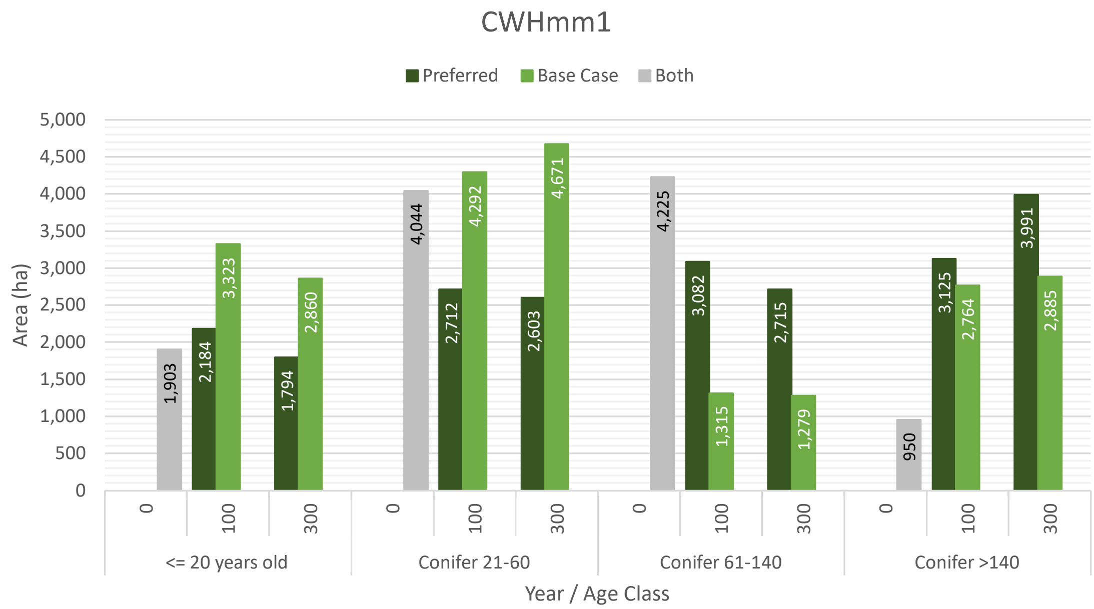


Figure 76: Forecast of the diversity of age classes for the CWHvm1 biogeoclimatic ecosystem variant.

Figure 77: Forecast of the diversity of age classes for the CWHvm2 biogeoclimatic ecosystem variant.

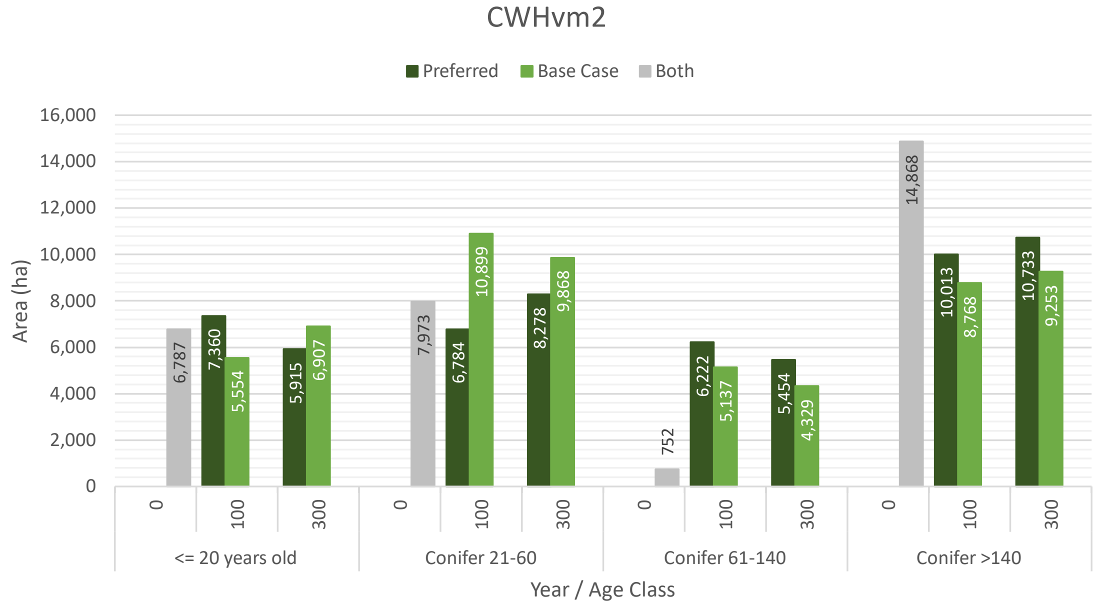
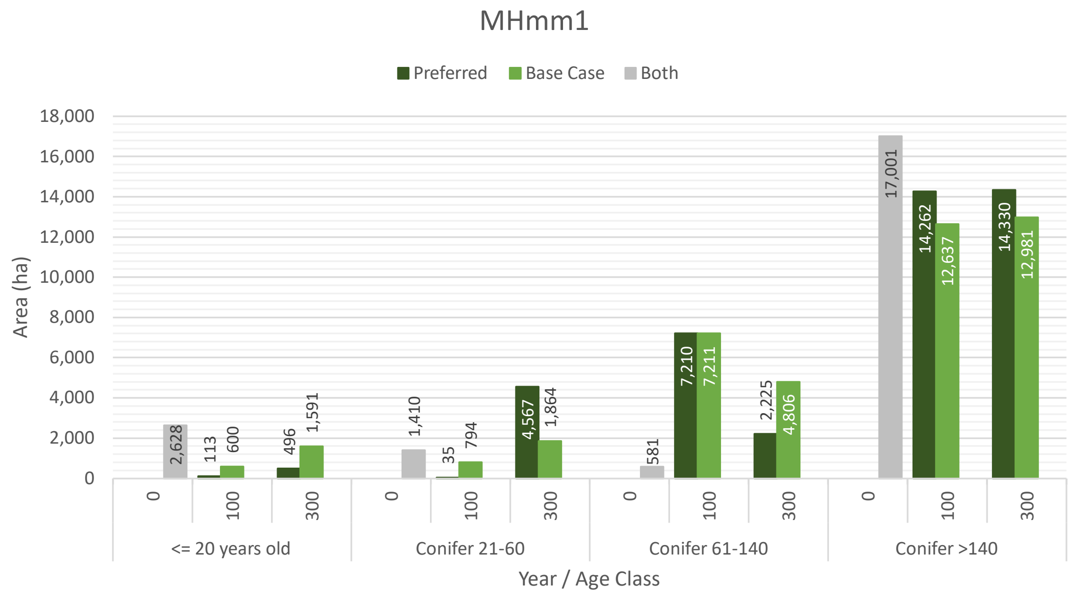


Figure 78: Forecast of the diversity of age classes for the MHmm1 biogeoclimatic ecosystem variant.



FF 11 – Forest Connectivity and Forest Interior Conditions

The forecast of connectivity over the next 300 years is summarized in Figure 79 and Figure 80. The preferred scenario results in significantly more connected forest than the base case and especially in forests older than 140 years. The forecast of forest interior conditions over the next 300 years is summarized in Figure 81 and Figure 82. The preferred scenario results in significantly more forest interior conditions than the base case, especially in forests older than 250 years.

Figure 79: The area (ha) with connected forest at present and forecast at year 100 and 300 by age category.

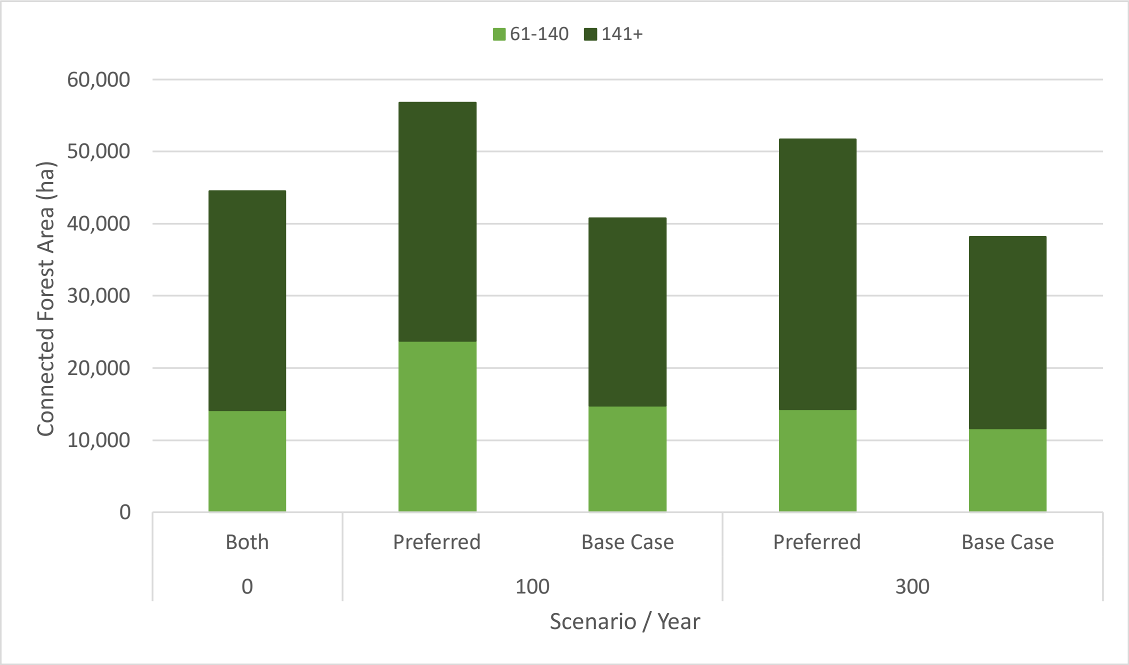


Figure 80: The area (ha) of connected forest at present and forecast at year 100 and 300 by age category.

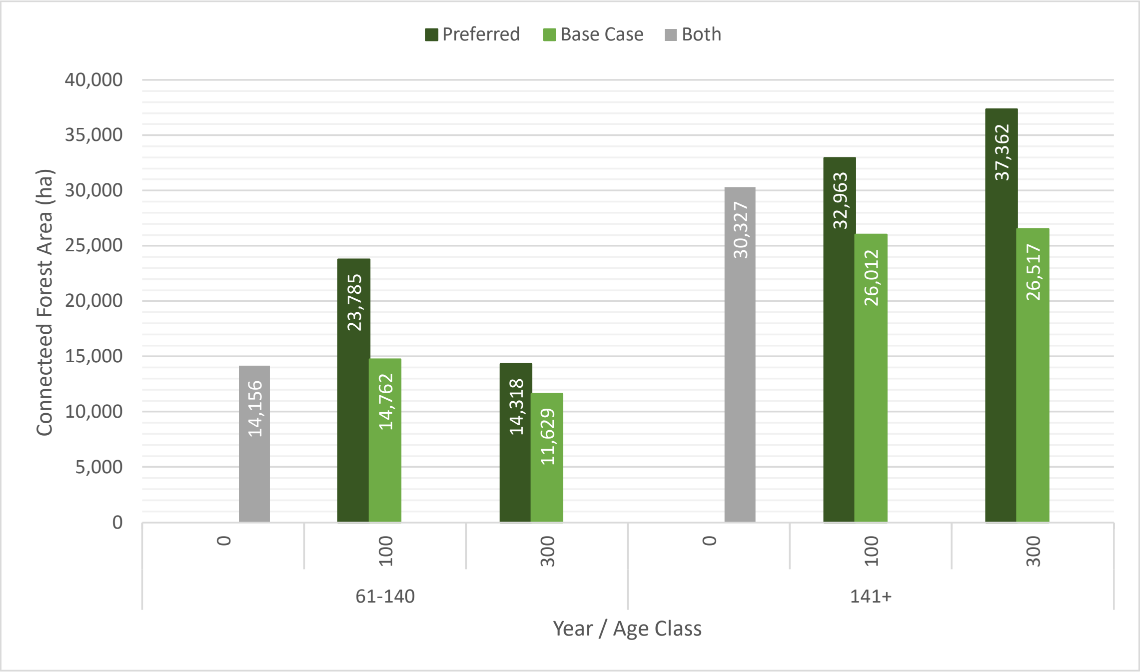


Figure 81: Forecast of the area (ha) with forest interior conditions by age category.

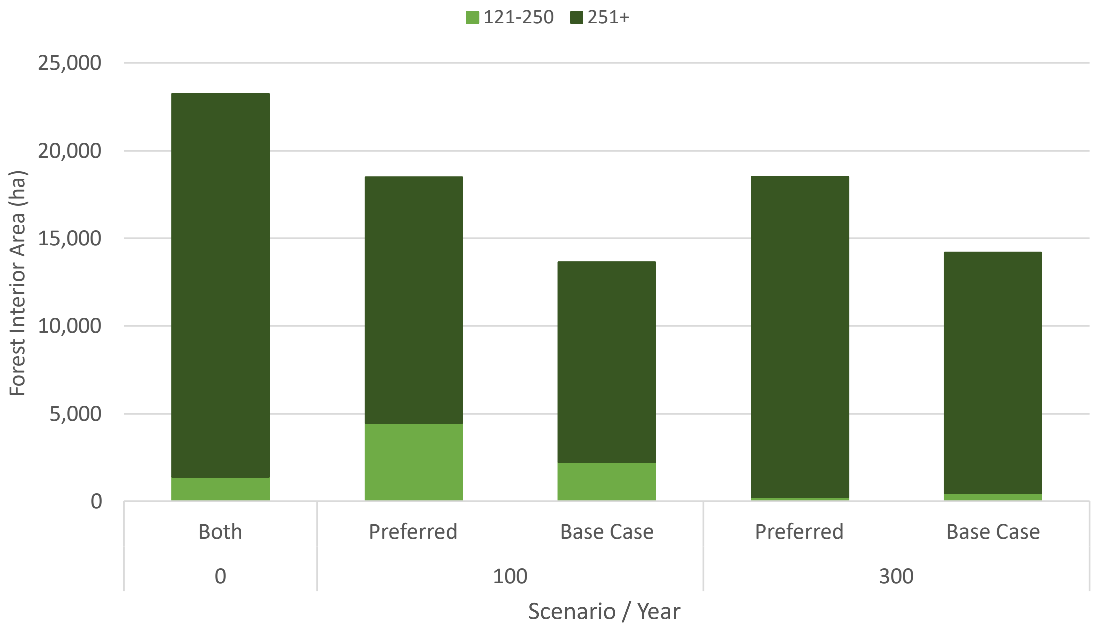
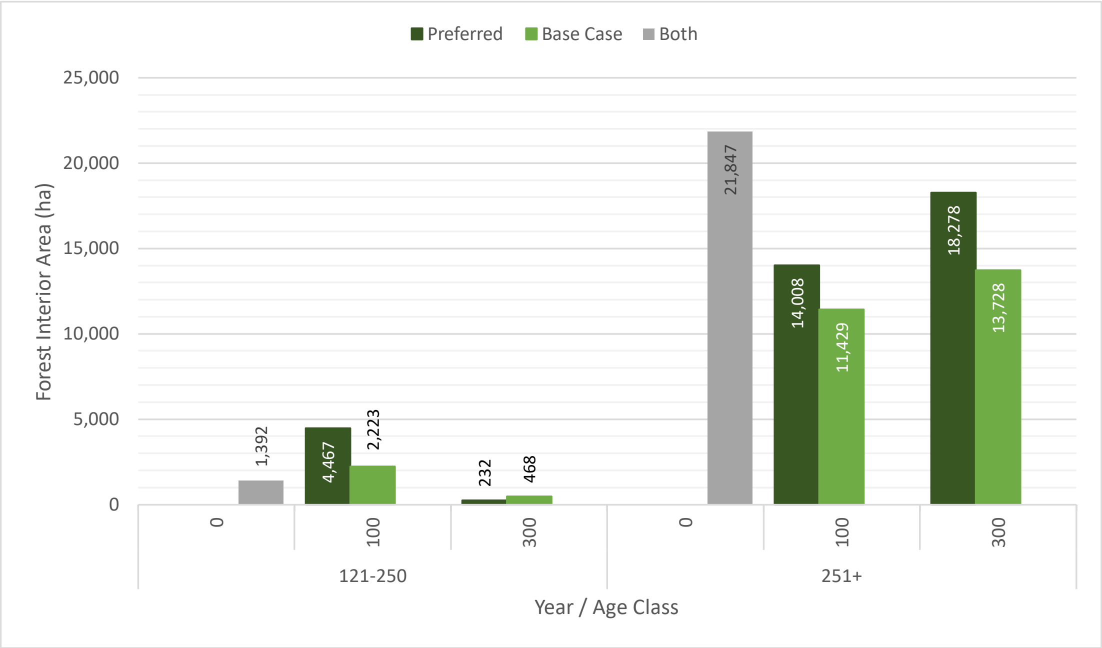


Figure 82: Forecast of the area (ha) with forest interior conditions by age category.



FF 12 – Rare Ecosystems

The forecast of ecosystem integrity of rare ecosystems by biogeoclimatic ecosystem variant over the next 300 years is summarized in Figure 83 to Figure 86. The ecosystem Integrity of rare ecosystems is improved by the preferred scenario across all biogeoclimatic ecosystem variants, especially the dry variants of the CWHxm2 and CWHmm1.

Figure 83: Forecast of ecosystem integrity of rare ecosystems in the CWHxm2.

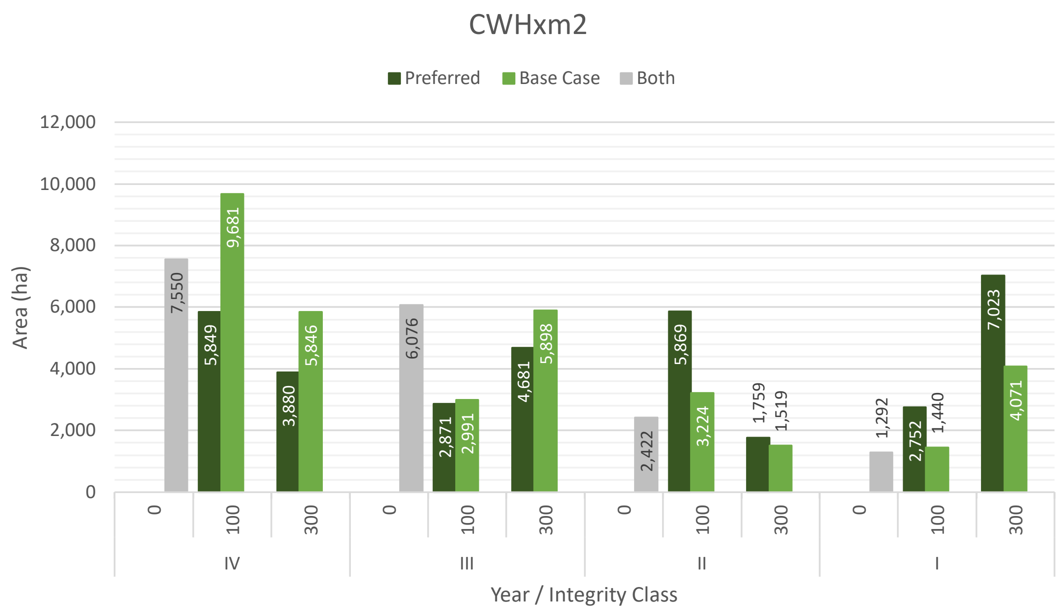


Figure 84: Forecast of ecosystem integrity of rare ecosystems in the CWHmm1.

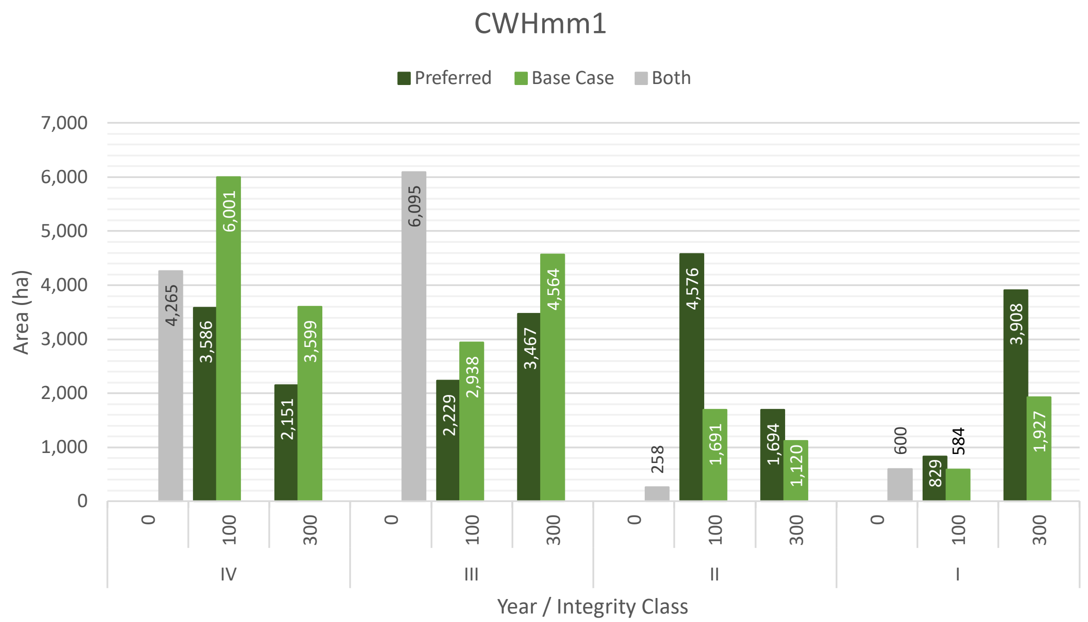


Figure 85: Forecast of ecosystem integrity of rare ecosystems in the CWHvm1.

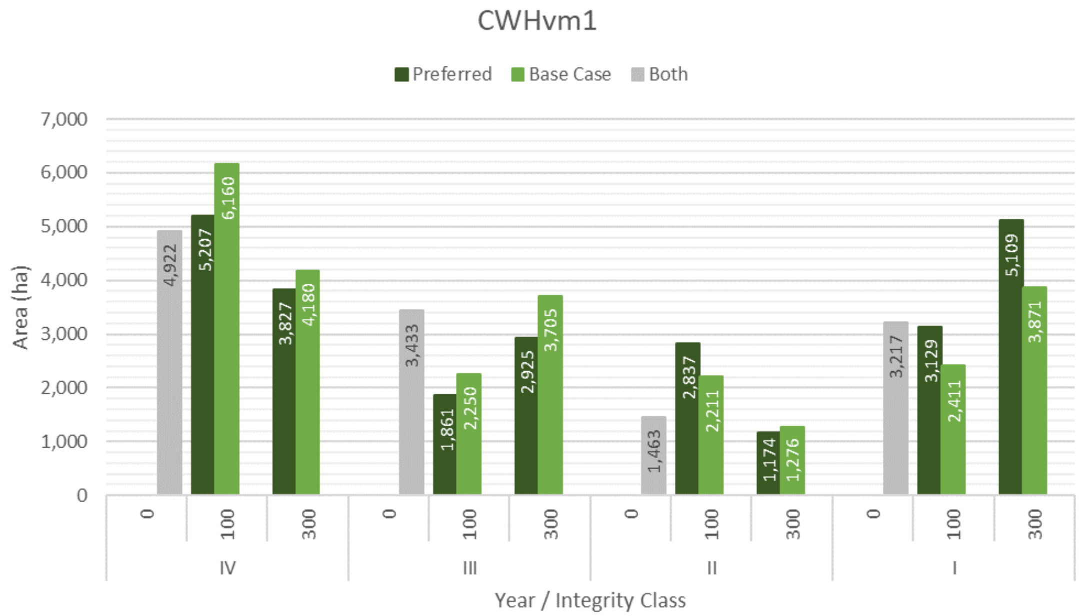
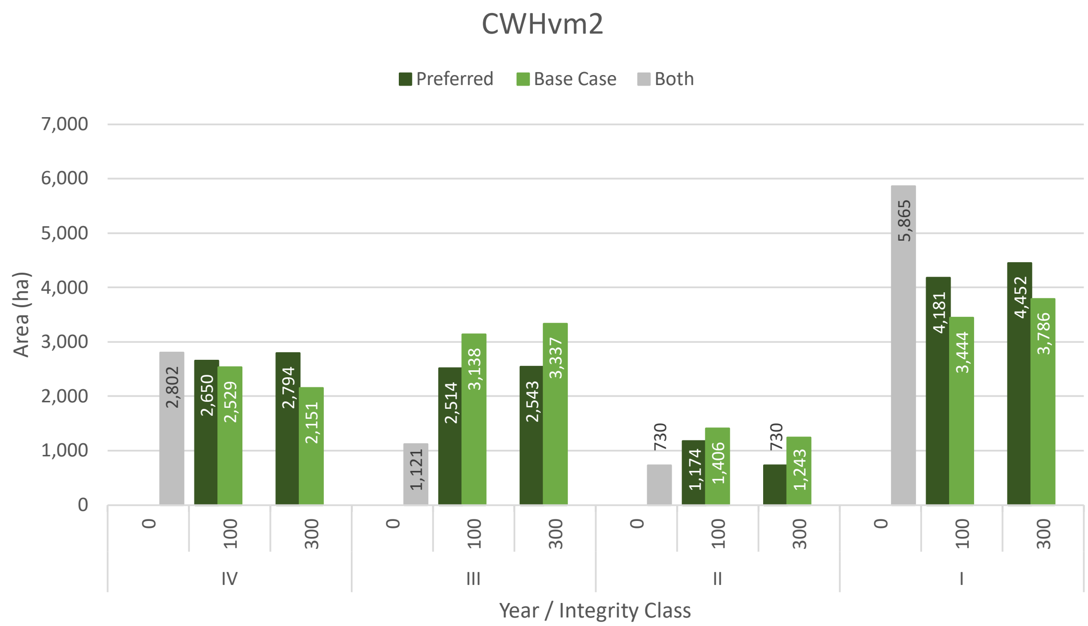


Figure 86: Forecast of ecosystem integrity of rare ecosystems in the CWHvm2.



Appendix E

Engagement Completed During Development of the FLP and FOP

Summary of Engagement

Engagement was completed during development of the TFL 37 pilot in coordination with Gwa'ni Project. While we focused on engagement with local communities, in recognition of the broader interest in the TFL 37 pilot, we also made a concerted effort to honour all requests for updates and learnings to a wide range of interested parties across the province. The draft FLP and FOP were also made available for formal review for 60 days from March 14 to May 13, 2024, with a total of 12 written submissions received.

A summary of engagement completed during development of the FLP and FOP is included in Figure 87. Where the Province is listed in this table, it is with groups external to those directly involved in the preparation of the FLP and FOP. A summary of working sessions and collaborations with the Province in the preparation of the FLP and FOP through the TFL 37 pilot are summarized in Figure 89.

The formal review and comment of the FLP and FOP was completed from March 14 to May 13, 2024. A total of 12 responses were received during the review and comment period and each letter and email was responded to in detail. We appreciate the overwhelming support for the FLP and FOP and insightful recognition of the benefits of connected planning. A summary of clarifications provided, and changes made to the FLP and FOP are in Figure 88.

Figure 87: Summary of engagement completed during development of the FLP and FOP.

Date	Type	Group	Theme
2021-01-12	Province	Forests Practices Board	Introduction to the TFL37 pilot
2021-09-01	Stakeholders and Local Government	Municipalities, Regional District of Mount Waddington, Aʼłi, and Danyas	TFL37 FLP pilot announcement letters
2021-11-10	Province	Provincial FLP Steering Committee	TFL 37 Pilot update
2021-11-15	Stakeholders	Mount Cain (MCAPS)	Letter from MCAPS

2021-11-16	Local Government	Regional District Mount Waddington board and staff	Information session
2022-02-22	Local Government	Regional District Mount Waddington board and staff	Update on FLP Pilot process and Provincial Old Growth Technical Advisory Panel (TAP) deferrals.
2022-03-10	Province	Provincial Monitoring Working Group	Monitoring - observations & pilot learnings to date
2022-04-07	General Interest	Pacific Business & Law Institute	Presentation on, 'Building Together on the Foundation of Relationships'
2022-05-24	Province	Provincial FLP Steering Committee Workshop	TFL 37 pilot update
2022-05-26	Local Government and Stakeholders	Gwa'ni Open House	Presentation on 'Working Together - TFL 37 Forest Landscape Plan Pilot'
2022-06-09	Stakeholders	Nimpkish Woodlands Advisory Committee	Gwa'ni Project update
2022-06-09	Stakeholders	Nimpkish Woodlands Advisory Committee	Presentation on, 'Working Together - TFL 37 Forest Landscape Plan Pilot'
2022-09-28	Province and General Interest	Coast Operational Issues Forum	Presentation on, 'Building & Learning Together' with a progress update
2022-09-28	Province	Provincial Forest Analysis and Inventory Branch	Presentation on, 'Building & Learning Together' - Forest Analysis & Data Management Staff Workshop
2022-10-20	Province	Provincial Forest Analysis and Inventory Branch	Follow-up presentation on, 'Building & Learning Together' - FLP Pilot Project Workshop
2022-11-17	Local Government	Gwa'ni Targeted Stakeholder Focus Group	TFL 37 pilot update
2023-01-24	Province	Minister's Practices Advisory Council	TFL 37 pilot update and presentation on, 'Local, Holistic. Integrated, Insights & Status'
2023-02-10	Stakeholders and General Interest	Forest Professionals BC Conference	Presentation on, 'Embracing the Paradigm Shift'

2023-03-23	Stakeholders	United Steelworkers Union	Gwa'ni update
2023-04-05	Stakeholders	Regional District of Mount Waddington Economic Forum	Na̲mg̲is Forestry Planning
2023-04-24	Stakeholders	Woss Residents Association	Gwa'ni update
2023-06-08	Stakeholders	Public Advisory Group	TFL 37 pilot update
2023-06-28	Province and General Interest	Coast Operational Issues Forum	TFL 37 pilot update
2023-07-18	Province	Forest Practices Board	TFL 37 pilot update
2023-07-25	Province	Forest Practices Board	Top 3 Takeaways To Date
2023-07-26	Province and General Interest	Chief Forester Leadership Team	Ecosystem integrity approach
2023-09-15	Province	Michelle Babchuk, MLA	Letter
2023-09-15	Local Government	Mayor James Furney, Port McNeill	Phone Call w/ email summary
2023-09-15	Local Government	Village of Port McNeill	Letter - TFL 37 pilot update
2023-09-15	Local Government	Regional District of Mount Waddington	Letter - TFL 37 pilot update
2023-09-28	Local Government	Mayor James Furney, Port McNeill	TFL 37 pilot update
2023-10-27	Province	Michelle Babchuk, MLA	TFL 37 pilot update
2023-11-02	Local Government	Port McNeill, Regional District Mount Waddington - Areas C&D	TFL 37 pilot update
2023-11-24	Province	Provincial Ecosystem Health and Biodiversity Initiative	Update on approach utilized in the TFL 37 Forest Landscape Plan Pilot
2023-12-06	Province	Natural Resource Ministries Webinar	TFL 37 pilot update
2024-01-24	Province	Minister’s Forest Practices Advisory Committee	Presentation on, ‘Connected Planning, Insights and Status’

2024-01-25	First Nations	First Nations Forestry Council	TFL 37 pilot update
2024-01-24	Province	Office Chief Forester committee update	Connected Planning, Insights and Status
2024-01-25	General Interest	Al Gorley, RPF	TFL 37 pilot update
2024-01-30	Province	FLP/Gwa'ni 'Deep Dive'	Planning alignment and coordination
2024-02-01	Province	Minster of Forests and Minister of Water, Land, and Resource Stewardship	TFL 37 pilot update
2024-02-08	Stakeholders and General Interest	Forest Professionals BC Conference	Connected Planning
2024-04-11	Province	Provincial Forest Analysis and Inventory Branch	TFL 37 FLP pilot modelling
2024-04-23	Province	OCF Carbon Group, and Provincial Forest Analysis and Inventory Branch	TFL 37 FLP Pilot modelling and documentation
2024-05-30	Province	Coast Operational Issues Forum	Presentation on, 'What does and FLP and FOP look like'.
2024-06-12	Province	Forest Practices Board	Presentation, Tour, and Q&A
2024-06-13	General Interest	Council of Forest Industries	TFL 37 pilot update
2024-07-08	General Interest	Nature Conservancy of Canada	Connected planning and biodiversity and ecosystem health
2024-09-08	General Interest	Indigenous Forestry Conference	Connected planning

Figure 88: Summary of comments received during the formal review and comment of the FLP and FOP.

Feedback Received	How Item was Addressed
Interest in the crossing of schoolhouse creek to access Block 184.	A note has been added to Block 184 file on whether to utilize the rail grade or establish a new crossing.
Interest in access and management of wells, water tower and waterlines for the Woss community water system.	Clarified that the access and management of the Woss water system are outside the scope of FLP and FOP however, a note has been added to the Block files for 201, 210, 189, and 191 noting the interest in the water table in this area.
Interest in the Woss airstrip.	Clarified that the airstrip us outside of the scope of the FLP and FOP and that the Regional District of Mount Waddington’s North Island Regional Emergency plan indicates that the Woss airstrip is not maintained and that air access to Woss is provided by a Transport Canada approved and licensed helicopter pad.
Interest in the Woss trail system.	Clarified that the legislated requirements for building and maintaining trails will not change with establishment of the FLP and approval of the FOP.
Interest in exploring options for establishing a regional park.	Clarified that establishing a regional park is outside the scope of the FLP and FOP however the Gwa’ni Project has advanced two new areas.
Identified that the Woss gun range is in the ‘Na̱mg̱is Conservation Network	Gun range has been removed from the ‘Na̱mg̱is Conservation Network.
Question on what guided the identification of rare ecosystems in FF 12.	Clarified that they are based on the BC Conservation Data Centre as well as those uncommon on Western’s tenures and that the listing is for the late seral plant community only.
Noted that CWH mm2 is not in the Stocking Standards.	Clarified that the CWH mm2 is in the stocking standards.
Interest in continued reforestation with amabalis fir.	Clarified that amabalis fir is an acceptable species for reforestation and is in the stocking standard for the FOP, but there is recognition of wooly adelgid risk and climate change projections indicating a reduced range in drier ecosystems
SS 1 - Interest in whether bats are included in the ‘Na̱mg̱is Conservation Network.	Noted that there are two Wildlife Habitat Areas for bats in TFL 37.

SS 4 to SS 7 – Interest in whether work of previous specialist has been incorporated in the plans.	Noted that a comprehensive review of reports was completed, and the subject matter experts who directly contributed are noted in the acknowledgement section.
SS 4 - Question on Oktwanch-Alston watershed being in two different sections of table.	Clarified in an email subsequent to the original response that the watershed is listed in two sections of the table as the acceptable level of landslide risk is in relation to two different planning features.
SS 5 – Interest in classification of S4 streams.	Clarified that a high-level of importance was placed on stream management and retention along small fish streams is based on unique site-specific factors.
SS 8 Interest in the use of retention silvicultural systems and rare and unique trees.	Noted that variable retention provides the opportunity to capture a wide range of biological anchors and the list in SS 8 is not intended to be exhaustive.
SS – 9 – Interest in Douglas-fir, stream flows, and commercial thinning.	Noted that commercial thinning is being considered in the future where it can be linked to a specific objective and economically achieved. There is a provincial working group focused on enabling the increased use of commercial thinning.
SS 12 - Recommendation that Sitka spruce be included as a managed species with alder.	SS 12 was updated to include the practice of retaining red alder that are located in the vicinity of Sitka spruce trees during brushing treatments.
SS 15 - Question on scotch broom not included in the stewardship strategy.	Clarified that scotch broom is included in SS 15.
SS 18 – Interest in karst features in second growth.	Clarified that the ‘Na̲mg̱is Conservation Network contains a significant amount of karst terrain and karst features are also managed at the site level as defined in SS 18.
SS 20 – Interest in the long-term presence of bear dens.	Clarified that FF 8 demonstrates a range of habitat types into the future including old conifer stands. SS 20 also includes the identification and retention of bear dens.
FF 3 – Interest in stream stabilization and that not all streams were historically stable.	Clarified that the intent of FF 3 is to restore riparian forests to an age where they are generally large enough to support channel bank stability and large wood inputs. It is recognized that not all rivers are naturally stable.
FF 6 and FF 7 – Interest in healthy communities and economic impact over the short term.	Explained that the connected approach to plan is expected to bring increased predictability and that the Province is concurrently completing a SEEA.

FF 12 (new) - Question on the ecosystem integrity subclasses referenced.	FF 12 was simplified to remove the complexity of subclasses.
FF 12 (old) Interest in other information being considered regarding climate change.	Clarified that the climate change projections were supported by the Future Forest Ecosystems Centre, BC MoF and there is recognized uncertainty in how the climate will change and the impact on ecosystems. This stewardship strategy has subsequently been removed from the plan and climate change is now addressed in a detailed way as part of each future forest outcome and stewardship strategy.
A total of 17 block specific comments	Each has been added to the individual block files.

Figure 89: A summary of working sessions and collaborations with Provincial staff directly involved in the development of the FLP and FOP under the TFL 37 pilot.

Date	Group	Theme
2022-03-10	Office Chief Forester	Adaptive management and monitoring
2022-04-13	Office Chief Forester	Progress update on activities
2022-05-31	Office Chief Forester	Progress update and learnings - connectedness
2022-08-08	Office Chief Forester	Update on learnings to date
2022-08-09	Office Chief Forester	Working session on learnings to date and opportunities
2022-08-10	Office Chief Forester	Update and strategic versus tactical planning, timber supply, and aquatic ecosystems.
2022-12-01	Office Chief Forester	Working Session on FLP principles and approaches – connectedness, future forest condition, building up from values etc.
2022-12-12	Office Chief Forester	Update presentation, scenario alignment, and discussion
2023-03-09	Office Chief Forester	Working session on Bill 23 and adaptive management
2023-04-05	Office Chief Forester	Working Session on documenting the plans
2023-04-14	Gwa'ni Project Steering Committee	Gwa'ni Project Steering Committee update and maintaining Gwa’ni and FLP integrations

2023-05-31	Office Chief Forester	Working session on plan documentation
2023-06-06	Office Chief Forester	Working session on plan documentation
2023-06-22	Office Chief Forester	Working session on plan documentation
2023-06-29	Office Chief Forester	Working session on engagement
2023-07-20	Office Chief Forester	Working session on future forest outcomes associated with the desired future forest condition and associated maps
2023-09-14	Office Chief Forester	Working Session on engagement
2023-09-15	Office Chief Forester	Chief Forester update
2023-10-12	FLP Pilot and Gwa'ni Coordination Working Group	Working session on MLUP/FLP integrations and next steps
2023-10-16	Office Chief Forester	Working Session on plan documentation
2023-11-21	FLP Pilot and Gwa'ni Coordination Working Group	Working session on MLUP/FLP integrations and next steps
2023-11-27	Office Chief Forester	Working Session on plan documentation
2023-12-15	FLP Pilot and Gwa'ni Coordination Working Group	Working session on MLUP/FLP integrations and next steps
2024-01-30	FLP Pilot and Gwa'ni Coordination Working Group	Working session on MLUP/FLP integrations and next steps
2024-02-27	Office Chief Forester	Draft FLP and FOP documents
2024-03-07	Office Chief Forester	Working session on documentation
2024-04-11	Office Chief Forester and Forest Analysis and Inventory Branch	FLP, FOP, and SEEA modelling
2024-04-23	Office Chief Forester, Forest Analysis and Inventory Branch, Carbon Group	Working session on documentation of scenario modelling, modelling standards, input from carbon branch
2024-06-28	Office Chief Forester	FLP and FOP update and documentation refinements
2024-09-09	Office Chief Forester	Working session on documentation and future forest outcomes

Appendix F

Assessing, Mapping, and Forecasting Integrity – a Lidar-based GIS Approach

Attached is a copy of copy of the report referenced in FF5.

Assessing, Mapping, and Forecasting Ecosystem Integrity – a Lidar-based GIS Approach

Developed in conjunction with the TFL 37 Forest Landscape Plan,
Hišuk ma ćawak Integrated Resource Management Plan,
Tla'amin Forest Resource Plan, and
Nanwakolas TFL 64 Integrated Resource Management Plan

Allen Banner RPBio RPF (Ret.), Del Meidinger RPBio, Steve Platt RFT,
Joel Mortyn RPF

with contributions and support from Western Forest Products and the technical planning teams

July 22nd, 2025

Project Participants

This project was conceptualized in early 2022 to address a collective desire within the TFL37 Forest Landscape Plan (FLP) Technical Team to better characterize ecosystem integrity. The project was a cooperative initiative that benefited greatly from technical work, discussions, and brainstorming among the authors and the planning team members.

The methods continued to evolve during the application of the procedure to other planning initiatives in the Nanwakolas TFL 64 Integrated Resource Management Plan (IRMP), the Hišuk ma c̓awak IRMP, and the Tla'amin Forest Resources Plan (FRP).

The following individuals contributed to various aspects of the project.

- TFL 37 FLP Technical Team Members:
  - 'Namgis First Nation: Rachel Dalton RPF, Mike Green RFT, Brian Svanvik
  - Western Forest Products Inc.: Mike Davis RPF, Stuart Glen RPF, Charlotte Mellstrom RPF
- Contributors: Allen Banner RPBio RPF (Ret.), Del Meidinger RPBio, Steve Platt RFT, John Deal RPF, Joel Mortyn RPF, Suzanne Hopkinson FIT

Signed. See original hard copy.

Allen Banner, RPBio, RPF (Ret.)

Signed. See original hard copy.

Del Meidinger, RPBio

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Steve Platt, RFT

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Joel Mortyn, RPF

Table of Contents

Abstract

This report outlines an approach to evaluating the degree of ecosystem integrity and recovery within managed forest landscapes. The approach utilizes attributes available through forest cover inventory, lidar data, and terrestrial ecosystem mapping to evaluate ecosystem integrity. The approach was developed for application in a set of forest landscape planning projects being developed collaboratively by Western Forest Products (Western) and several First Nations.

The approach utilizes lidar technology to assess forest structural complexity, focussing on the metric "rumple", a measure of canopy roughness or rugosity. The use of lidar is a significant step forward in assessing ecosystem integrity, as it allows us to consider the structural complexity of all stands, moving beyond simplified age-based approaches to assessing ecosystem integrity and risk. Standard deviation of rumple is also used to help assess variability in canopy complexity within a forest cover inventory polygon. Canopy complexity is an important forest attribute that correlates with other indicators of ecosystem recovery and integrity, such as understory vegetation development and habitat diversity. Four additional attributes (stand age, tree species diversity, polygon size, and landscape context) are assessed to develop an ecosystem integrity score for each forest cover polygon. Current conditions (year 0) are assessed using recent lidar and forest inventory data. Future conditions (year 100 and 300) are modelled based on the Patchworks™ forecast of the future forest condition. The ability to evaluate both the current and future condition of ecosystem integrity is integral to the landscape planning initiatives.

Methods for assessing and mapping both the current and forecasted ecosystem integrity are described in detail. The ecosystem integrity polygon score can theoretically vary from 2 to 42.5. In application in the four areas, it ranged from 3.1 to 38.6. Stand age and rumple are the primary values influencing ecosystem integrity, however all factors influence the polygon score.

Mean integrity values are calculated for each planning area and for each time period (Year 0, Year 100, Year 300). Four Ecosystem Integrity classes (IV – III – II – I), each with two subclasses, were developed. The four integrity classes align broadly with the BC Conservation Data Centre ecosystem integrity assessment classes of poor, fair, good, and excellent, respectively. These classes are displayed on maps to show the spatial distribution and the change over time.

The forecast for ecosystem integrity was developed using draft scenarios from each plan area to develop and refine the approach. Final ecosystem integrity forecasts will be reported out separately for each plan once completed.

Managing for the range of values associated with diverse landscapes and ecosystems often includes a range of age classes and forest structure patterns. This integrated approach to assessing and mapping the current and future ecosystem integrity is therefore a very useful tool to visualize and evaluate this diversity and complexity as part of maintaining ecosystem health and biodiversity. The ecosystem integrity maps also provide a framework for more detailed ground sampling of ecological integrity and a basis for monitoring and further refining the assessment over time.

1 Introduction/Background

This report outlines an approach to evaluating the degree of ecosystem integrity and recovery within managed forest landscapes. As regenerating stands develop along a successional trajectory, they develop attributes of older stands, including height, horizontal and vertical structural diversity, species composition and cover, and forest floor development (Banner and LePage 2008, Gerzon et al 2011, LePage and Banner 2014, Price et al. 2017). While the importance of old-growth forests is recognized, young and maturing forests also contribute to the ecological integrity of a forest landscape (Bunnell and Dunsworth 2009, Gerzon and Banner 2011).

The approach outlined here utilizes attributes available through forest cover inventory, lidar data, and terrestrial ecosystem mapping to evaluate ecosystem integrity. We recognize that ecosystems are complex and dynamic and that there is uncertainty regarding rates of recovery, including the specific nature of old-growth in different landscapes and ecosystems. Factors such as climate change, forest health, and disturbance events all impact on individual species and ecosystems. Nonetheless, attributes such as age, stand structure, and species diversity, combined with landscape context, are all appropriate and useful for assessing current ecosystem integrity across the forested landscape, and predicting how it will change over time. Bringing together the attributes of ecosystem integrity in combination with the other elements that comprise ecological integrity provides for a more thorough evaluation of ecosystem health and biodiversity now and into the future.

1.1 Concepts/Definitions

1.1.1 Ecological Integrity and Ecosystem Integrity

1.1.1.1 Ecological (Landscape) Integrity

A dictionary definition of integrity is "the state of being whole". Ecological integrity has been defined as the ability of an ecological system to support and maintain a community of organisms that has species composition, diversity, and functional organization comparable to those of natural habitats within a region (Parrish et al. 2003, Wurtzebach and Schultz 2016). Aldo Leopold (1949) emphasized the need to "save all the parts" as a goal in managing ecosystems ("intelligent tinkering") and this is the essence of maintaining ecological integrity.

The concept of ecological integrity incorporates multiple elements and scales from the stand to landscape level, including habitat and species diversity, riparian and wetland function, carbon uptake and storage, habitat connectivity, etc. It encompasses the diverse range of ecological values within the forest landscape.

1.1.1.2 Ecosystem Integrity

Here we consider ecosystem integrity as a component (subset) of the broader concept of ecological integrity. It is assessed at the stand or polygon level using a suite of ecosystem attributes such as stand age and disturbance history, stand structure (including canopy complexity/differentiation, snags, coarse woody debris), vegetation development (including terrestrial and epiphytic community composition and diversity), and soil physical and biological properties.

NatureServe (2002, Faber-Langendoen et al. 2016), as applied in British Columbia by the Conservation Data Centre (BCCDC; BC Ministry of Environment 2006), assesses ecosystem integrity using three components – Condition, Size, and Landscape Context (see Appendix 7.1). Condition incorporates the ‘internal’ stand/site factors mentioned above; Size considers the physical extent of an ecological community; Landscape Context considers what surrounds the ecological community in terms of recent natural and human-caused disturbance, age classes, and permanently altered habitats such as roads, and other human infrastructure. The BCCDC adopted this approach in their assessment of rare and at-risk ecosystems, and we also incorporate these concepts in the approach presented in this paper.

A managed forest landscape comprises all age classes from young to old and thus includes a broad range of integrity classes. Mean ecosystem integrity within such a landscape would generally be lower than in an unaltered forest landscape such as a large, protected area. It is therefore informative and helpful to assess integrity within managed landscapes. Evaluating the current condition provides a basis for evaluating different management scenarios and how ecosystem integrity is forecast to change into the future. This includes monitoring how the spatial patterns change over time as part of integrated planning that connects the full range of values.

1.1.1.3 Recovery and Resilience

Other concepts such as ecosystem recovery and ecosystem resilience are also linked to integrity. Ecosystem recovery is the degree of development of older forest conditions through succession following natural and human-caused disturbance (Banner and LePage 2008, LePage and Banner 2014, Price et al. 2017). Resilience is the ability of an ecosystem to absorb external influences (natural and man-caused disturbance, climate change) and remain intact (Holling 1973, Campbell et al. 2009). A fully recovered ecosystem with a diverse species composition is generally considered to rank high in terms of ecosystem integrity and resilience. Younger forests can also be managed with an emphasis on resilience through practices that focus on species and structural diversity, and old forest legacies (Bauhus et al. 2009, Bunnell and Dunsworth 2009). Resilience must also consider the natural disturbance pattern, as some landscapes would be considered to have higher resilience with a greater range of stand ages.

1.2 Applications of Ecological/Ecosystem Integrity and Related Concepts in BC – Brief History for Context

The concept of ecological integrity has been implicit in many policies relating to forest management in BC going back many decades. A benchmark initiative was the adoption of biogeoclimatic ecosystem classification (BEC) by the British Columbia Forest Service in the late 1970s/early 1980s (Meidinger and Pojar 1991) which promoted the ecosystem as a fundamental unit/framework in forest management. Out of this initiative came the development of field guides, maps, and management interpretations, providing tools for foresters and others to apply ecological principles to management decisions. The provincial ecology program continues today with further refinement of ecologically based maps and other field tools.

During the same era, the British Columbia Ministry of Environment developed a biophysical classification with more of a wildlife habitat interpretation focus (Demarchi 2011) and today both biogeoclimatic units (zones, subzones, etc.) and biophysical units (ecoregions, ecosections) provide the framework for management and conservation plans and decisions throughout the province.

The BCCDC was established in 1991 (Harcombe 2000) to compile/organize information on rare and at-risk organisms and ecosystems in the province and to coordinate with parallel national and international programs through the NatureServe network. As previously noted, NatureServe and the BCCDC explicitly use the concept of ecosystem integrity to assess occurrences (called element occurrences) of listed plant communities in the province.

In the mid 1990's a new Forest Practices Code was implemented by the government, incorporating numerous ecologically based initiatives related to ecosystem integrity, including the Biodiversity Guidebook and Riparian Management Area Guidebook (British Columbia Ministry of Forests and British Columbia Ministry of Environment 1995). This Act was replaced with the Forest and Range Practices Act in 2004 with some updating of guidebooks (e.g., British Columbia Government 2004).

A large ecosystem-based management initiative for the central coast of British Columbia began in the late 1990s and resulted in the Great Bear Rainforest Order (GBRO; Price et al. 2009, British Columbia Government 2016) which developed an approach based on representation targets for old forests and red and blue-listed communities for the plan area.

Other initiatives such as the Old-growth Strategy (British Columbia Ministry of Forests 1992) and Protected Areas Strategy (British Columbia Government 1993) in the early 1990s, also reflected the government's goals and priorities of the time related to ecological/ecosystem integrity. A second old-growth strategic review (OGSR) was recently completed (Old Growth Review Panel 2020) which included fourteen implementation recommendations. The OGSR embraces the concept of ecosystem health and biodiversity and recognizes that old growth is only one component of the larger management system.

Shortly after the release of the Old-Growth Strategic Review in 2020, the BC government released an Interim Assessment Protocol for Forest Biodiversity in British Columbia as part of BC's Cumulative Effects Framework (Provincial Forest Biodiversity Technical Working group 2020). This document presents some initial standards for assessing forest biodiversity at a broader (provincial) scale and it recognizes the need to engage local experts to conduct integrated planning (strategic, tactical, operational) at a finer scale.

In 2021, the Province, 'Namgis, and Western announced the TFL 37 Forest Landscape Plan pilot, which will replace the current TFL 37 Forest Stewardship Plan. Also in 2021 and 2022, Western began working with Huu-ay-aht First Nation[1], Nanwakolas Council[2], Tla'amin First Nation[3] and Quatsino First Nation[4] on separate Integrated Resource Management Plans. These landscape level planning processes are conducted at a fine-scale, connecting the stewardship of all local values, including forest biodiversity, by utilizing local knowledge, wisdom, expertise, and the best available data. Patchworks™ (Spatial Planning Systems; https://spatial.ca/) was used to connect the stewardship of the many different values, providing a spatially and temporally explicit description of the integrated future forest outcome. One of the many benefits of this integrated approach is that it enables a comprehensive evaluation of the future forest, considering all the elements that contribute to ecological integrity. This necessitates being able to visualize and evaluate how the spatial pattern of ecosystem integrity changes over time for different management scenarios being assessed. This also supports adaptive management by enabling

[1] https://huuayaht.org/2021/03/huu-ay-aht-moves-forward-on-integrated-resource-management-plan/
[2] https://news.gov.bc.ca/releases/2022FLNRO0003-000078
[3] https://www.westernforest.com/community_news/bridging-agreement-between-quatsino-first-nation-and-western-forest-products-represents-a-meaningful-step-towards-reconciliation-and-rights-recognition-on-north-island/
[4] https://www.westernforest.com/community_news/bridging-agreement-between-quatsino-first-nation-and-western-forest-products-represents-a-meaningful-step-towards-reconciliation-and-rights-recognition-on-north-island/

monitoring against this forecast to ensure the forests continue to progress towards the desired future forest condition.

1.3 Incorporating Forests of All Ages in the Assessment of Ecosystem Integrity

In BC and elsewhere, there is considerable emphasis placed on older forests as the primary contributor to ecological integrity. One approach has been to complete an ecological risk analysis based on the percentage of old forest remaining in the forest landscape relative to the amount expected under historic disturbance regimes (Price et al. 2021). This is referred to as the range of natural variability or RONV and was the concept used in the development of the management targets and scenarios within the GBRO (Coast Information Team 2004). Under this approach, where remaining old is 70% of RONV, ecological risk is considered to be low, whereas 30% RONV is considered to constitute high risk to ecological integrity. This approach, however, does not account for the ecological services that mature and younger forests provide (Sullivan et al. 2009, Banner and Warttig 2011) and therefore does not adequately recognize the contribution of all forests to ecosystem integrity.

In BC, due to forest inventory approaches and limitations, 250 years on the coast and 140 years in the interior, are commonly used as the age thresholds to define old-growth (Old Growth Review Panel 2020). Estimates of disturbance return intervals throughout the province, however, have a much broader range – varying from under 120 years in the interior to several thousand years on the wetter portions of the coast (Provincial Forest Biodiversity Technical Working Group 2020). As well, mature forests between 80-250 years of age are recovering many important ecosystem attributes, including vegetation composition and many structural elements (Gerzon and Banner 2011). The value of such forests in providing ecological services such as riparian function, water conservation, carbon sequestration, and habitat values for a variety of organisms is thus significant and must be factored into the assessment of ecological integrity. Old forests are an important part of this integrity assessment and where they are rare in the landscape, integrity will generally be limited without mature forests. However, even where old forests occur to a limited extent, an assessment that includes the full diversity of age classes, provides for a more complete characterization of ecosystem integrity.

The biodiversity assessment protocol for BC (Provincial Forest Biodiversity Technical Working Group 2020) emphasizes the limitations of using forest age as a surrogate for forest structure and function. It recommends developing alternative assessment approaches that better capture the variation in forest structure associated with different types of disturbance. Lidar technology now allows attributes of ecosystem integrity to be assessed across broad forested landscapes. Lidar provides a systematic measure of forest canopy complexity, an attribute that correlates with other indicators of ecosystem integrity, such as understory vegetation development and habitat diversity. GIS methods to assess ecosystem integrity prior to lidar were limited to considering the attributes in forest inventory polygons, which assume uniformity within a polygon and often contain little information about stand structure. As a result, these methods often relied on the proportion of old forest, which assumes that a stand only contributes to ecosystem integrity once it reaches a certain age, and that this age is consistent across stand types. Lidar now enables us to expand beyond age-based forest cover assessments as the structural complexity across the entire forested landscape can be assessed.

In managed forest landscapes where the spatial distribution of forest age classes changes over time, it is possible to assess the current and future forecast of ecosystem integrity, utilizing spatially explicit forest estate models. Management approaches that maintain or improve integrity over time can be established, and monitoring carried out to ensure the desired future forest condition is being met. This integrated approach enables the dynamic nature of managed forest landscapes to be evaluated spatially and temporally, including the use of silvicultural systems and stand enhancement treatments (Chamberlain et al. 2021) that can improve structural complexity and ecosystem integrity.

GIS approaches are preferable to ground assessments given the extensive areas (>100,000 ha) requiring assessment. While methods for on-the-ground assessments of ecosystem integrity applicable to young and mature stands have been developed (Banner et al. 2019), these are labour-intensive and more applicable to ground truthing selected polygons to refine and substantiate the GIS-based assessments.

This background provides a basis for this case study and the need to develop a new and innovative lidar-based approach that includes the multiple stand attributes of ecosystem integrity. Lidar data gives us the ability to measure stand structural diversity, a critical component of ecosystem integrity, at a finer scale than has been possible before. The connection of fine-scale data through Patchworks™ gives us the ability to predict how various components of ecosystem integrity change through time. These two factors led us to develop this new and innovative approach to assessing and forecasting ecosystem integrity.

2 Developing a GIS Approach for Assessing Ecosystem Integrity

2.1 The Approach to Assessing Ecosystem Integrity – Overview

2.1.1 NatureServe and BC Conservation Data Centre Approaches to Assessing Ecosystem Integrity

The approach developed here draws from some earlier initiatives developed primarily for assessing individual element occurrences of rare/at-risk ecological communities. NatureServe and the BCCDC utilize a three-factor approach to developing an ecosystem integrity score for individual element occurrences (British Columbia Ministry of Environment 2006; Faber-Langendoen et al. 2016). The three factors are Condition, Size, and Landscape Context, with each factor scored individually., The scores are then combined to develop an overall integrity score (see Appendix 7.1 for further details). Each factor is defined as follows:

- Condition
    - The degree of development/maturity/stability of the ecological community with old-growth examples ranking the highest.
    - Considers attributes such as species composition and biological structure (species richness, evenness of distribution, presence of exotics).
    - Incorporates ecological processes (degree of disturbance by land use, e.g., grazing, harvesting, changes in hydrology or natural disturbance regime) and abiotic physical/chemical factors (stability of substrate, physical structure, water quality).
- Landscape Context
    - Landscape structure and extent (pattern, connectivity, e.g., measure of fragmentation/patchiness, measure of genetic connectivity).
    - Condition of surrounding landscape (i.e., development/maturity, species composition and biological structure, ecological processes, abiotic physical/chemical factors.
- Size
    - Area of occupancy of the ecological community.

Assessment guidelines are provided for each of the above factors to facilitate scoring the element occurrence. A four-class ranking system is used to score each of the factors. Classes are assigned a numerical value to enable a total score to be calculated and an overall integrity rank (poor, fair, good, and excellent) assigned to the element occurrence. The weighting of the components varies by ecosystem community type (matrix, large patch, small patch, linear). For example, size is weighted more heavily in matrix-type ecosystems (e.g., zonal/mesic site units) than in linear (e.g., floodplains) or small patch (e.g., skunk cabbage swamps) ecosystems.

The above system provides a useful framework for developing a GIS approach and de Groot and Casley (2016) developed a tool (for the BCCDC) to rank the ecological integrity of individual ecological community occurrences, using available spatial data inputs. The tool is designed to be used primarily to assess rare and at-risk (red and blue-listed) element occurrences. We have utilized aspects of the above three factors in the approach applied here; however, since our objective focusses on the collective assessment of all forest polygons within a management unit, rather than individual (isolated) element occurrences, a modified assessment procedure was required.

2.1.2 Tools for Assessing Ecosystem Integrity from Land Management Handbook 72

A field guide for assessing integrity that focusses mainly on condition was recently developed to assist with field implementation of the GBRO (LMH 72; Banner et al. 2019). This guide was specifically developed to identify rare and at-risk ecological communities and old forest stands that meet minimum age and structural criteria for conservation. The guide presents a field tool called the Forest Attribute Score (FAS) which assesses stands in the field according to six ecological attributes as indicators of ecosystem recovery and integrity:

- Density of veteran overstory trees
- Density of snags
- Vertical canopy differentiation
- Understory shrub and herb cover
- Coarse woody debris
- Disturbance history

The FAS assessment integrates structural, compositional, and disturbance history elements to calculate a score that reflects the degree of ecosystem integrity and recovery. While it is not possible to capture all these stand attributes from GIS spatial coverages, characterizing stand structure, especially vertical canopy differentiation, is most important. Forest canopy structure is an important indicator of integrity since it both reflects, and impacts on, important developmental features tied to integrity. As a forest canopy opens up and differentiates in terms of heights, diameters, and canopy gaps, understory re-initiation begins with tree regeneration and shrub, herb, and bryophyte communities re-establishing (Lertzman et al. 1996). As well, epiphytic canopy communities begin to re-establish. If structural elements of the previous stand are retained through variable retention, this will hasten structural development/diversity within the regenerating stand (Bunnell and Dunsworth 2009).

2.1.3 Applications of Lidar Technology to Characterizing Stand Structure

Lidar (light detection and ranging systems; Wasser 2022) technology has become a very useful tool for capturing canopy complexity, thanks to significant technical advances over the last 20 or so years. Lidar "point clouds" provide extremely accurate and detailed 3-dimensional measurements of the ground and vegetation layers and can thus be used to accurately measure tree heights and forest canopy complexity (McGaughey 2022). There are numerous lidar metrics that can be calculated from lidar point clouds. We examined many, but focussed on three that showed the greatest promise based on the literature:

- Rumple – a measure of canopy roughness or rugosity
    - Rumple is the ratio of canopy outer surface area to ground surface area as measured by the lidar-derived canopy surface model and digital terrain model. It is therefore a three-dimensional measure of canopy structural heterogeneity (Kane et al. 2010a, 2010b).
- VCI – vertical complexity index
    - A fixed normalization of the Shannon vertical complexity index. Applied to quantify the diversity and the evenness of an elevational distribution of las points (Roussel and Auty 2020).
- CRR – canopy relief ratio
    - Canopy Relief-Ratio is a quantitative descriptor of the relative shape of the canopy from altimetry observation, defined as mean height returns, minus the minimum height, divided by the maximum height, minus the minimum height. This ratio reflects the degree to which canopy surfaces are in the upper (> 0.5) or in the lower (< 0.5) portions of the height range (Parker and Russ 2004).

Using FUSION Software (McGaughey 2022), we examined a cross section of age classes within pilot study areas throughout TFL 37[5]. We created point cloud images of stands that visually portrayed individual tree heights and canopy structure within forest cover polygons. In our evaluation of lidar metrics, we also evaluated the pixel size used to calculate the metrics (25, 40, 50, 75, 100 m). We determined that a 40 m pixel is appropriate for determining stand structure and is well-suited to field checking of lidar stand structure interpretations. Lidar metrics were plotted for each pixel to look at relationships between each metric and stand age/structure. An example of one of our sample transects in shown in Figure 1.

We examined each of the above lidar metrics in this way and concluded that 'rumple' was best suited to capturing variation in canopy structure; the other supporting/descriptive metrics were also useful but didn't add significant information over rumple. Relationships between rumple statistics and stand age and height are shown in Figure 2. While there is a strong positive relationship between rumple and age, there is also variation within age classes that reflects differences in canopy characteristics. Thus, rumple is useful for distinguishing structural differences among stands of similar age.

The standard deviation of rumple is also a useful metric to indicate the variation in structure within a polygon (stand). For example, differences in density within a stand will result in different rates of structural development (e.g., self thinning giving rise to a transition from a more even canopy to a more complex canopy). Also, structural legacies (leave patches/trees) remaining at the time of harvest, through the use of variable retention silvicultural systems, will give rise to higher mean rumple values (for a forest cover polygon where leave patches were not delineated) as well as higher rumple standard deviation values, compared to harvest areas with no retention.

[5] Numerous in-house reports documenting earlier phases of this project are on file with Western Forest Products.

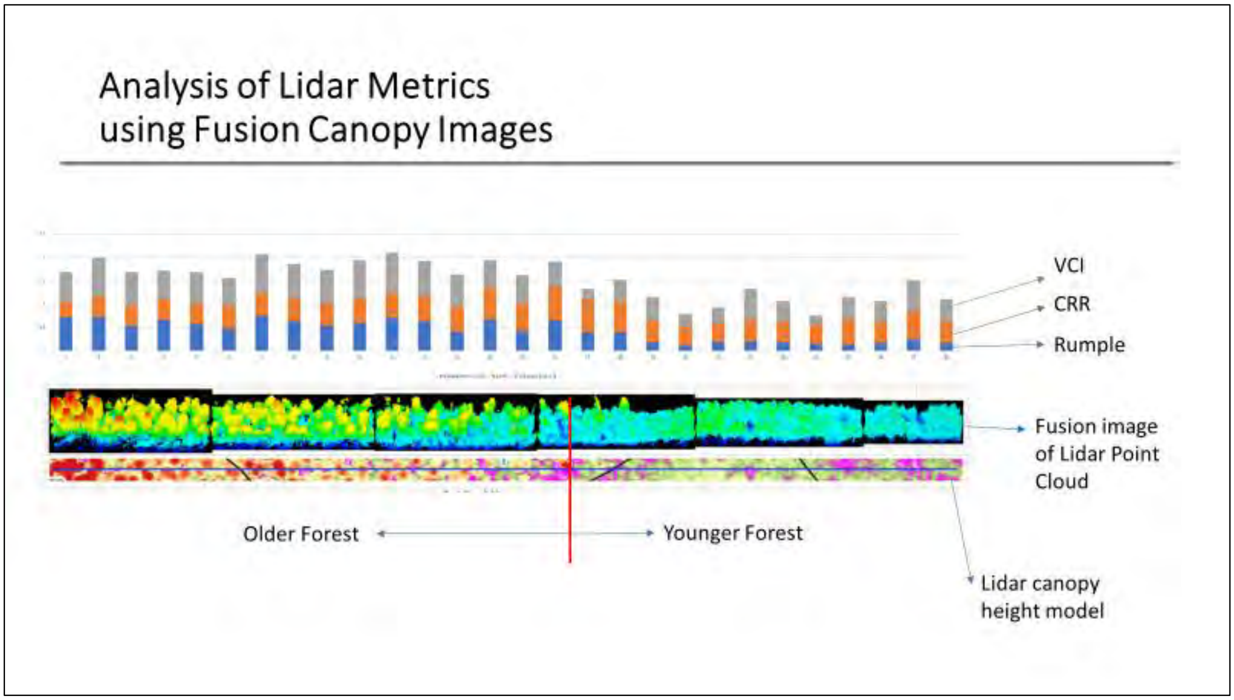


Figure 1. Example of lidar sample transect, TFL 37. Stacked graphs of three lidar metrics are shown above the Fusion lidar point cloud canopy images. VCI = vertical canopy index; CRR = canopy relief ratio; see text for further explanation.

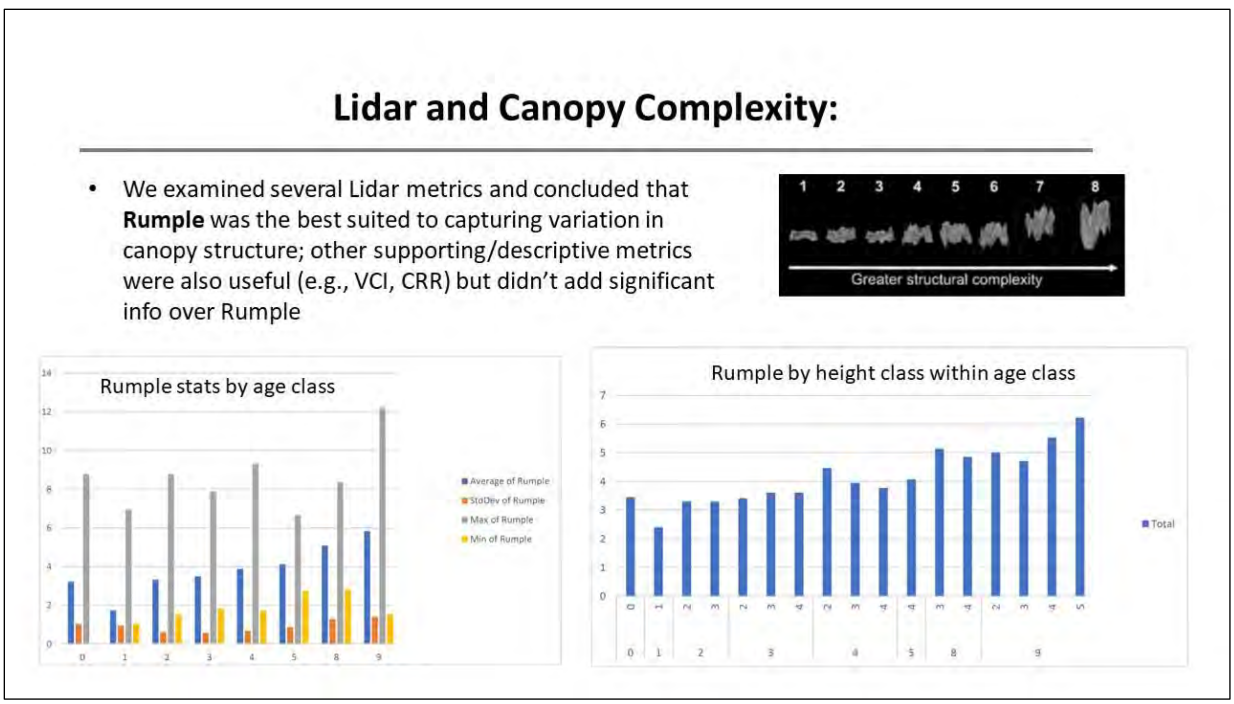


Figure 2. Rumple statistics (left graph: mean, standard deviation, max, min) by age class (0-9) and (in right graph) mean rumple by height class (0-5) within age class (0-9). See Table 4 for description of age classes; height classes as follows: 0: 0 m; 1: 1 – 10.3 m; 2: 10.4 – 19.3 m; 3: 19.4 – 28.4; 4: 28.41 – 37.4; 5: 37.41 – 46.4; 6: 46.41 – 55.2; 7: > 55.2.

Our conclusion from exploratory work with lidar metrics was that rumple (including rumple standard deviation) is a very useful metric to characterize forest structure; a fundamental attribute for assessing ecosystem integrity and recovery. Figure 3 illustrates the relationship between rumple and canopy structure. It shows the contrasting rumple values between young and old stands but also the variation in rumple values among the raster pixels within polygons of one age class. This would be reflected in the rumple standard deviation for these polygons.

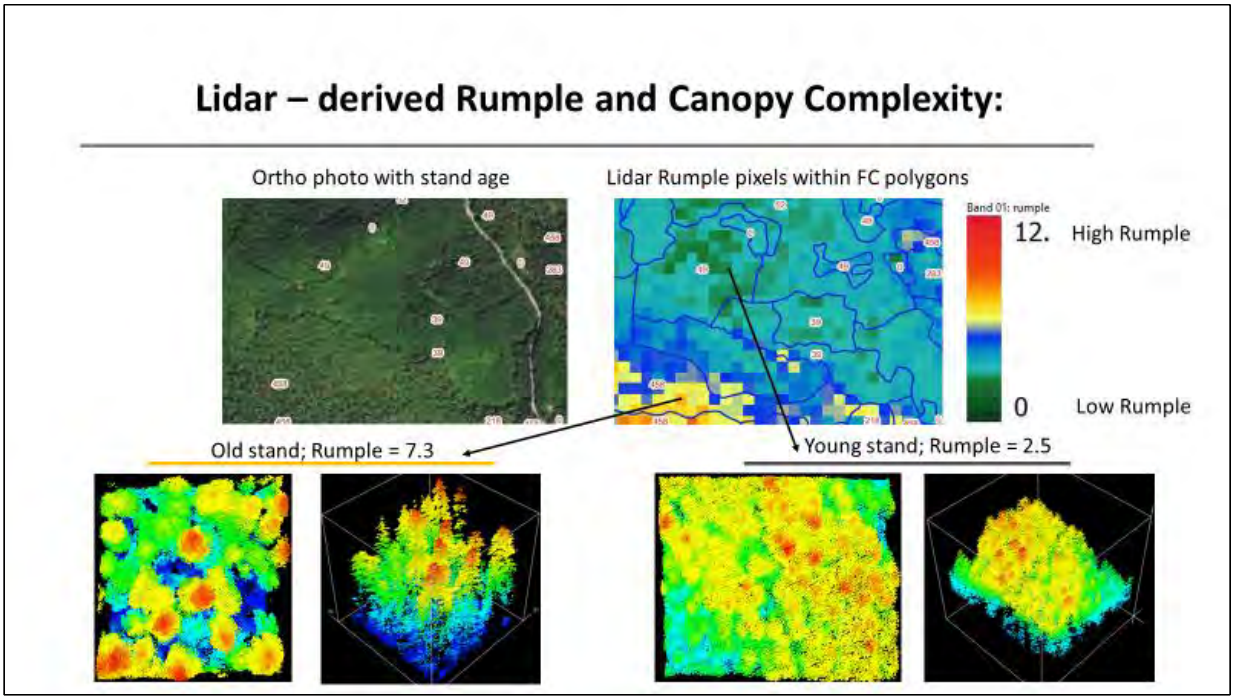


Figure 3. Rumple and canopy complexity

2.1.4 Overview of Available Inventory Attributes for Ecosystem Integrity Assessment

With rumple as one of the baseline inventory attributes for assessing ecosystem integrity, we then set out to examine what other attributes available from the forest cover inventory would be useful in a GIS-based assessment of ecosystem integrity. In a field-based assessment of integrity/recovery, all of the FAS attributes from LMH 72 (Banner et al. 2019) would be assessed, in addition to potentially collecting other more detailed information on understory species composition, tree species diversity, epiphytic communities, soil and humus characteristics, etc. For the assessment of large areas many thousand hectares in size, this level of detailed assessment is not feasible. We thus looked at what we could utilize from available inventories to assess integrity in more of a predictive manner using GIS. Field sampling of specific polygons to confirm relationships can then be carried out over time to refine the GIS assessments.

Five integrity components were chosen to support the GIS assessment of ecosystem integrity:

- Canopy complexity
- Stand age
- Tree species diversity

- Polygon size
- Landscape context

The five components are illustrated and summarized in Figure 4. Components were chosen based on their importance as potential drivers or indicators of integrity, in combination with the availability of reliable inventory attributes to derive them. Individual components are derived from one or more inventory attributes. For example, the canopy complexity component includes both mean rumple and standard deviation of rumple as attributes that are scored separately. Landscape context incorporates a more complex analysis of several attributes into one score. The five analysis components are introduced here as an overview of the approach. Section 3 will describe each of the components in detail, including the methods for calculating component scores and combining the scores to derive total ecosystem integrity scores for each polygon.

2.1.5 Base Polygons for Ecosystem Integrity Analysis

The base polygons selected for analysis of the current and future condition were forest cover polygons aggregated into patches with similar forest characteristics. Forest cover polygons are closely related to future harvest units and the inventory attributes of interest.

As several of the plans spanned multiple licensees and forest cover inventories, the polygons were aggregated into patches with similar forest characteristics, to address issues with the resulting number of small polygons. See Section 3.3 for more information.

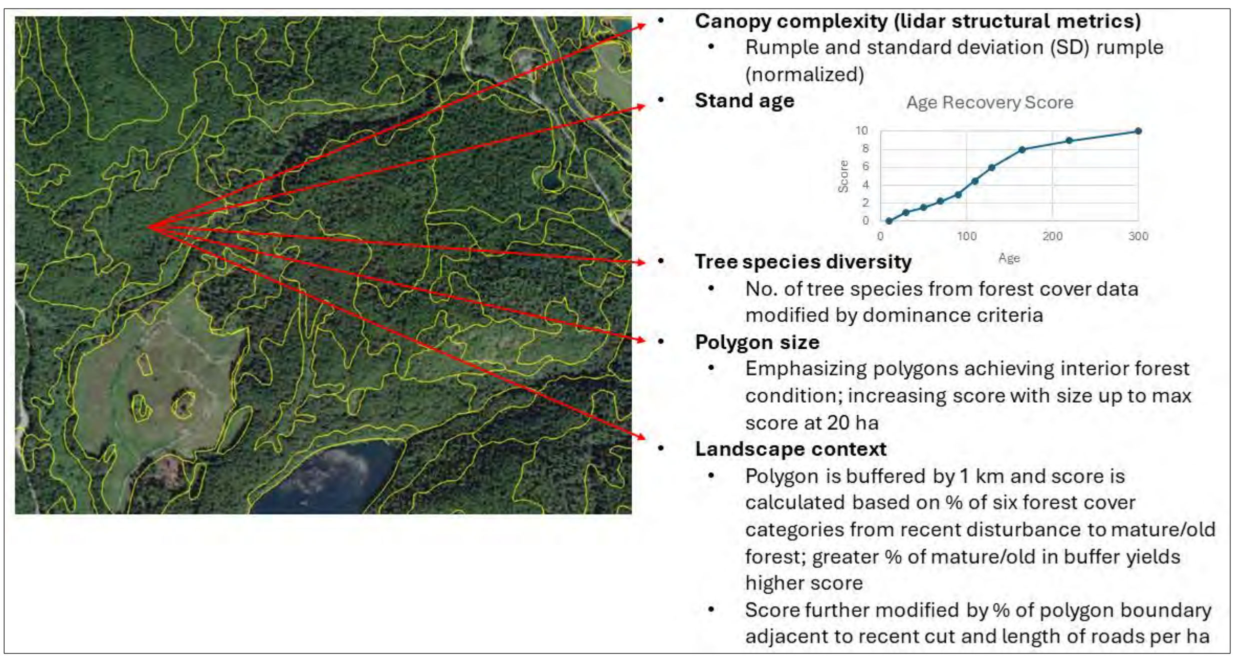


Figure 4. Overview of inventory components used in Ecosystem Integrity Analysis

3 Methods for Assessing/Scoring Integrity Components and Deriving Polygon Integrity Scores

3.1 Individual Attribute Assessment

This section describes the methods used to score the following five components in the GIS assessment of ecosystem integrity.

- Canopy complexity
- Stand age
- Tree species diversity
- Polygon size
- Landscape context

Polygons with no forest cover attributes were excluded from the calculation of the integrity score, as they lack data for key attributes (i.e., age, tree species diversity, and usually, rumple). These included river, swamp, non-productive (NP) brush, rock, gravel pit, roads, and most NP forest polygons, among others. Some NP Forest polygons were included in the analysis as they had age, rumple, and species diversity scores.

3.1.1 Canopy Complexity

Canopy complexity is a fundamental component of the ecosystem integrity assessment procedure since many other ecosystem attributes are impacted by canopy differentiation (Chamberlain et al 2021). Understory development, for example, is sensitive to understory light regimes which are directly impacted by canopy openness and gaps.

3.1.1.1 Deriving Rumple Statistics from the Lidar Coverage – Year 0 Assessment

To characterize both mean stand structure and the variation of structure within polygons, this component incorporates two lidar-derived scoring metrics in the assessment procedure – mean rumple and standard deviation of rumple (SD rumple). See Section 2.1.3 for the background exploratory work on lidar metrics and the rationale for choosing rumple and SD rumple to assess canopy complexity.

Rumple values are calculated based on 40 m raster pixels within polygons and mean rumple and SD rumple are calculated for each polygon. Figure 5 depicts forest cover polygons with the lidar pixels displayed. The colour variation of the pixels illustrates the variation in rumple value throughout the polygons. Note that edge pixels overlap with adjacent polygons; to minimize this edge effect, which could be significant for smaller polygons with contrasting neighboring polygons (e.g., old forest next to a recent harvest block), an internal buffer of 12.5 m is created. Rumple statistics are then generated based on the raster pixel centroids that fall inside the remaining polygon. Where the remaining area within a polygon is less than a quarter hectare, rumple statistics are created using the modelling approach described below (Section 3.1.1.2). Where there is retention within harvested blocks, the mean rumple and SD rumple values will reflect this additional structural variation/complexity.

Polygons that have been harvested, roaded, or otherwise altered since the lidar was captured also require rumple to be modelled. In some cases, e.g., TFL 37, the lidar (2016) is 5 years older than the Forest Cover dataset (2021); therefore, stands that have been harvested in this time period will not have representative rumple scores if they were directly sampled.

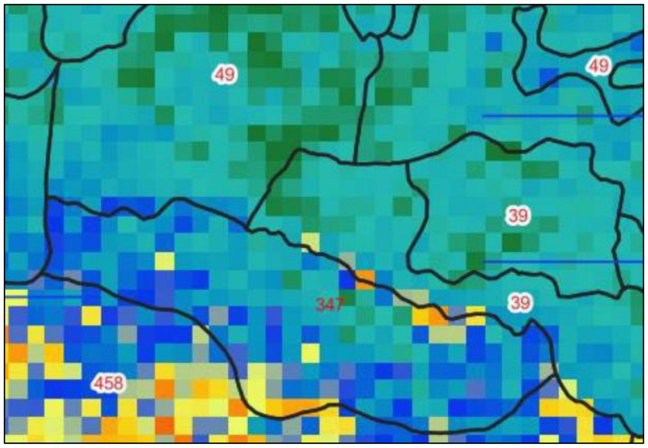


Figure 5. Example Forest Cover polygons with raster pixels coloured by rumple value; yellow-orange = high rumple, blue = mid values, green = lower values. Note overlap of pixels with adjacent polygons; internal polygon buffers are required for calculating rumple stats for polygons to remove edge effect. Numbers in polygons represent forest age.

The rumple values mostly ranged from near zero to 6.777 (Table 1). There were some “outlier” values in the Tla’amin FRP project area, with values up to 10.370, but 99.96% of the values were less than 6.8.

Table 1. Rumple Values by Plan Area

Plan Area	Min. rumple	Max. rumple	Max. SD rumple
TFL 37 FLP	0	6.777	1.798
Hišuk ma cáwak IRMP (incl. TFL 44)	0.121	6.255	2.355 (99.87% <1.8)
Tla’amin FRP (incl. TFL 39 Block 1)	0	10.370 (99.96% <6.8)	4.614 (99.97% <1.8)
Nanwakolas TFL 64 IRMP	0	6.185	1.686

Rumple is an important attribute, as it is mostly sampled directly from the data, and is one of the top attributes of ecosystem integrity. As a result, the rumple values were weighted by an additional 50% up to a maximum score of 10 (equal to other highly weighted attributes).

Standard deviation of rumple values ranged from near zero to 4.614, but 98-99% of values were 1 or less. As SD rumple values were relatively small numbers, we applied normalization to increase the weighting of the attribute to a maximum value of 5. This was to increase the weighting of SD rumple in the final integrity calculation but not to overweight the influence of stand structure too much (qualitative assessment). Calculated SD rumple values of 1 or more were set at 5. Polygons with SD rumple values greater than 1 are relatively few (1-2%). In determining our approach to normalization, we reviewed numerous polygons with higher SD rumple values, and they were mostly old with a bit of young or *vice versa*, old with a slide through it, old with a deep gully that perhaps made rumple hard to interpret, riparian with lots of disturbance so lots of height variation, mid age plus a slide, odd polygon boundaries, or floodplains that have shifted since last update. If included, a small number of polygons created a strongly skewed distribution of the value. Hence, our decision to maximize the value to 5 for all polygons with a value of 1 or more. All these areas still have the highest SD rumple, but just not exceptionally high. Adding to the decision was that the highest modelled SD rumple in the future Patchworks™ datasets was 1.

3.1.1.2 Modelling Canopy Complexity – Future Scenarios (year 100 and beyond)

Rumple metrics for current conditions (Year 0) were derived from the most recent lidar coverage for the area. Projections into the future required predictive models of the relationship between canopy complexity and age. Other attributes including lidar stand height were considered as predictor variables, but stand age was selected as it explained the most variability. Models were developed for both the mean and standard deviation of rumple using the year 0 dataset for each plan area.

The mean and standard deviation rumple scores were calculated for each resultant polygon. These polygons include a stand age estimate which is based on the photo-interpreted age, adjusted to account for photo-interpretation bias using tree ring count samples. For younger stands with a known age (i.e., recent harvests, wildfires), stand ages are determined from the time of planting.

Both rumple mean and standard deviation models were developed using R version 4.2.1 (R Foundation, 2023; https://www.r-project.org/). Additional explanatory variables including stand density, site index, biogeoclimatic ecosystem classification (BEC) zone, subzone, variant and site series, stand height, leading species, elevation, aspect, and crown closure were tested in the models. These were included in the final models if they were found to be significant at the 95% confidence level.

3.1.1.2.1 Modelling Canopy Complexity – Mean Rumple

TFL 37 is provided as an example of the approach used to forecast canopy complexity through time. Separate equations were developed for each plan area using the same approach. An initial review of the data identified that mean rumple appeared to increase rapidly in the first 100 years before slowing (Figure 6). The data were bimodal, with most records either <100 years or 459 years of age. This spike at age 459 is a result of photo interpreters assigning a consistent age for old stands, due to the difficulty of determining age for very old stands from aerial photographs. The data also contained a lot of variability, particularly stands <25 years of age with high rumple values. This is likely the impact of unmapped stand-level retention within recent harvested areas, and the impact of edge effect from the 40m Rumple grid cells overlapping the boundary of young and older stands.

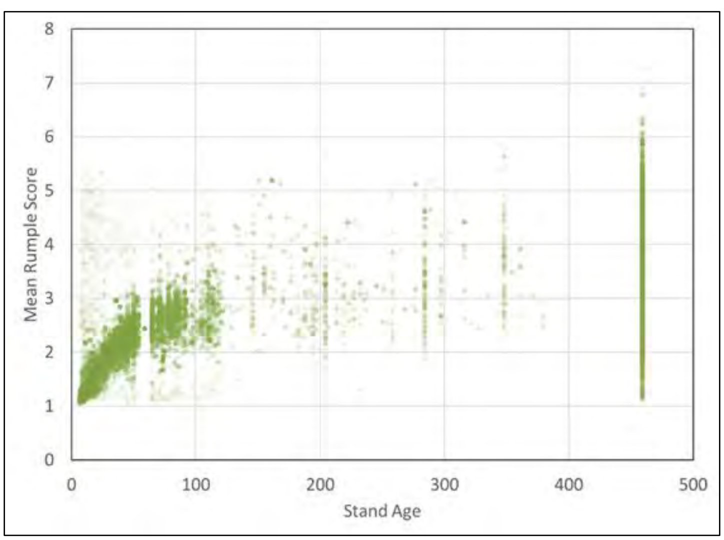


Figure 6. Mean rumple values for stands within TFL 37 by stand age.

The relationship was well described using a power function. Non-linear least squares regression was used to fit the expected rumple at different ages. The final model contained six parameters (Equation 1). Explanatory variables to account for BEC zone and site index were found to be significant (Table 2). None of the other variables tested were found to be significant, likely due to the high variability in the data.

$$\bar{r} = (t_1 + t_2 b + t_3 s) \times a^{(t_4 + t_5 b + t_6 s)} \qquad \text{[Equation 1]}$$

Where:

a = Stand age
b = BEC zone (1 if CWH, 0 if MH)
$\bar{r}$ = predicted mean rumple
s = site index (m)
t_1-t_6 = parameters to be estimated

Table 2. Parameters for the mean rumple model in TFL 37

Parameter	Estimate	Std. Error	t value	p value
t_1	0.8302	0.01073	77.356	<0.001
t_2	-0.03486	0.00982	-3.551	<0.001
t_3	-0.006985	0.00023	-29.990	<0.001
t_4	0.2069	0.00229	90.347	<0.001
t_5	0.02526	0.00218	11.591	<0.001
t_6	0.004178	0.00007	63.101	<0.001

A residual plot (Figure 7) shows that the model provides a good fit of the data. However, the residuals are not evenly distributed for stands <25 years of age, due to the variability in the data (likely caused by unmapped stand-level retention and the edge effect from the boundary of cut blocks and existing stands).

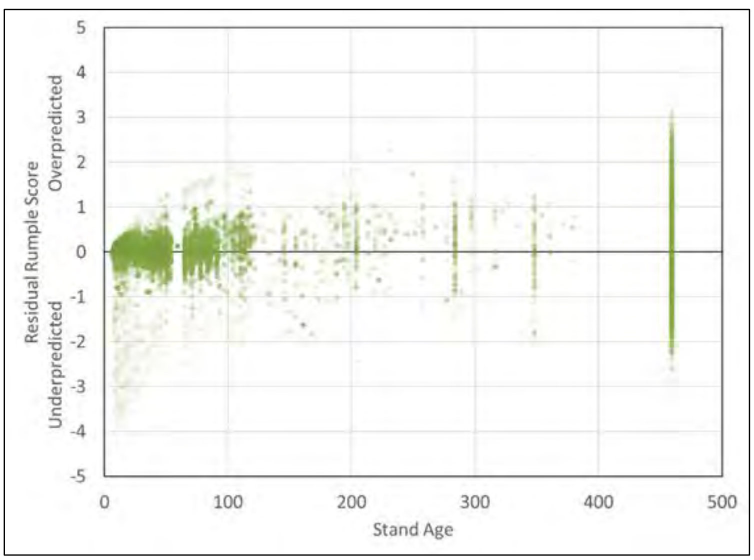


Figure 7. Residual plot of rumple/stand age regression in TFL 37

The model behaviour is shown in Figure 8 for the two BEC zones in TFL 37 with two different site indices (10m and 20m). Mean rumple is predicted to be higher in the CWH zone than the MH zone and in stands with higher site index. This makes logical sense; rumple scores are impacted by stand height and stands are generally taller in the CWH zone than the MH zone. We would thus expect to see increased rumple scores in the CWH. Stand growth rates should be higher in stands with higher site index, so we would also expect accelerated change in rumple in these stands compared to lower site index stands.

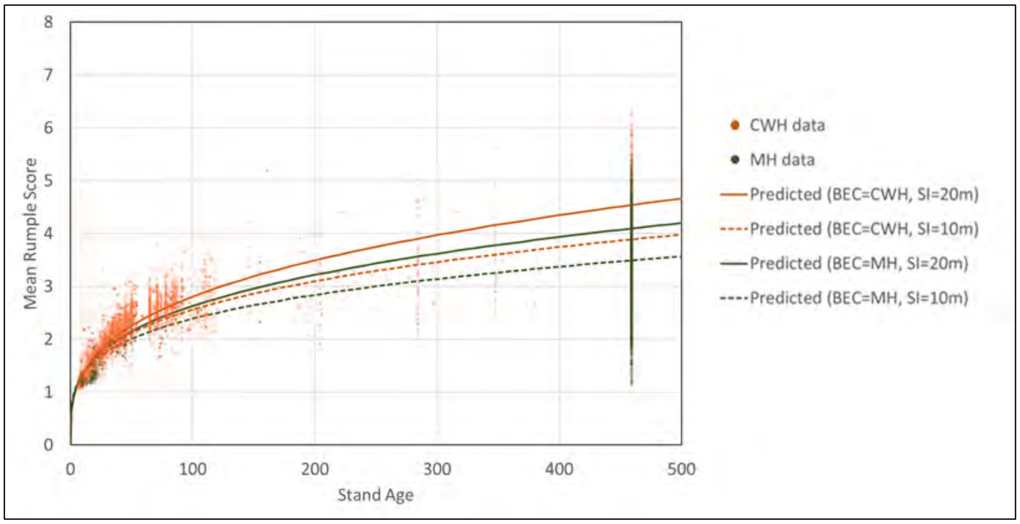


Figure 8. Predicted values of mean rumple for two BEC zones and two site index classes versus age data from TFL 37.

3.1.1.2.2 Modelling Canopy Complexity – Standard Deviation of Rumple

An initial review of the TFL 37 data identified that the standard deviation of rumple (SD rumple) within a polygon had a weak relationship with age (Figure 9). Stands <25 years of age had consistently higher SD rumple scores than stands in the 25-100 age range. This was attributed to the impacts of unmapped stand-level retention and edge effects caused by polygon boundaries not accurately aligning with the stand edge in lidar. Prior to 2006, stand-level retention was not typically mapped in cut blocks in TFL 37. So, in the forest cover inventory, blocks are represented as a single age class in a single polygon. However, the variation in rumple scores in these stands would be considerable due to them containing a mix of young and mature trees. Similarly, the stand boundaries which were delineated from aerial photo interpretation often do not align with the actual stand edge as seen in lidar. As a result, polygons from recent cut blocks often include some large trees from adjacent mature stands. This impact was mitigated by buffering the stand edges (internally) by 12.5m, so this is considered likely to be less of a contributing factor than the unmapped stand-level retention.

After age 25, the data for TFL 37 shows that the SD rumple generally increases with age.

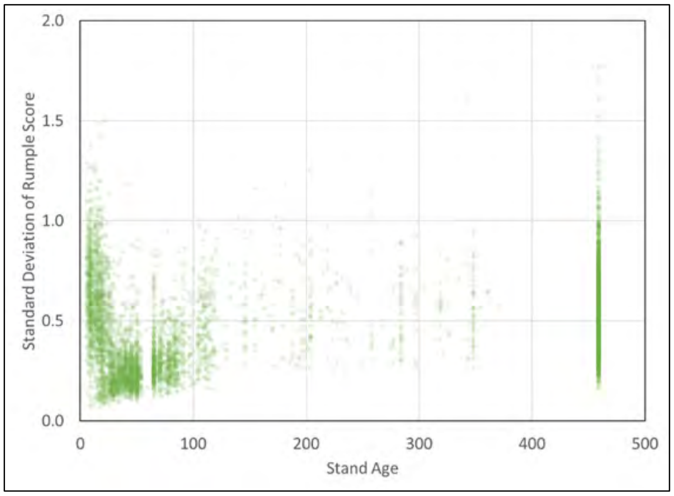


Figure 9. Standard deviation of rumple values for stands within TFL 37 by stand age.

Without an obvious non-linear relationship in the data, a linear equation was used to describe SD rumple and age. Least squares regression was used to fit the expected rumple at different ages. The final model contained three parameters (Equation 2). An explanatory variable to account for site index was found to be significant (Table 2). None of the other variables tested were found to be significant, likely due to the high variability in the data.

$$r_\sigma = t_1 + t_2 a + t_3 s \quad \text{[Equation 2]}$$

Where:

a = stand age
r_σ = predicted standard deviation of rumple
s = site index (m)
t_1-t_3 = parameters to be estimated

Table 3. Parameters for the standard deviation of rumple model for TFL37

Parameter	Estimate	Std. Error	t value	p value
t_1	0.2069	0.01516	13.645	<0.001
t_2	0.0007035	0.00002	29.172	<0.001
t_3	0.002346	0.00051	4.626	<0.001

A residual plot (Figure 10) shows that the model provides a weak fit of the data, with the points unevenly spread around the x-axis. This is most significant in stands <25 years of age, where the model consistently underestimates the SD rumple, due to the prior mentioned issues in the data for young stands.

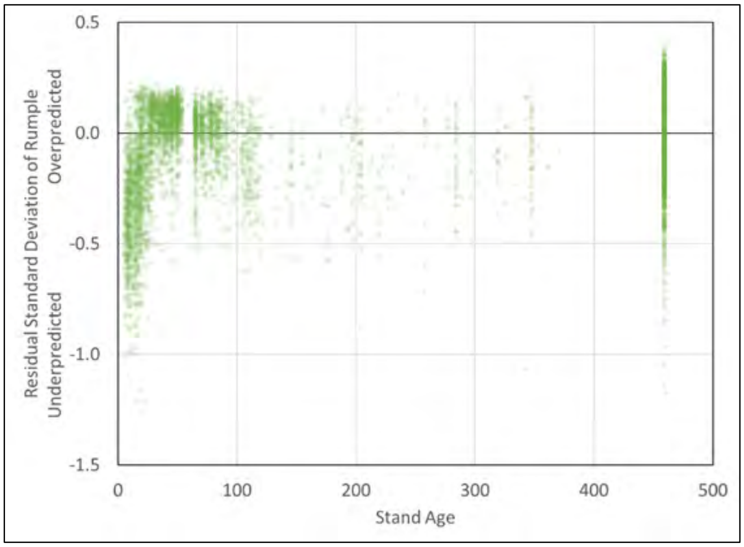


Figure 10. Residual plot of standard deviation of rumple/stand age regression

The model behaviour in TFL 37 is shown in Figure 11. The model predicts the SD rumple to increase over time. The standard deviations of rumple are predicted to be marginally higher in stands with higher site index. Although only providing a weak fit of the data, it is still considered important to include as the SD of rumple in stands is likely to increase through time as canopy structure becomes more varied.

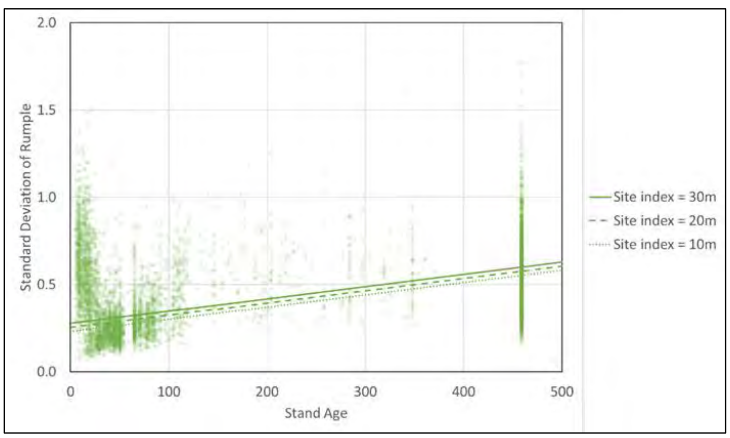


Figure 11. Predicted values of standard deviation of rumple for three site index classes versus age data from TFL 37.

Separate models were developed for each plan area.

3.1.2 Stand Age

3.1.2.1 Age Scoring for Year 0 Assessment

Stands recover with age, but the relationship is not linear (Table 4 and Figure 12). Recovery studies indicate gradual (but limited) recovery in stands up to 60-80 years old followed by increased rates of recovery over the next 100 years or so (Gerzon and Banner 2011). Recovery rates after 180-200 years are uncertain since studies are very limited. The age scoring proposed here reflects an estimated degree of recovery following a precautionary approach.

Projected age is available in the forest cover database and is reasonably accurate for stands up to about age 200. The age of older stands is less accurate but stand age differences above age 250 are not as critical to this method, as these stands are in later stages of recovery.

Table 4. Age recovery scoring for integrity assessment

Age class	Age range	Age Recovery Score
0, 1	0-20	0
2	21-40	1
3	41-60	1.5
4	61-80	2.2
5	81-100	3
6	101-120	4.5
7	121-140	6
8	141-190	8
8	191-250	9
9	250+	10

Note: age class eight split into two classes due to wide range of ages and subsequent recovery

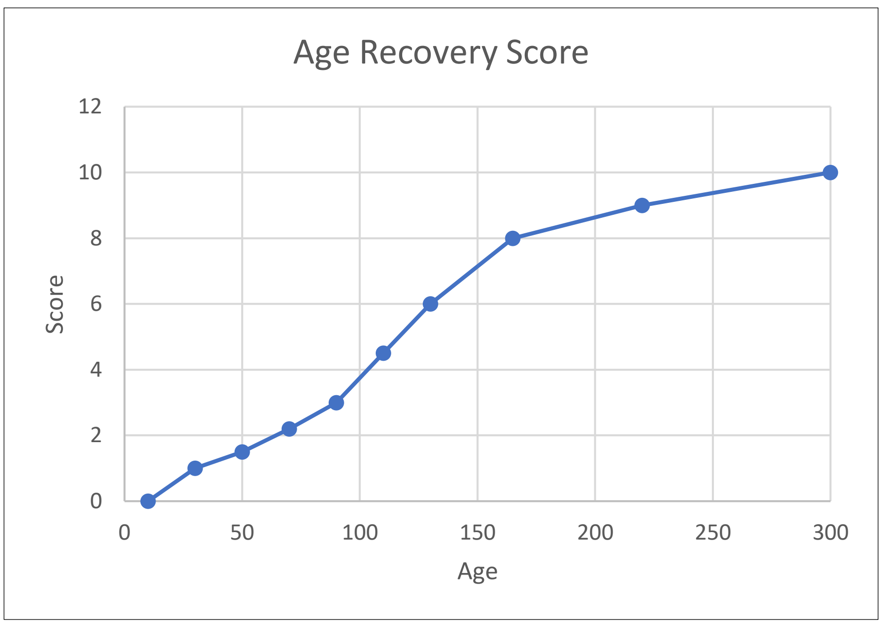


Figure 12. Age recovery curve generated from Table 4.

Age is an important factor in ecosystem recovery, and from the perspective of evaluating integrity over time, the weighting was increased from a maximum score of 5, in our earlier work in TFL 37, to 10 (a doubling of all scores).

3.1.2.2 Modelling Age – Future Scenarios (year 100 and beyond)

The Patchworks™ modelling projects age into the future for all polygons accounting for harvesting and predicted natural disturbance. Polygon age for a future time period is taken directly from the Patchworks™ resultant output.

Managed polygons output from Patchworks™ will have stand level retention that is not represented spatially. This stand level retention represents area within the resultant polygon that is not harvested. This creates polygons with multiple ages. For example, a polygon may represent mostly a young regenerating stand with some 'patches' of mature or old growth forest within it. The Patchworks™ output has attributes describing how much area of the polygon is Managed (harvested) versus Unmanaged (retention).

In order to calculate an age recovery score for these polygons, we used an 'area weighted' age approach. A separate age recovery score was calculated for both the Managed and Unmanaged portions of the polygon and combined by weighting the scores based on the area occupied by each.

3.1.3 Tree Species Diversity

3.1.3.1 Tree Species Diversity Scoring for Year 0 Assessment

We use forest cover for the species diversity assessment. The analysis uses the number of tree species listed for a forest cover polygon, modified based on species dominance in the polygon and stand age. Table 5 outlines the approach. A dominance score is combined with the total number of species to yield the diversity score. For example, a polygon may contain two species but if one of them has 80% or greater dominance, the diversity score would be reduced from 2 to 1. An age multiplier is applied to reduce the scoring for younger stands, as the influence of species diversity on ecosystem integrity is less in young stands. Stands aged 0-40 years old get a diversity score of 0, diversity scores in stands aged 41-60 are multiplied by 0.25, while stands aged 61+ are multiplied by 0.5. The maximum species diversity score was thus lowered by half to 2.5 reflecting the lower degree of confidence in forest inventory species diversity data.

Table 5. Tree species diversity scoring for integrity assessment.

Number of tree species	Dominance score (see Dominance score table)	Diversity score
1	1	1
2	1	1
	2	2
	3	2
3	1	2
	2	3
	3	3
	4	3
>/=4	1	2
	2	3
	3	4
	4	5

Dominance score	Leading Species %
1	>=80%
2	65 to <80%
3	50 to <65%
4	<50%

Stand Age	Diversity Score Multiplier
0-40	0
41-60	0.25
61+	0.5

3.1.3.2 Modelling Tree Species Diversity – Future Scenarios (100 years and beyond)

Patchworks™ assigns regenerating tree species and dominance to managed polygons. The same tree species diversity scores as above are applied to these future stands based on the Patchworks™ model output. However, the Patchworks™ output file used listed volume by species which was used to determine the number of species in a regenerated polygon. Very young stands have no volume and therefore, the Patchworks™ output shows NULL values for these stands (generally <10 yrs). These young managed polygons must be assigned regenerating tree species and percentages. Based on a review of free-growing stands, we decided to assign a default 3 species with a 50/30/20 dominance split to these polygons, which holds over time. Diversity scores for young stands are reduced, as noted in Section 3.1.3.1.

3.1.4 Polygon Size

Size has proven to be one of the more challenging components to incorporate effectively; several modifications were made to our initial proposal after studying trial results. The NatureServe/BCCDC approach (assessing rare and at-risk ecosystems) emphasizes the importance of element occurrence size differently depending on ecosystem type (matrix, large patch, small patch, linear). Size ranks highest for matrix ecosystems (e.g., zonal site series) and lowest for small patch and linear ecosystems (e.g., lower slope seepage sites, skunk cabbage sites, floodplains). This is complicated further by the fact that a single occurrence can be defined by several separate polygons within minimum separation distances.

In our case we are assessing integrity for every forest polygon within a managed landscape rather than for individual (often isolated) rare or at-risk ecosystem occurrences. Applying the same size criteria to young, recently disturbed polygons and mature/old polygons presents some challenges; from an integrity ranking perspective an old forest polygon would be considered to have greater integrity with larger size, yet increasing cut block size would generally be associated with a reduction in integrity (depending on factors such as levels of retention, shape etc.). Though various sliding assessment scales for size, based on ecosystem type and/or stand age, were considered, implementation of the concept was problematic; it was uncertain whether such an approach would yield the desired/ ecologically appropriate contribution of size to overall integrity.

After considering several options, we ultimately landed on an approach that assigns stands a score of between 1 and 5, with a maximum score for stands >20 ha. Stands 0 – 40 years of age get a zero size score; and the size score is halved in polygons of ages 41 – 60 (Table 6). These scores emphasize the achievement of interior forest condition, but do not apply the same size ‘benefit’ to young polygons where interior forest conditions are developing.

The ability to aggregate forest cover polygons with similar attributes into larger patches was integral in applying an effective size score. Without this approach and relying only on forest cover polygons, small polygons of old forest surrounded by more old forest, but delineated separately due to different species compositions are devalued. In contrast, large polygons of younger forest are typically overvalued.

Table 6. Polygon size scoring procedure

Size score	**1**	**2**	**3**	**4**	**5**
Polygon size	>0 – 2 ha	>2 – 5 ha	>5 – 10 ha	>10 – 20 ha	>20 ha

Stand age	**0-40**	**41-60**	**61+**
Size score multiplier	0	0.5	1

3.1.4.1 Modelling Polygon Size – Future Scenarios (year 100 and beyond)

Size scoring gets applied in the same fashion for future stands. The polygon size concerns mentioned above are especially true regarding the Patchworks™ modelling of future polygons (see Section 3.1.2.2). Patchworks™ schedules the harvesting of individual resultant polygons to meet multiple simultaneous goals, including spatial targets. Patchworks™ models stand and landscape stewardship practices including the associated harvest pattern over multiple rotations in order to ensure long-term sustainability. The cumulative effect of this is the accretion of the number of polygons in the dataset. The managed polygon sizes tend to decrease over time (mean polygon sizes were 6.6 – 3.7 – 3.0 ha for years 0 – 100 – 300 respectively, in earlier tests), but adjacent polygons are often very similar in age. For example, a Patchworks™ model may show a managed polygon that is 30 years old adjacent to another managed polygon that is 29 years old, separated by a road. These polygons likely have very similar inventory attributes and could be considered as one unit.

3.1.5 Landscape Context

NatureServe/BCCDC consider landscape context as an important component of an ecosystem integrity assessment. Landscape context factors in what surrounds the polygon in question, from recent disturbance to old forest condition. Factors that are considered in the surrounding landscape are the integrity of ecological processes, species composition, and age/structure of the vegetation. This includes maturity and stability of the biotic and abiotic features of the landscape (British Columbia Ministry of Environment 2006).

The GIS procedure for scoring the landscape context component of the integrity assessment is computationally the most complex and time consuming of the five assessment components. The procedure draws on previous work in Metro Vancouver and Abbotsford (Meidinger et al. 2013) and integrates many factors/attributes to characterize what surrounds each polygon in terms of age class, recent disturbance, and roads.

The method considers conditions within a 1 km buffer around the edge of the polygon being assessed (see Figure 14). Within this buffer polygon, six forest cover categories or 'buckets' are considered:

- **NP** – not natural (non-Forest, Road) with no Forest Cover attributes
- **NP Forest** with no Forest Cover attributes **and natural** (lake, river, swamp, etc.)
- **Recent harvest** – age class 0, 1 (0-20 years old)
- **Young forest** – age class 2, 3 (21-60 years old)
- **Maturing forest** – age classes 4, 5, 6 (61-120 years old)
- **Older forest** – age classes 7, 8, 9, (121-250+ years old)

The area occupied by each of the above buckets in the 1 km buffer area is calculated and each area total is weighted as per Table 7, then summed.

Table 7. Weighting of the Forest Cover buckets in Landscape Context area calculations.

Forest Cover Bucket	Area Weighting
NP not natural	0%
NP natural	100%
Recent cuts	10%
Young forest	40%
Maturing forest	70%
Older forest	100%

Two subtractions from this area total are then applied as follows:

- Length of polygon boundary adjacent to recent harvest as a %; this % is divided by 6
- Metres per ha of major roads (highways, mainlines) within the buffer area; this is divided by 2.5

The resulting score is then divided by 10; the potential score range is thus 0 to 10.

Figure 13 illustrates the assessment of landscape context for two contrasting example polygons from TFL 37.

3.1.5.1 Modelling Landscape Context – Future Scenarios (100 years and beyond)

Landscape Context scoring gets applied in the same fashion for future stands. Figure 14 shows a Patchworks™ projection of future spatial configurations, including road networks (NP). As mentioned above, these spatial configurations tend to have more (and thus smaller) polygons than what might be considered logical for ecological assessment.

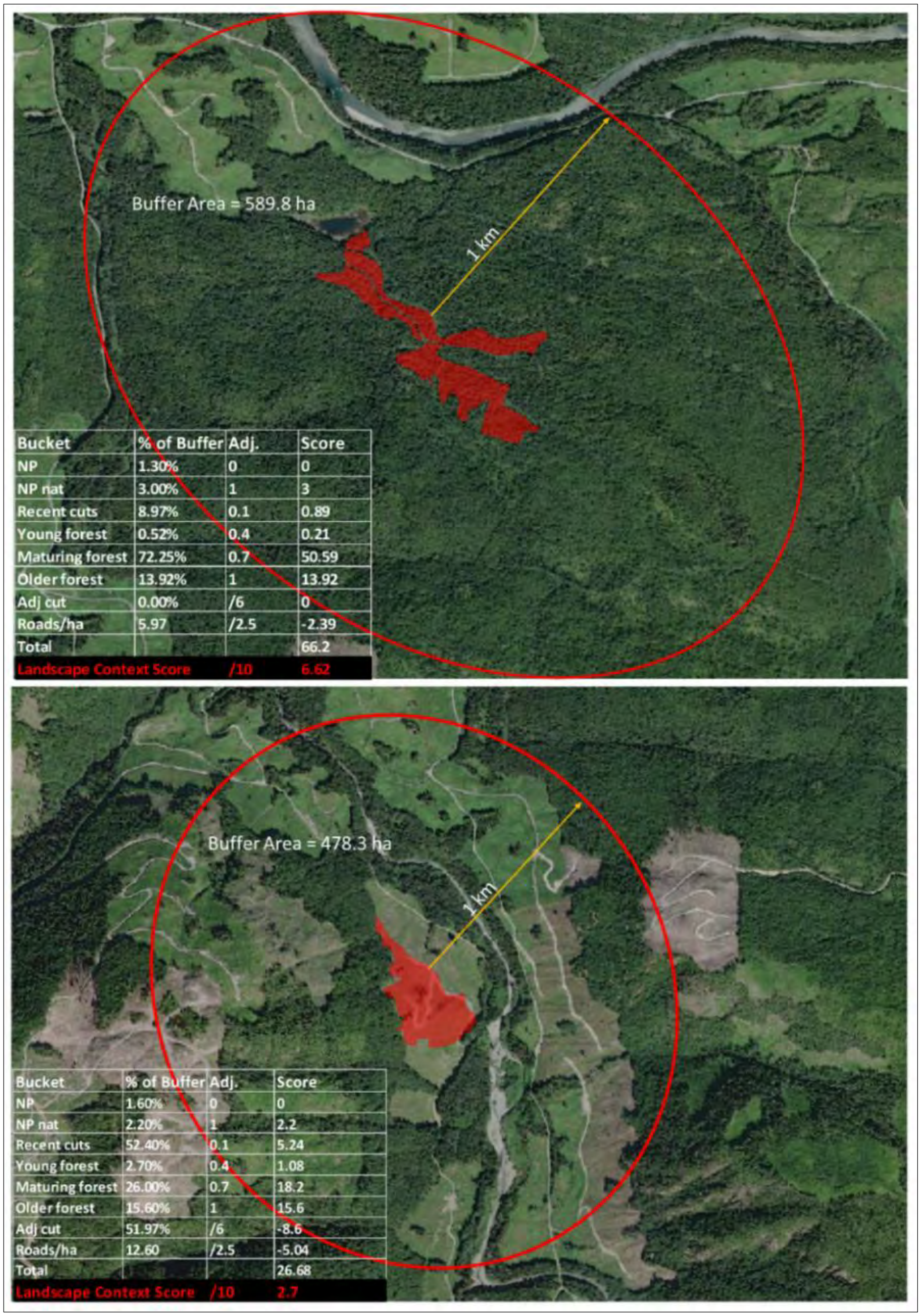


Figure 13. Calculation of the Landscape Context Score for two contrasting sample polygons. See text for further explanation.

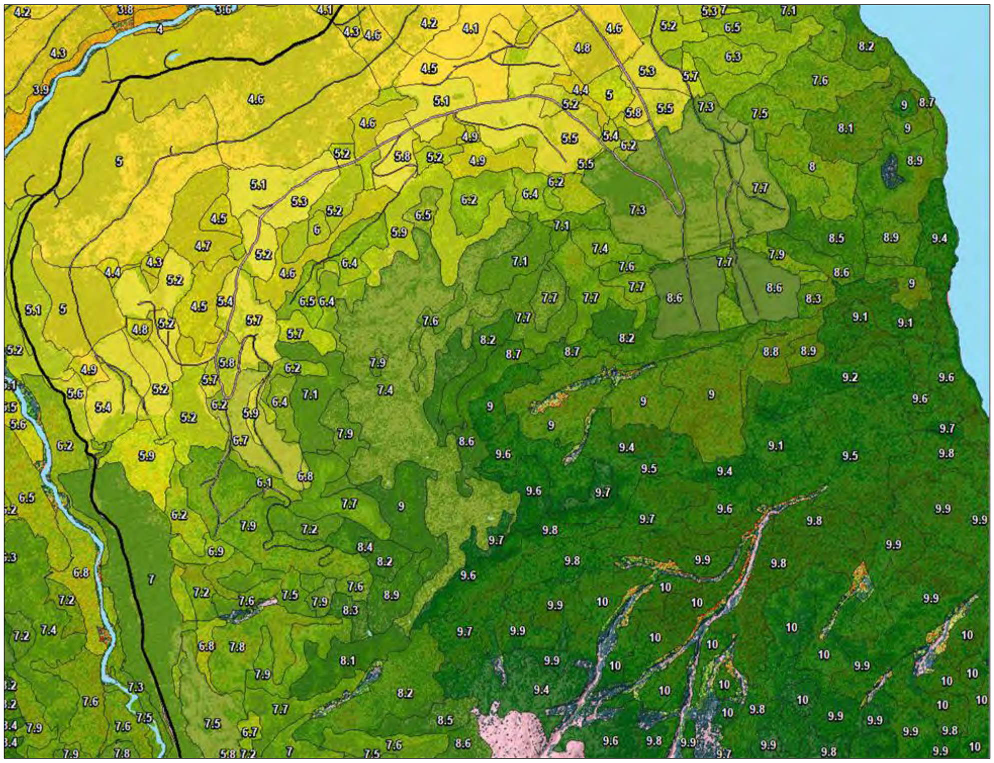


Figure 14. Patchworks™ projection of future spatial configuration of polygons, colour-themed and labelled according to landscape context scoring.

3.2 Calculating Polygon Integrity Scores

Assessment of the five integrity components results in six scores being calculated for each forest cover polygon (the canopy complexity component has scores for two attributes – mean and SD rumple). An ecosystem integrity total score is calculated by simply adding the six individual scores. No individual component score weightings are applied at this step since they were applied earlier through the calculation/normalization of individual scores. The range of each of the attribute scores (and thus relative weighting) is presented in Table 8. A theoretical maximum ecosystem integrity score is 42.5. For the four plan areas, the maximum score, under current conditions, is 38.6. The range of ecosystem integrity scores for each plan area is presented in Table 9.

Table 8. Score ranges for the Ecosystem Integrity components (Year 0)

Component/attribute	Score Range
Canopy Complexity	
- rumple	0 – 10
- SD rumple	0 – 5
Age	0 – 10
Tree species diversity	1 – 2.5
Polygon size	1 – 5
Landscape context	0 – 10
Total score	2 – 42.5

Table 9. Mean, minimum, and maximum ecosystem integrity scores for plan areas (Year 0)

Plan Area	Ecosystem Integrity Polygon Score			
	Minimum	Mean	Maximum	Area Weighted Mean
TFL 37 FLP	3.2	19.9	36.9	20.2
Hišuk ma ćawak IRMP (incl. TFL 44)	3.3	17.6	37.7	18.7
Tla'amin FRP (incl. TFL 39 Block 1)	4.0	21.6	37.9	23.0
Nanwakolas TFL 64 IRMP	3.1	20.1	38.6	18.1

3.3 Determining the Base Polygon for Analysis

3.3.1 Base Polygon Aggregation

As discussed in Section 3.1.4, the aggregation of forest polygons is integral to be able to apply an effective size score. Using forest cover polygons as the base polygon for evaluation would devalue forest stands with adjacent stands that are only separated due to a slight difference in species composition. This aggregation process also creates two other process benefits. By grouping polygons of similar attributes, it helps to eliminate artificial polygon boundaries. Artificial splits in the forest cover appear in areas where tenure and administrative boundaries exist, even if there is no change in forest attributes. Aggregation also reduces the overall number of polygons to be assessed and scored. This reduces the amount of processing time it takes to calculate a Landscape Context Score across the land base.

The polygon groupings are built directly from the Patchworks™ resultant and are based on adjacent polygons with the same or similar attributes.

Several different potential combinations of attributes were considered. Patches were grouped using different combinations of Non-Productive Descriptor (NP_DESC), Site Index Class, Age Class, Leading Species (SP1), Species Diversity Score, and Biogeoclimatic Zone (BEC / BEC variant). These were evaluated for effectiveness in reducing the overall number of polygons to be assessed, the polygon size distribution, and how they affected size scoring.

After several potential combinations were assessed, the 'baseline' grouping using just the three main attributes of NP Descriptor, Age, and Site Index was selected. This combination created the least number of polygons and the polygon boundaries aligned well with ecological splits. The addition of the other variables (BEC, SP1, Species Diversity Score) increased the total number of polygons and did not show any real benefit ecologically. Some of the polygon splits appeared to be non-ecological in nature.

The final Base Polygon groupings are based on the following:

1) NP Descriptor – Productive and NP Forest w/ SI and Age attributes
2) Age Classes
   0-20, 21-40, 41-60, 61-80, 81-100, 101-120, 121-140, 141-190, 191-250, 250+
3) Site Index Classes – Leading Species dependent Site Index classes of Poor, Moderate, and Good.
   - Hemlock, Spruce, Balsam
     - SI < 15 = Poor
     - SI >= 15 & SI < 23 = Moderate
     - SI >= 23 = Good
   - Red and Yellow Cedar
     - SI < 17 = Poor

SI >= 17 & SI < 25 = Moderate
SI >= 25 = Good

Douglas Fir

SI <19 = Poor
SI >= 19 & < 27 = Moderate
SI>= 27 = Good

Deciduous / Pine / Other

SP1 - At, Ac, La, Pl, Plc, Pw = Poor
SP1 - Mb, Act, Dr = Moderate

3.3.2 'Sliver' Polygon Eliminations

One of the unfortunate results of using a Patchworks™ resultant that combines several GIS datasets is that is carves up the land base into hundreds of thousands of polygons. After aggregation, the total number of polygons is reduced to tens of thousands, but the result includes thousands of small 'sliver' polygons. These tiny polygons do not share the same attributes of adjacent polygons but are so small that they have little influence on the overall Ecosystem Integrity scoring. However, these polygons do negatively impact processing time and the overall dataset size. These sliver polygons should be eliminated and dissolved into neighboring polygons while still maintaining the topological and ecological integrity of the dataset.

The first set of eliminations are for all productive polygons that are less than 0.25 ha. These eliminations are only dissolved into adjacent productive polygons and are age class dependent. This means that a sliver can only be dissolved into an adjacent polygon that is within one age class. This prevents a sliver from a younger regenerating forest from being dissolved into an old growth polygon, and *vice versa*.

Once these age-based eliminations are complete, a second round of eliminations is done for all polygons under 0.1 ha. These eliminations are not restricted by age or if a polygon is productive or not. These eliminations greatly reduce the number of small 'sliver' polygons, and by extension, the overall number of polygons to calculate in the dataset.

3.3.3 Future Years Base Polygons

Modelling future years in Patchworks™ is based on the same original resultant as used for Year 0. The harvest schedule is burned into this resultant. The resulting polygons are aggregated into base polygons in the same fashion as detailed above, and the same sliver elimination procedure is conducted. These grouped polygons may be broken up into smaller groups depending on when the harvesting was scheduled, where it was located, and what forest practices were modelled. Naturally, the land base gets further fractured as years pass and more rotations of harvesting are modelled. Relative to the current state at Year 0, the total number of polygons will generally increase, and the average size will decrease, although this may not be representative of actual harvest practices. As the base polygons get further fractured, the percentage of polygons that are less than 1 ha increases.

Table 10. Number of base polygons for each of Year 0, Year 100, and Year 300, including proportion of small polygons

Plan Area	< 1 ha	>=1 ha	percent < 1 ha	Polygon total
TFL 37 FLP				
Year 0	1593	6899	19%	8492
Year 100	13103	4740	73%	17843
Year 300	17325	6249	86%	20120
Hišuk ma ćawak IRMP				
Year 0	2220	3786	37%	6006
Year 100	9350	12069	44%	21419
Year 300	11469	16371	41%	27840
Tla'amin FRP				
Year 0	5572	12625	31%	18197
Year 100	19163	12776	60%	31939
Year 300	19950	15227	57%	35177
Nanwakolas TFL 64 IRMP[6]				
Year 0	6052	5403	53%	11455
Year 100	[redacted]	[redacted]	[redacted]	[redacted]
Year 300	[redacted]	[redacted]	[redacted]	[redacted]

4 Results

4.1 Ecosystem Integrity Assessment – Current Conditions (Year 0)

4.1.1 Broad Scale Assessment

The ecosystem integrity assessment over the four plan areas encompassed 546,028 ha, including 44,150 individual forest cover polygons, for the analysis of current (year 0) conditions. NP polygons without forest cover information representing natural habitats like wetlands and permanently altered sites such as roads, could not be assigned an ecosystem integrity score but these polygons were included in the landscape context scoring of nearby/adjacent polygons (see Section 3.1.5).

Individual polygon integrity scores range from 3.1 to 38.5. The histogram of the combined polygon integrity score values is shown in Figure 15. The histogram shows a bimodal distribution of polygon integrity scores with peaks around 13.5 and 26. Individual histograms for each plan area are available in Appendix 2. When comparing to the age class distribution of the individual areas (not included), it is evident that the distribution is related to the age distribution on the area of interest.

[6] Numbers redacted since the IRMP is ongoing at the time of publication and the results reflect a draft scenario.

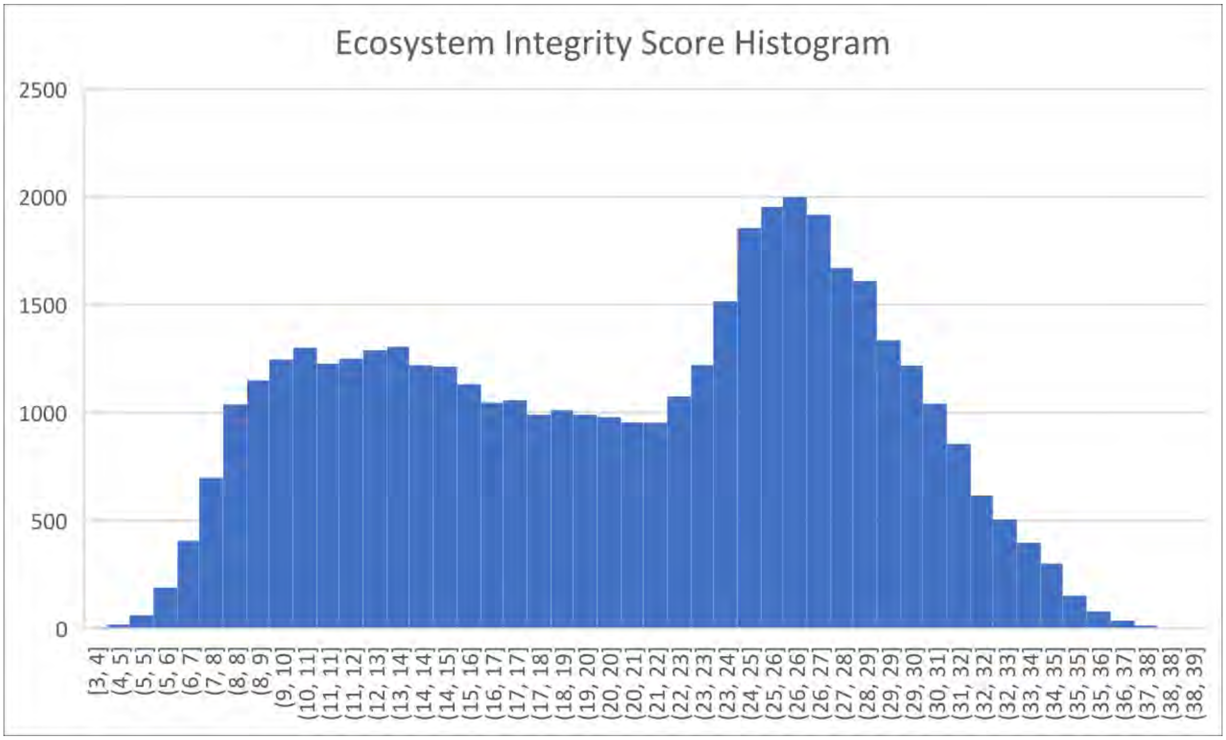


Figure 15. Histogram of polygon integrity scores for combined data across four plan areas (current conditions - Year 0)

4.1.2 Looking at Variation – Defining Integrity Score Classes

While summarizing mean values for areas of interest are useful at a broad scale, applying integrity score classes to the assessment is required to better analyze/summarize how integrity varies across a broad area. Classes are also useful to examine (through modelling) how integrity scores change over time in response to future proposed management scenarios. Initially, scores for individual areas were split into eight categories—with each category containing an equal number of polygons (Figure 16). There were four classes (quartiles), which were split in half, for the eight categories.

This method of polygon 'count-based' quartiles was used initially in each of the plan areas to colour maps at Age Zero, Age 100, and Age 300, and to summarize the change in each of the classes/subclasses at each of these time periods.

The polygon count-based approach simply divided the total number of observations (polygon integrity scores ordered from smallest to largest) into quartiles with the 50% quartile being the median. Quartile classes are labelled as per Figure 19 with 'IV' being the lowest score class. Each class is further subdivided into 'a' and 'b' subclasses with 'b' being the low subclass.

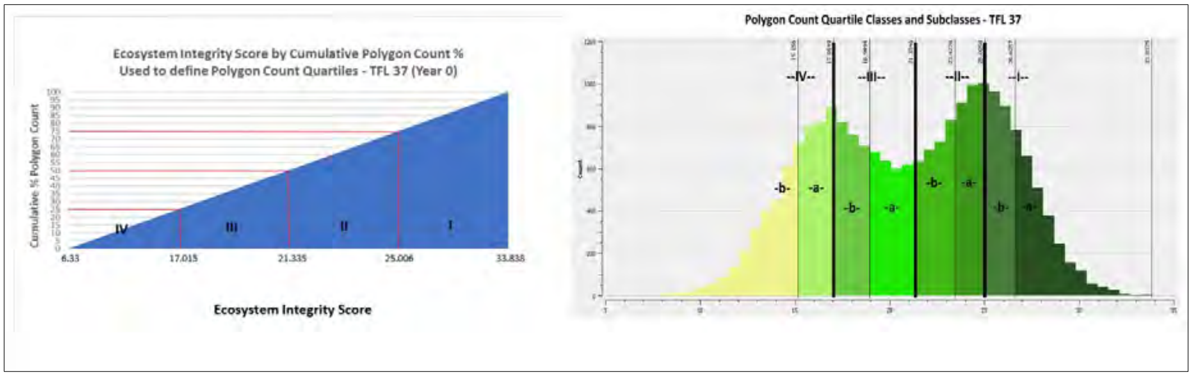


Figure 16. Defining polygon integrity score quartile classes/subclasses – example for TFL 37 (year 0).

The main challenge with this method was that class/subclass thresholds varied quite a lot between the plan areas. The main factors influencing the thresholds appeared to be the age class distribution of forests, and issues associated with the forest cover of the area. For example, some areas had a lot of small polygons, resulting from the historical development of the forest cover layer, and the need to combine forest cover from various licensees. These small polygons add to the count but contribute little area. Even with this limitation, the eight class/subclass categories were useful for observing change over time (Year 0, Year 100, Year 300) at the initial stages of planning, both spatially and aspatially.

However, to better represent the actual integrity of the forests and to be able to compare between areas, an "absolute" or single scale was required, where class/subclass thresholds divide the range of scores into categories that portray an ecologically meaningful ranking of integrity,

4.1.2.1 Developing an Absolute Ecosystem Integrity Scale

Once we had a reasonable range of areas, encompassing the full age class distribution, "absolute classes" were developed. The eight class/subclass scoring developed initially proved useful for spatial and aspatial evaluation, so it was retained. The task then was to develop thresholds for each class/subclass.

In BC, the NatureServe/BCCDC approach to assessing ecosystem integrity has been utilized primarily for the assessment of rare and at-risk ecological communities (British Columbia Ministry of Environment 2006; Faber-Langendoen et al. 2016; see Section 2.1.1). This approach provides a more absolute assessment scale for ecosystem integrity, but while similar in concept, it was designed for a different specific purpose (on-the-ground and GIS assessment of single ecological community occurrences) and uses different specific assessment criteria. We recognize these limitations but still consider the NatureServe/BCCDC approach to be the best available linkage to an absolute integrity scale.

Initially, we reviewed, on-screen, polygons of various ages and considered which of the NatureServe/ BCCDC system (Appendix 7.1) integrity classes (Poor, Fair, Good, and Excellent) seemed to best fit. This was accomplished by evaluating condition, context, and size. However, characterizing the NatureServe classes precisely using our assessment attributes was not straightforward. It was sometimes difficult to decide on just one class because of some combinations of attributes (e.g., young stands with high landscape context scores, or small old stands, etc.). Many examples were thus assigned a 'poor to fair' or 'fair to good' etc. integrity class. The goal was to develop thresholds for the classes/subclasses and relate these classes/subclasses to the NatureServe/BCCDC classes.

The absolute classes were developed as follows:

- Evaluating an ecologically meaningful 'score' for polygons of various sizes, ages, integrity scores, etc. visually on-screen, in each of the plan areas.
- Reviewing the range of ecosystem integrity (EI) scores by age class (Figure 17) and considering what would be a reasonable range of EI scores for a particular age class, but allowing for overlap across age classes, as the various EI attributes vary considerably across similarly aged stands, which determines their EI.
- Evaluating various iterations of class thresholds and whether they made ecological sense in each of the plan areas, and across all areas.

The resulting eight classes, and their threshold scores, are shown in Table 11. Figure 18 presents the approximate relationship between our classes/subclasses and the NatureServe/BCCDC classes.

Figure 18 illustrates that our classes show general alignment with the CDC classes, with the exception that our Class Ib extends into the higher end of the NatureServe Class B. This evaluation is qualitative, and the figure attempts to display the relationships as interpreted. All four BCCDC classes are represented in the study area but note that the high end of excellent (A) and the low end of poor (D) are not represented. The highest of the A category is likely restricted to large undisturbed (by humans) landscapes (e.g., protected areas) and the lowest end of the D category would include habitats that have been permanently altered from their natural condition, such as urban areas. Technically, roads and some landings would fall into this category, but these were not assessed as individual polygons in the study area, though they were considered in the landscape context assessment of nearby polygons.

Table 11. Ecosystem Integrity ranges for the absolute classes

Integrity Class	Integrity Subclass	Min Score	Max Score
I		**28.8**	**38.6**
	Ia	31.9	38.6
	Ib	28.8	<31.9
II		**21.7**	**<28.8**
	IIa	26.7	<28.8
	IIb	21.7	<26.7
III		**14.1**	**<21.7**
	IIIa	17.3	<21.7
	IIIb	14.1	<17.3
IV		**3.1**	**<14.1**
	IVa	11.5	<14.1
	IVb	3.1	<11.5
Overall		**3.1**	**38.6**

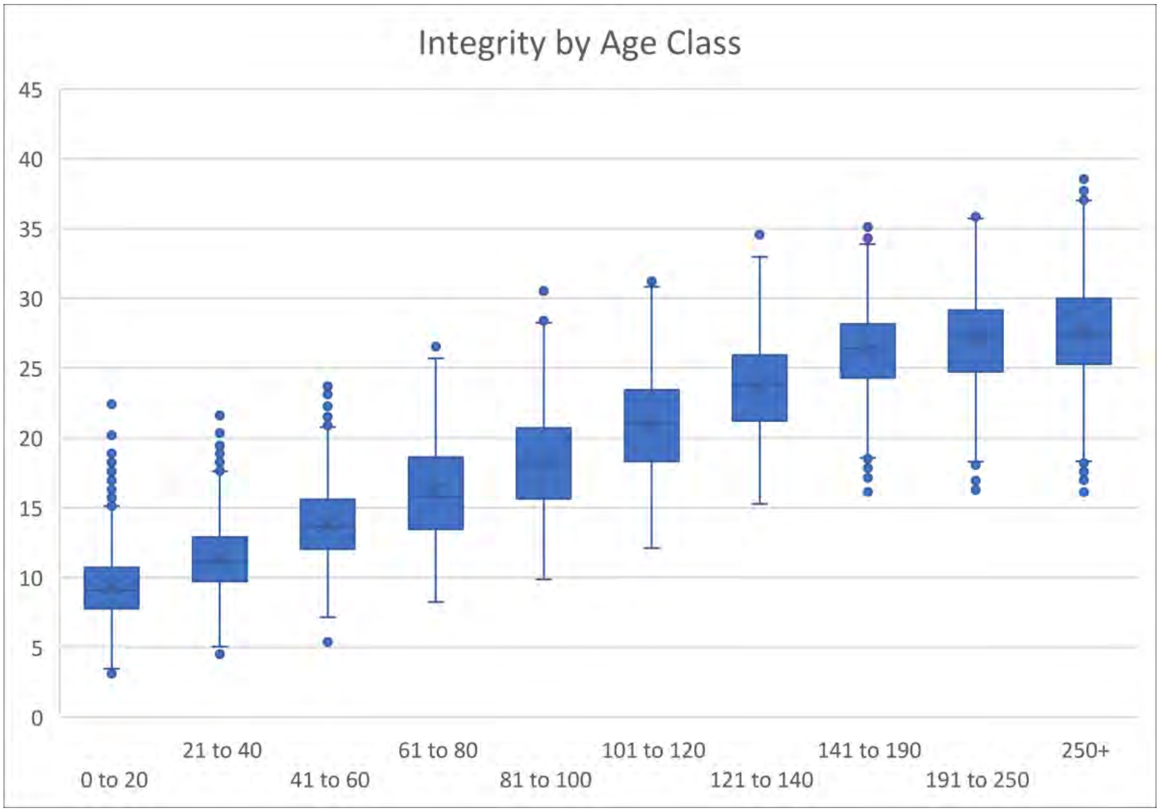


Figure 17. Relationship between age class and ecosystem integrity polygon scores.

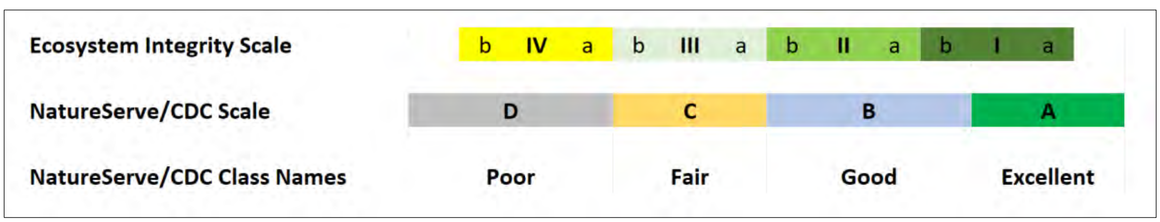


Figure 18. Linkages between 'absolute' ecosystem integrity classes/subclasses and the NatureServe/BC Conservation Data Centre (CDC) ecosystem integrity classes.

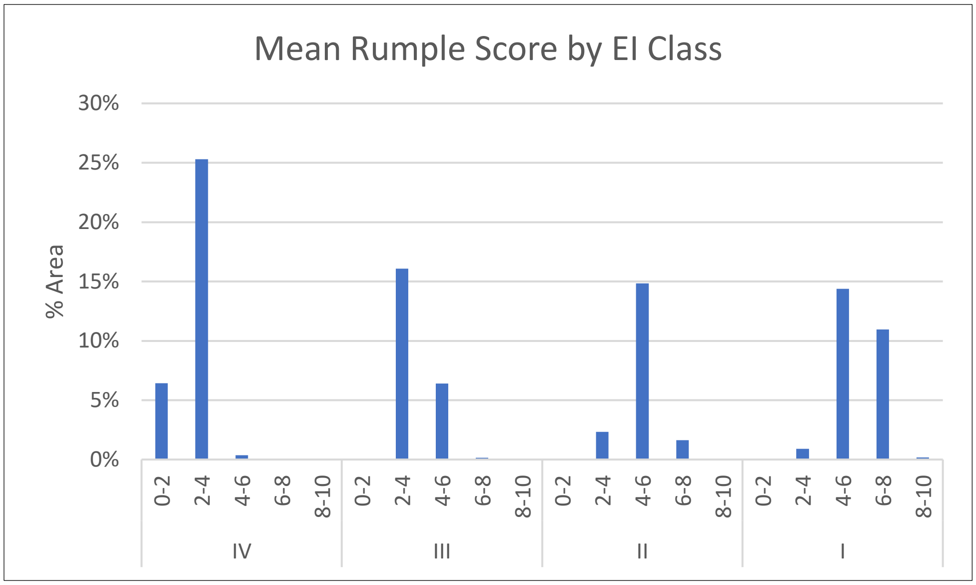
Table 12 shows the proportion of area, over all plan areas, of each EI subclass by age class. The table also shows the area of each age class over the combined areas, as well as the total area of each subclass over the entire area.

Table 12. Proportional area in ecosystem integrity subclass and age class for combined plan areas

		Age Class											
	Age:	0 to 20	21 to 40	41 to 60	61 to 80	81 to 100	101 to 120	121 to 140	141 to 190	191 to 250	250+	Area (ha)	% Area
EI Class/Subclass	**Ia**							1%	5%	19%	45%	68,427	13%
	Ib						2%	18%	50%	40%	41%	71,432	13%
	IIa					2%	19%	33%	26%	24%	8%	28,819	5%
	IIb				20%	54%	66%	45%	18%	16%	5%	71,028	13%
	IIIa		1%	12%	65%	38%	12%	4%	1%	1%		60,309	11%
	IIIb	3%	10%	57%	14%	5%	2%					59,675	11%
	IVa	12%	29%	30%	2%	1%						54,088	10%
	IVb	85%	60%	1%								115,943	22%
	Area (ha)	85,262	70,649	72,009	49,704	37,375	37,530	10,993	11,088	9,942	145,169	529,720	100%
	%. Area	16%	13%	14%	9%	7%	7%	2%	2%	2%	27%	100%	

4.1.3 Characterizing Integrity Classes – Importance of Individual Attributes as Drivers of Integrity

Figures 19, 20, and 21 illustrate the attribute score area profiles within each of the four integrity classes. Figure 22 summarizes these relationships slightly differently; mean integrity scores for each of the four classes are broken down by attribute means. Looking at the contribution of individual attributes across the classes is instructive for looking at what is driving the total integrity scores. Each of the attributes will be discussed individually in the following subsections.



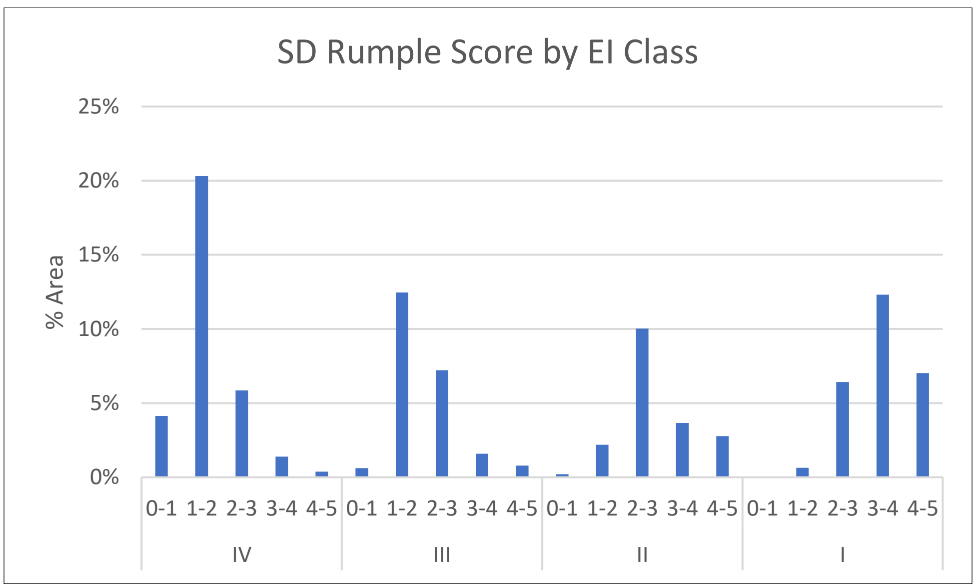
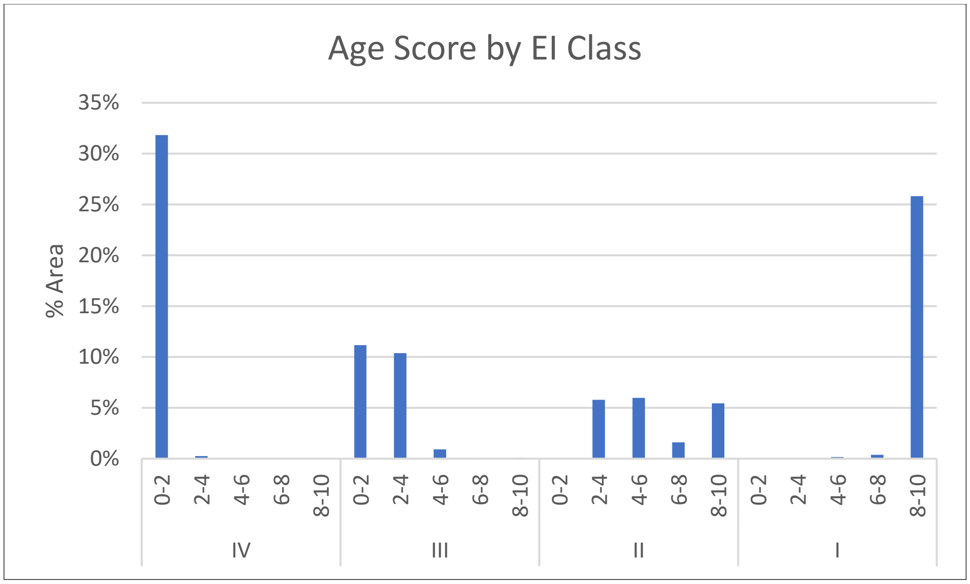


Figure 19. Attribute score area profiles for the integrity classes (IV, III, II, I) for all planning areas combined; current conditions (year 0). Top: rumple (the rumple scoring is continuous but for graphing, the scores have been converted to five classes); bottom: SD Rumple (standard deviation) (as per rumple, continuous scores have been converted to five classes for graphing).



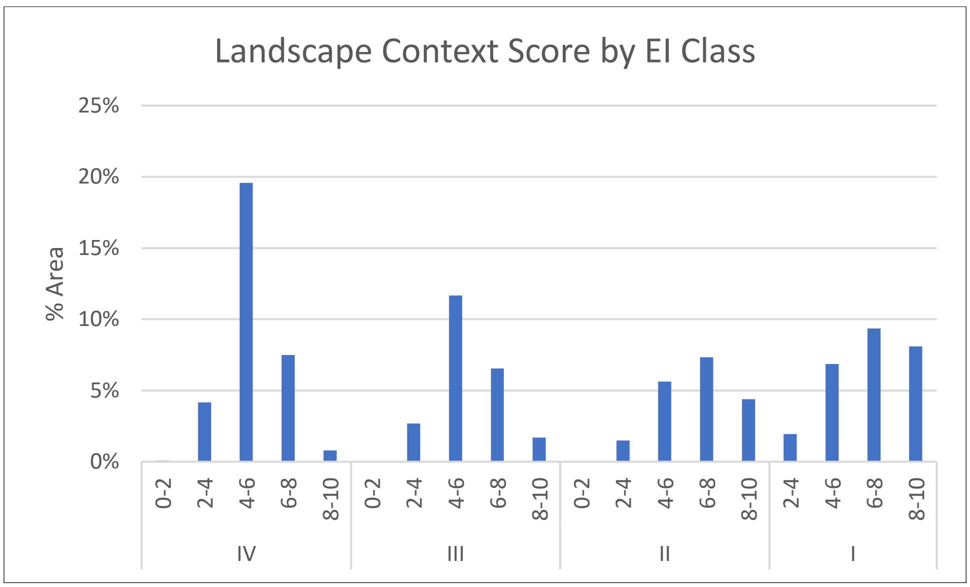
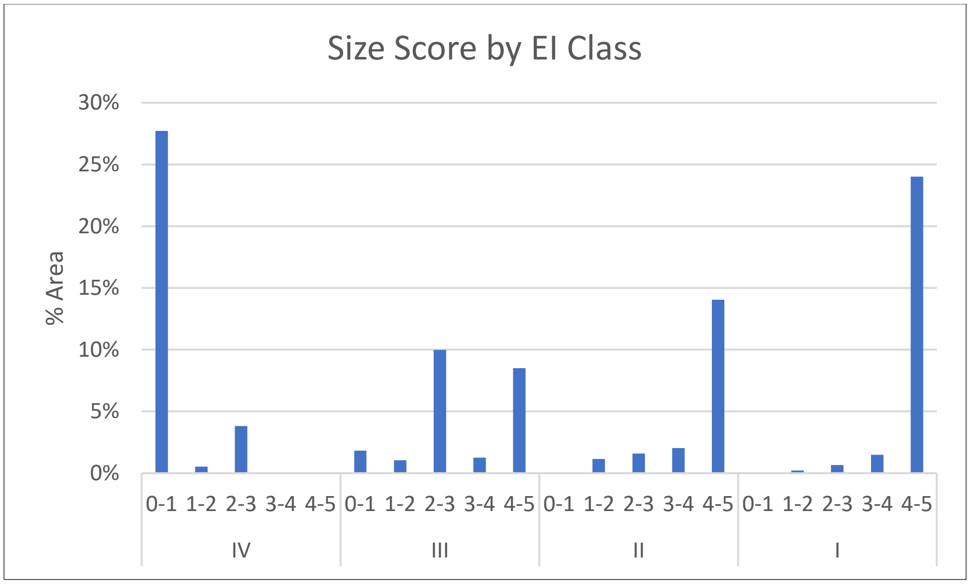


Figure 20. Attribute score area profiles for the integrity classes (IV, III, II, I) for all planning areas combined; current conditions (year 0). Top: age score (scores converted to five classes for graphing); bottom: Landscape Context (continuous scores have been converted to five classes for graphing).



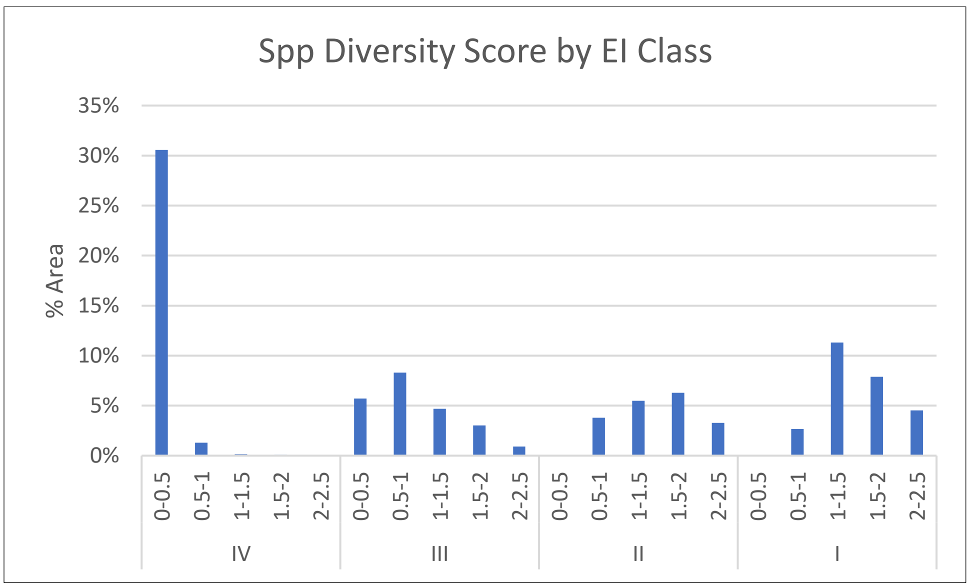


Figure 21. Attribute score area profiles for the integrity classes (IV, III, II, I) for all planning areas combined; current conditions (year 0). Top: size score (converted to five classes for graphing); bottom: Species (Spp) Diversity (converted to five classes for graphing).

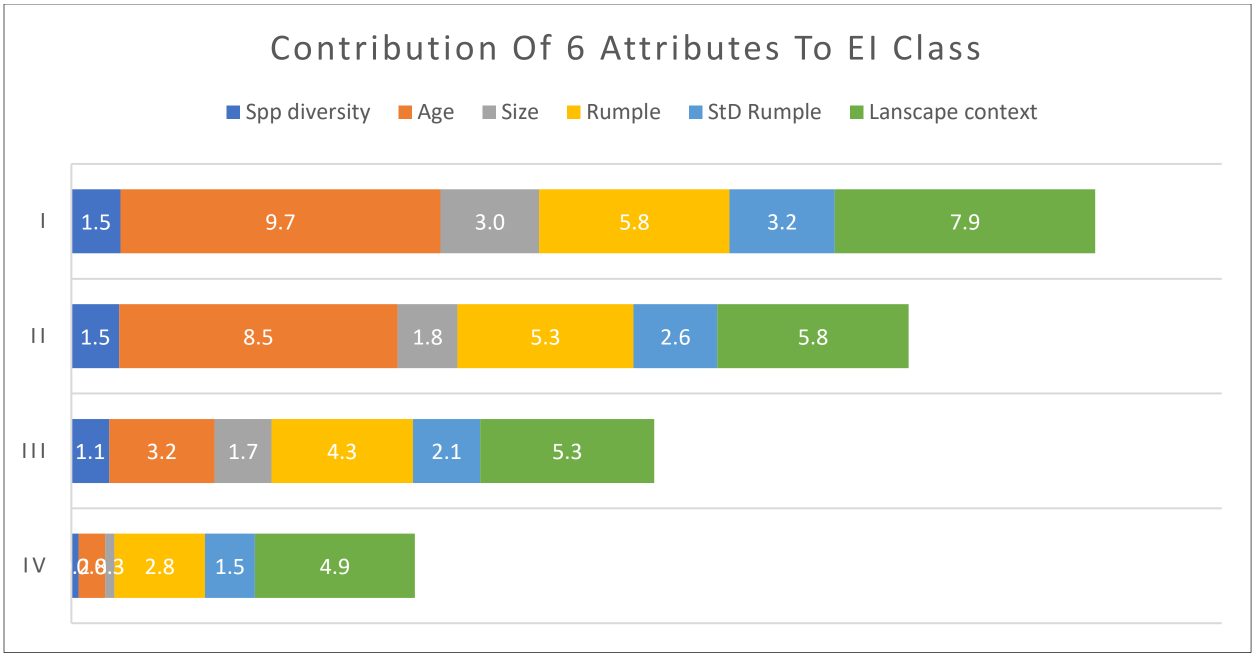


Figure 22. Mean integrity scores for each attribute across the four integrity classes; current conditions (year 0).

4.1.3.1 Rumple (Figure 19 top; and Figure 22)
Rumple is a primary driver for integrity with a clear increase in area occupied by higher score classes from class IV to I and a steady increase in mean rumple values from class IV to class I.

4.1.3.2 Standard Deviation of Rumple – Normalized (Figure 19 bottom; and Figure 22)
Standard deviation of rumple also shows steady increases in areas with higher scores from class IV to class I. Means for normalized SD rumple also show a steady increase from class IV to I. SD rumple is thus also a driver of integrity but to a lesser degree than mean rumple.

4.1.3.3 Age (Figure 20 top; and Figure 22)
It should be no surprise that age is unquestionably the greatest driver of ecosystem recovery and integrity. This is clearly illustrated in both the age score profiles (Figure 20) and the clear contribution of increasing mean age score to the increasing integrity mean (Figure 22).

4.1.3.4 Landscape Context (Figure 20 bottom; and Figure 22)
Both the score area profiles, and the score means across the integrity classes clearly indicate that landscape context is a significant driver of ecosystem integrity. Although the mean of this attribute increases from integrity class IV to I, the relationship is not as strong as some other attributes as lower integrity class stands can have high landscape context, depending upon what is going on around the polygon. Landscape context may boost the integrity score for a relatively young stand that would otherwise score lower without considering context. This is considered reasonable since landscape context is a key factor in evaluating important ecological factors such as habitat diversity, connectivity, interior forest condition, and surrounding hydrology. For example, a younger stand adjacent to older forest benefits significantly, in terms of habitat value, from that adjacency; it has quite different ecological values compared to being adjacent to a recent clearcut or younger forest.

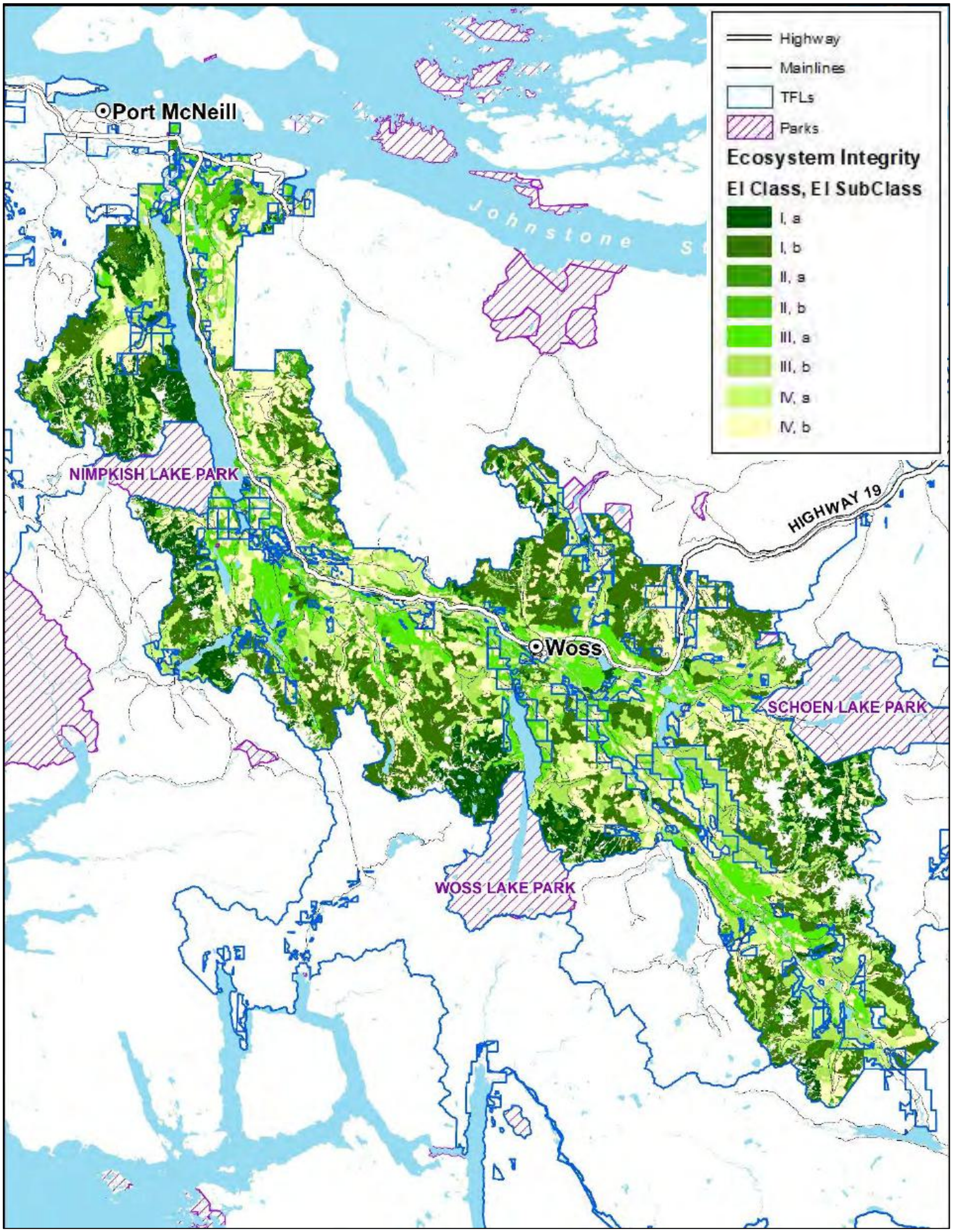
4.1.3.5 Size (Figure 21 top; and Figure 22)
As described in Section 3.1.4, size has been a challenging attribute to accommodate effectively. As presently scored, the average size score and the area of higher scores increases with EI class. While size can influence the total integrity score for specific polygons, it plays a relatively minor role in driving the integrity scores overall. As discussed in Section 3.1.4, polygon size and landscape context, in combination, impact on the degree of interior forest condition for each polygon.

4.1.3.6 Tree Species Diversity (Figure 21 bottom; and Figure 22)
Tree species diversity scores show increasing area and slightly higher mean scores in the higher EI classes (II, I) over the lower classes (IV, III). While the species diversity score can influence the integrity score up or down for specific polygons, it varies independently of the most important integrity driver, stand age.

4.1.4 Spatial Distribution of Integrity Classes
Figure 23 displays the current spatial distribution of integrity classes/subclasses in each plan area at year 0. Classes IV and III (light green and yellow colours) are most prevalent at low to mid elevations and classes II and I (darker greens) at mid to higher elevations (or Parks/Park Reserves). Section 5 provides further analysis and comparison of the integrity classes over time.

4.2 Assessing Changes in Ecosystem Integrity Over Time
Section 3 outlined the methods for developing ecosystem integrity scores for existing polygon conditions (Year 0) as well as modelling approaches to developing future attribute and polygon scores (e.g., Years 100 and 300). In the plan areas, ecosystem integrity was modelled for years 100 and 300, although any time period could be used. Section 5 presents the results of applying these methods and predicting integrity into the future based on management scenarios being developed by each planning team.

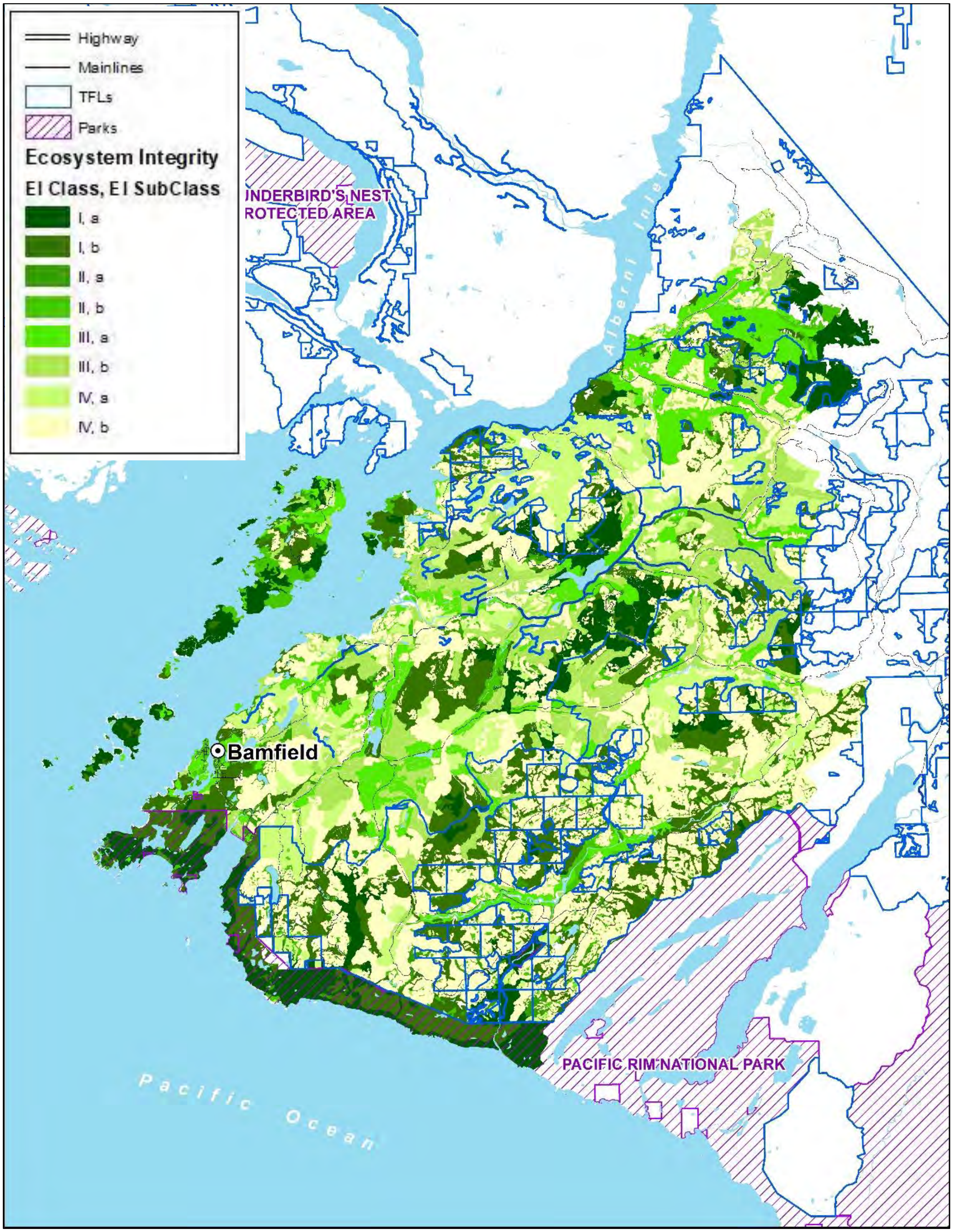
The management scenarios reflected in this section are not intended to reflect the preferred scenario or future forest condition selected for each plan area. The modelling of ecosystem integrity was completed utilizing draft scenarios in order to develop and refine the approach. The final ecosystem integrity through time will be reported out through each of the respective FLP and IRMPs.



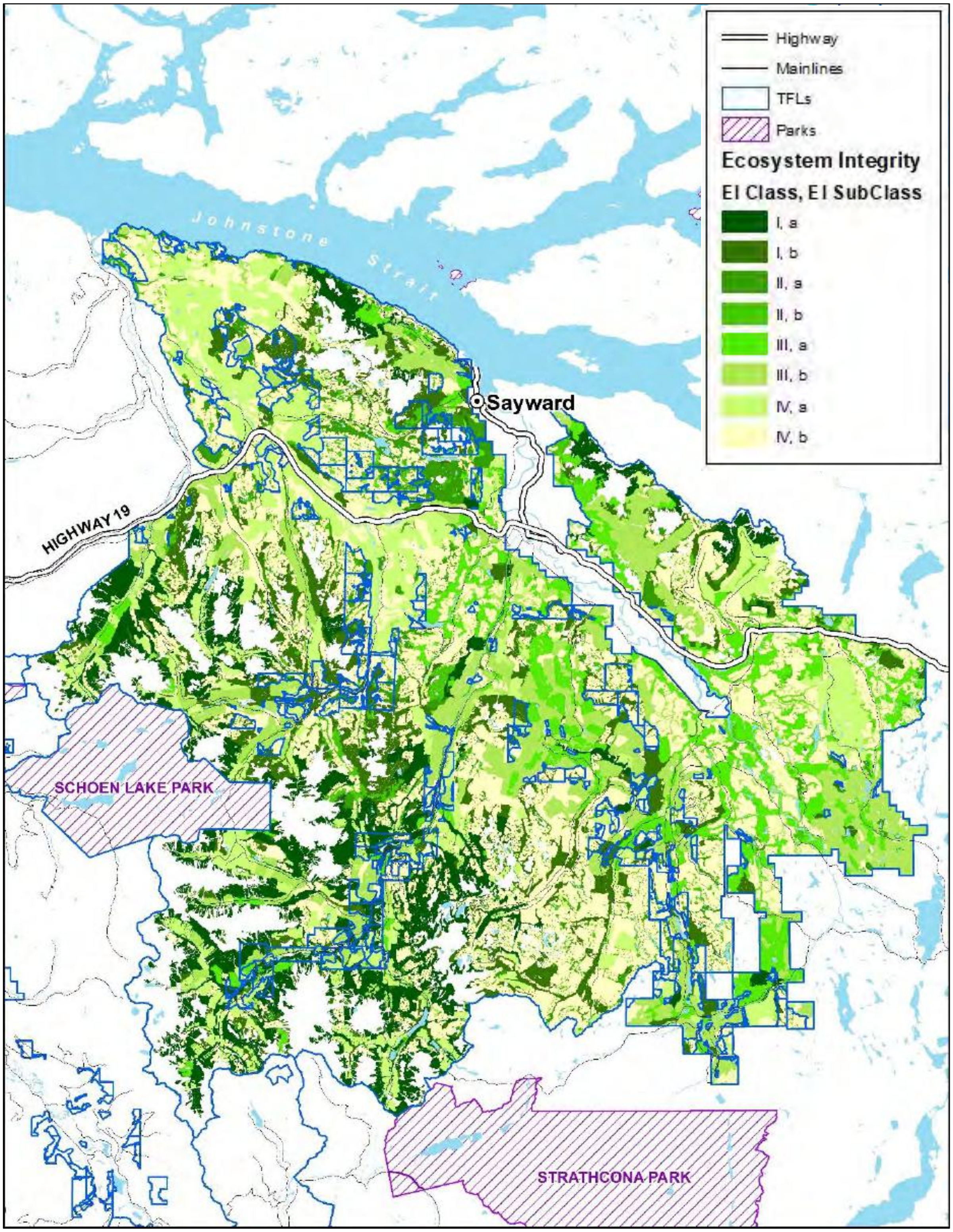
Highway
Mainlines
TFLs
Parks
Ecosystem Integrity
EI Class, EI SubClass
I, a
I, b
II, a
II, b
III, a
III, b
IV, a
IV, b
Port McNeill
Johnstone S
NIMPKISH LAKE PARK
HIGHWAY 19
Woss
SCHOEN LAKE PARK
WOSS LAKE PARK

a) TFL 37 FLP

b) Tla'amin FRP (incl. TFL 39 Block 1)



c) Hišuk ma ćawak IRMP (incl. TFL 44)



d)

Nanwakolas TFL 64 IRMP

Figure 23. Distribution of ecosystem integrity classes/subclasses in each plan area; current conditions (year 0); Integrity classes defined as in Table 11, with highest subclass (Ia) darkest green, grading to the lowest subclass (IVb) yellow in colour.

5 Reporting

The reporting to date has compared the change, over time, of the three time scenarios – Year 0, Year 100, and Year 300. Changes to the areas included within each of the classes and subclasses, combined with mapping of the future distribution of classes and subclasses, provides both aspatial and spatial descriptions of the predicted change in ecosystem integrity over time within the areas.

5.1 Aspatial Reporting of Predicted Changes in Ecosystem Integrity

For each plan area, changes in integrity between year 0, year 100, and year 300 are assessed aspatially, at a broad level, through comparison of mean integrity scores and individual attribute scores. Figure 24 illustrates the predicted change in ecosystem integrity scores (minimum, mean, area-weighted mean, maximum), between year 0 (current conditions), year 100, and year 300, based on comparing sampled data for year 0 with modelled data for future years. This predicts integrity changes generalized over the combined plan areas. Polygon means decrease at Age 100, and then rise (20.3 – 19.7 – 21.0), whereas area-weighted means increase slightly over each period (20.6 – 22.0 – 24.1).

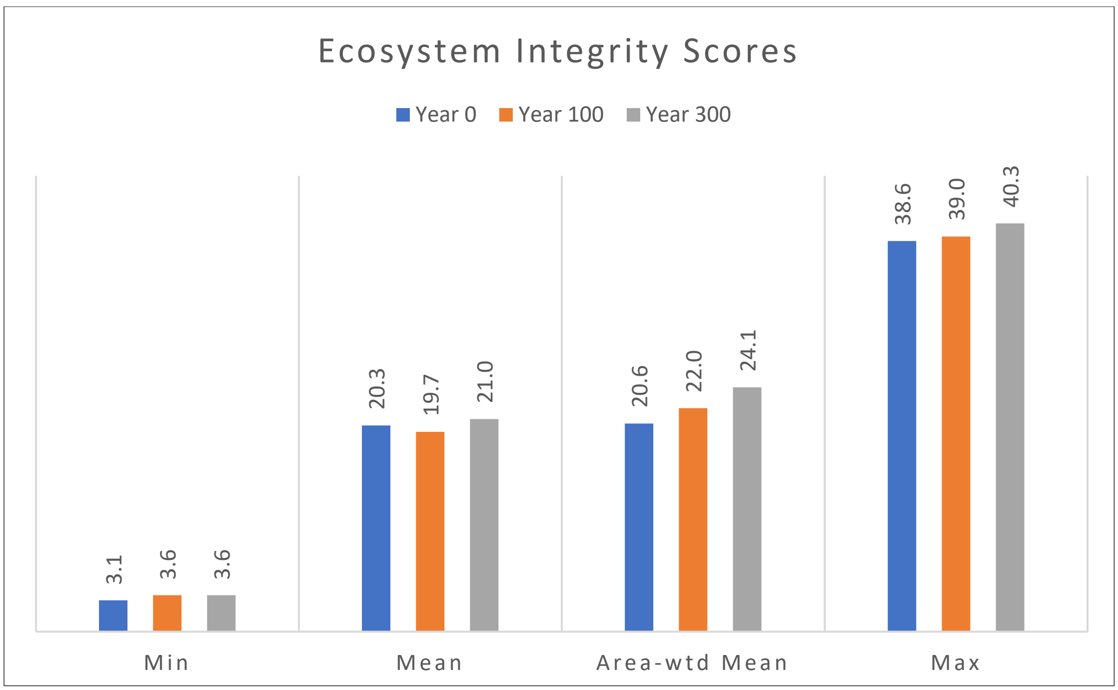


Figure 24. Current (Year 0) Ecosystem Integrity scoring compared with modelled integrity scoring for years 100 and 300 for all study areas combined.

The changes over time for each of the contributing attributes are also summarised—see Figure 25.

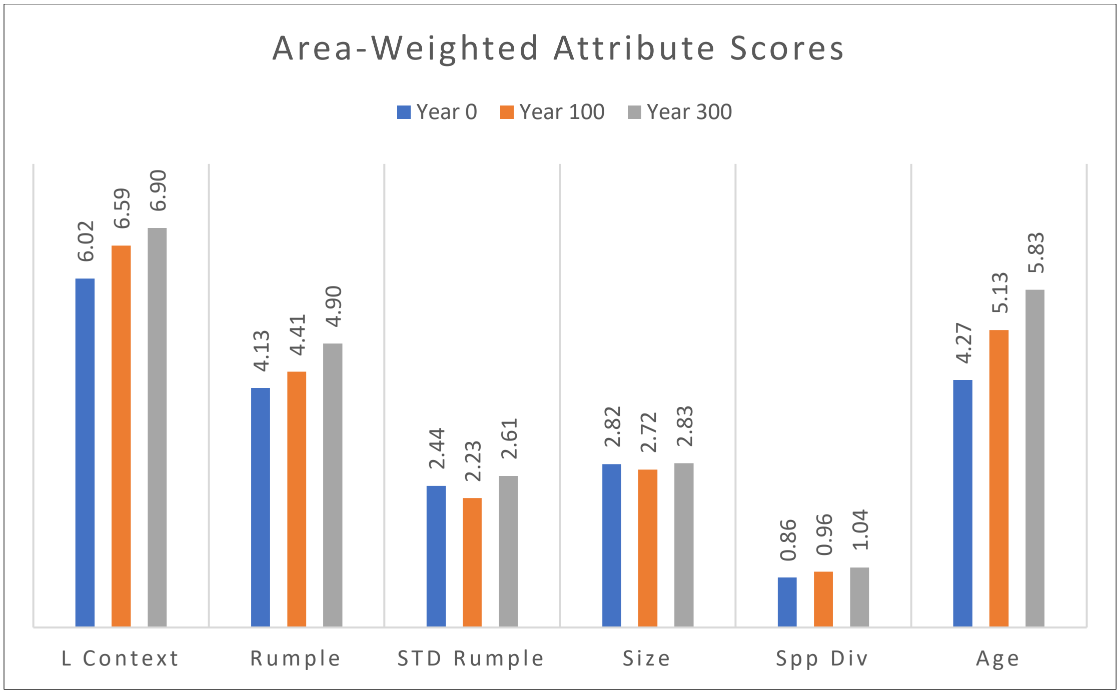


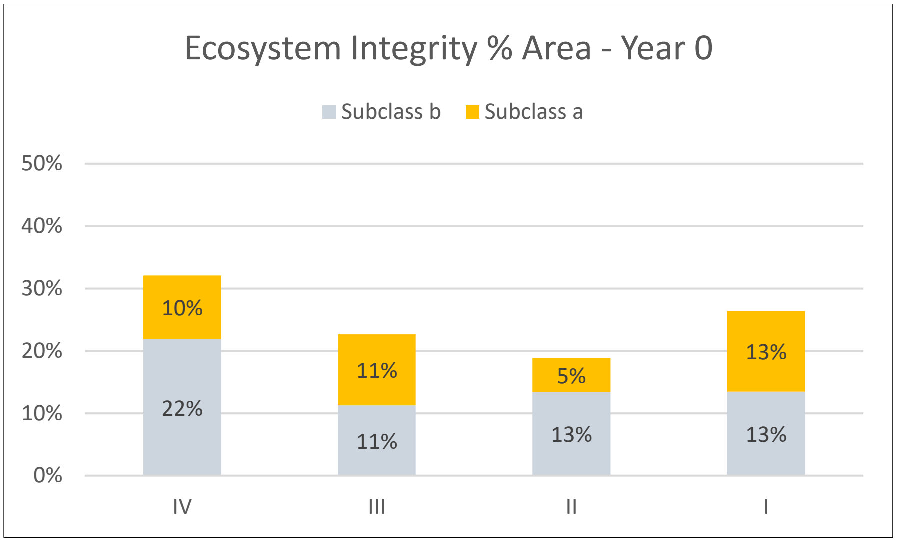
Figure 25. Current (Year 0) ecosystem integrity attribute scores compared with modelled attribute scoring for years 100 and 300 for all study areas combined. L CONTEXT = landscape context score; RUMPLE = mean rumple score; SD RUMPLE = standard deviation of rumple score; SIZE = size score; SPP DIV = species diversity score; AGE = stand age score.

Most of the area-weighted attribute scores are projected to increase over each of the selected time periods, with the largest increases in landscape context, mean rumple, and age scores.

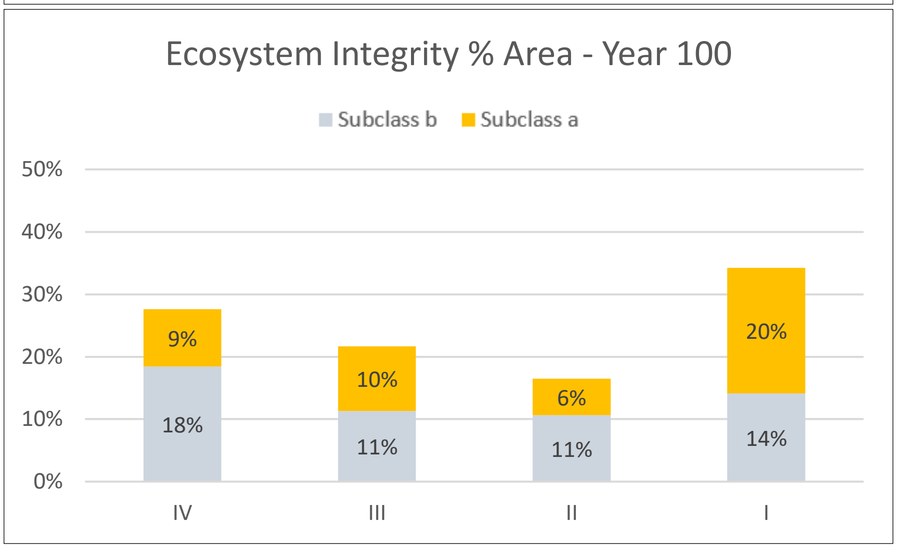
Figure 26 presents predicted changes in ecosystem integrity over the combined plan areas, over the three time periods: Year 0 (current), Year 100 and Year 300. For year 100, slight decreases in the area occupied by the lowest two integrity classes IV & III (about 6% of total scored area), and a corresponding increase in the highest two integrity class I & II are predicted. Slight decreases are predicted in Classes II, III and IV over the 100 years, with an increase of 8% in the highest integrity Class I.

By year 300, the largest predicted change from year 0 integrity occurs in class I (19% increase) as areas mature and shift through the other classes. At year 300, class I is predicted to make up 45% of the productive land base over the four plan areas (TFL 37 FLP, Hišuk ma ćawak IRMP, Tla’amin FRP; Nanwakolas TFL 64 IRMP). The other large change is in integrity class IV where there is a projected decrease in area of 9% over the plan areas. Comparing year 0 with year 300, there is approximately 10% less area of the combined classes III and IV (‘poor to fair’ integrity) and a corresponding 10% increase in the area of combined class I and II (‘good to excellent’ integrity).

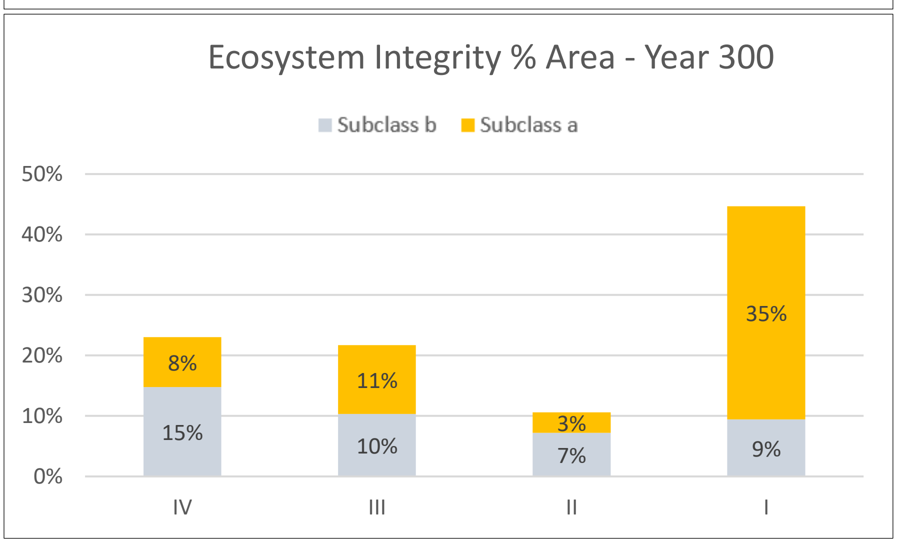
These combined area results are influenced by the proportional size of each areas (Table 13) and the planned management actions in each. Changes over time are best understood by reviewing the results in each plan area (Sections 5.1.1 to 5.1.4).



Year 0	
Class	Percent
IV	32%
III	23%
II	19%
I	26%
Total	100%



Year 100	
Class	Percent
IV	28%
III	22%
II	16%
I	34%
Total	100%



Year 300	
Class	Percent
IV	23%
III	22%
II	11%
I	45%
Total	100%

Figure 26. Area profiles for each ecosystem integrity class/subclass for year 0 (top), 100 (middle), and 300 (bottom) for all study areas combined.

Table 13. Size of Each Plan Area

Plan Area	Area (ha)
TFL 37 FLP	139,508
Hišuk ma c̓awak IRMP (incl. TFL 44)	73,747
Tla'amin FRP (incl. TFL 39 Block 1)	203,607
Na̱nwa̱kolas TFL 64 IRMP	129,166

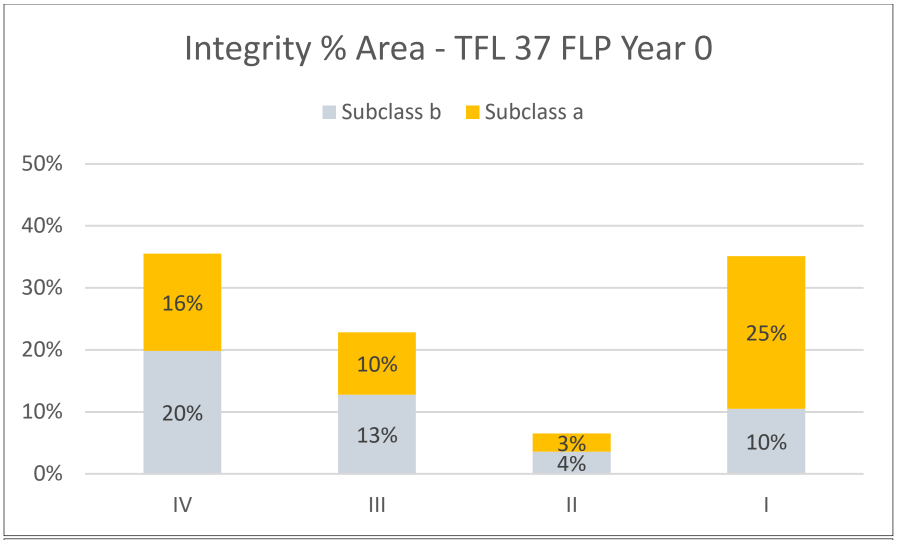
5.1.1 TFL 37 Forest Landscape Plan

Ecosystem Integrity area-weighted means for the TFL 37 FLP, for year 0, year 100, and year 300, are as follows: 20.2 – 20.7 – 22.0[7]. There is an increase over time because of the proposed changes in management, including an increase in landscape retention. The change in proportion of ecosystem integrity classes/subclasses over time is shown in Figure 27, and the change in the area by age class is shown in Figure 28.

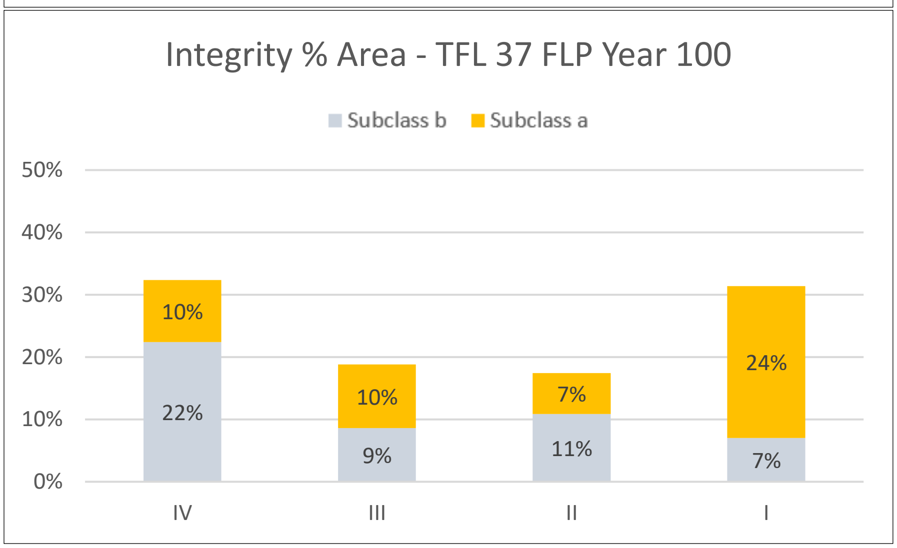
Predicted changes to ecosystem integrity over the 300-year period can be summarized (aspatially) as follows. For year 100, slight decreases in the area occupied by the lower integrity classes III and IV (decrease of 7 % of total scored area) are reflected in a 7% increase in the higher EI classes I and II. Subclasses Ia and Ib decrease slightly, whereas subclasses IIa and IIb increase as reserved young and mature stands further mature.

By year 300, the largest changes from year 0 integrity occur in class I (7% increase; 9,536 ha) as areas mature and shift through subclasses IIb and IIa; and in class IV, where there is a 9% decline (12,095 ha). At year 300, integrity class I forests are predicted to make up 42% of the productive land base. Comparing year 0 with year 300, there is approximately 6% less area of the combined classes III and IV ('poor to fair' integrity) and a corresponding 6% increase in combined area of class I and II ('good to excellent' integrity).

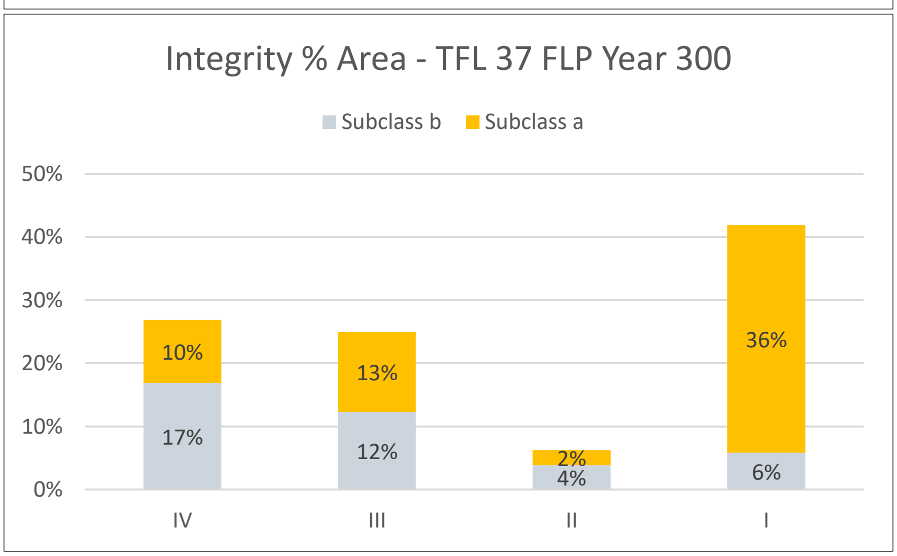
[7] These results are based on a draft scenario used to develop this approach and do not reflect the preferred scenario. The final ecosystem integrity results will be reported out separately in the FLP.



% Area	YEAR 0
Class	Total
IV	36%
III	23%
II	7%
I	35%
Total	100%



% Area	YEAR 100
Class	Total
IV	32%
III	19%
II	17%
I	31%
Total	100%



% Area	YEAR 300
Class	Total
IV	27%
III	25%
II	6%
I	42%
Total	100%

Figure 27. TFL 37 FLP – Area profiles for each ecosystem integrity class/subclass for year 0 (top), 100 (middle), and 300 (bottom). Class totals provided in small data table to right of each chart.

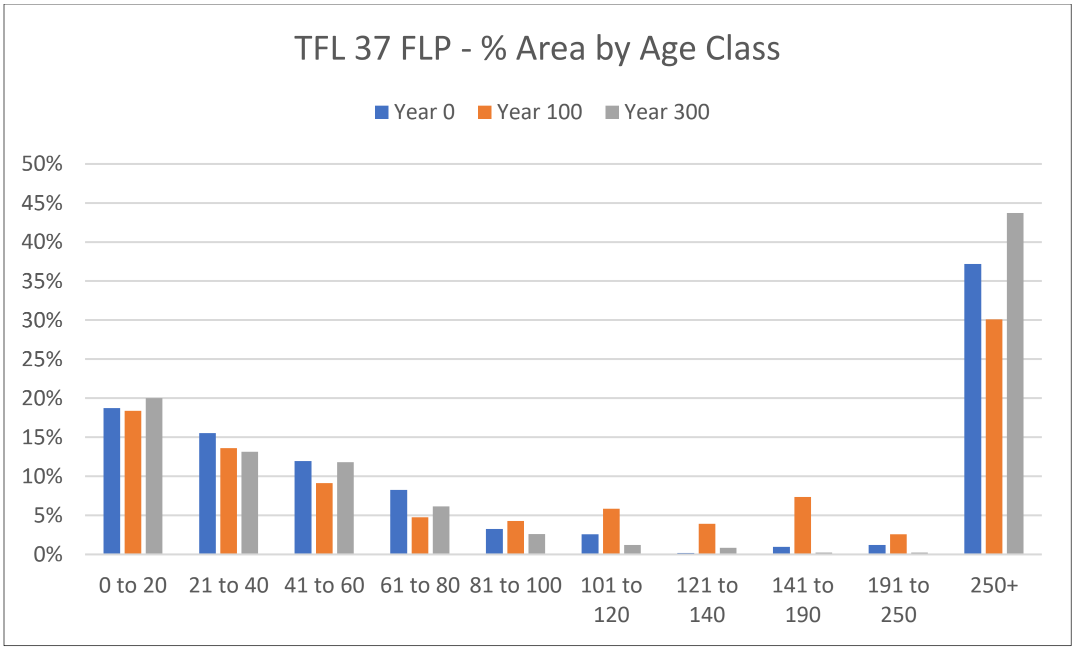


Figure 28. TFL 37 FLP – Area profiles for each age class for year 0, 100, and 300.

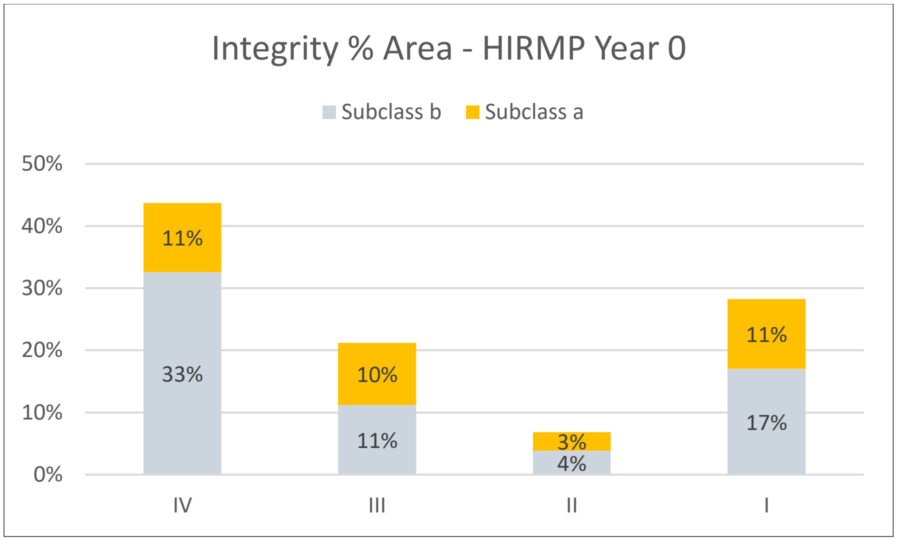
5.1.2 Hišuk ma c̓awak Integrated Resource Management Plan

Ecosystem Integrity area-weighted means for the Hišuk ma c̓awak Integrated Resource Management Plan (HIRMP) area, for year 0, year 100, and year 300, are as follows: 18.7 – 20.0 – 22.5[8]. There is an increase over time because of the proposed changes in management, including an increase in landscape retention. The change in proportion of ecosystem integrity classes/subclasses over time is shown in Figure 29, and the change in the area by age class is shown in Figure 30.

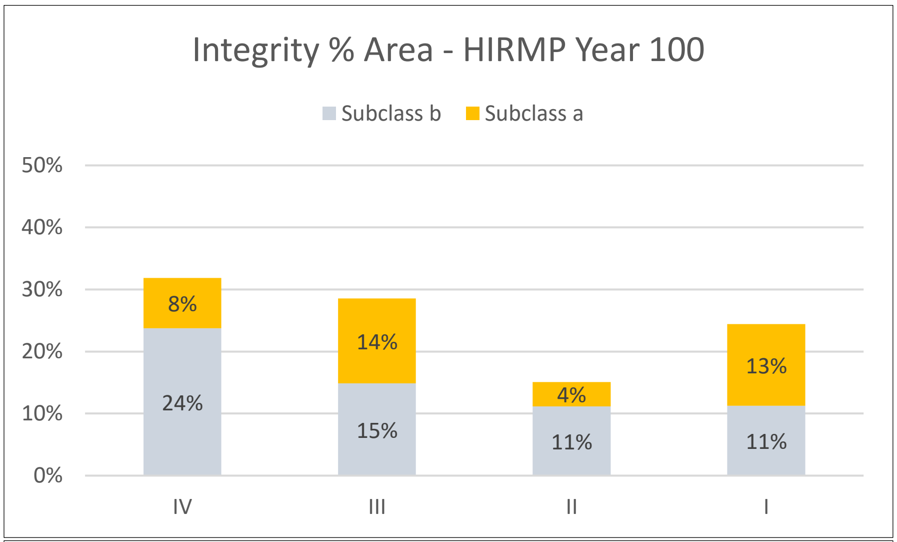
Predicted changes to ecosystem integrity over the 300-year period can be summarized (aspatially) as follows. For year 100, slight decreases in the area occupied by the lower integrity classes III and IV (decrease of 4 % of total scored area) are reflected in a 4% increase in the higher EI classes I and II. The largest increase is in class II, as reserved young and mature stands further mature.

Comparing year 0 with year 300, there is approximately 14% less area of the combined classes III and IV ('poor to fair' integrity) and a corresponding 14% increase in combined area of class I and II ('good to excellent' integrity). By year 300, the largest changes from year 0 ecosystem integrity occur in class IV (11% decrease; 15,786 ha). The other integrity classes all increase by about 7% (~ 5,000 ha each) as the reserved forests age and a greater balance occurs in the lower integrity classes. At year 300, integrity class I forests are predicted to make up 35% of the productive land base.

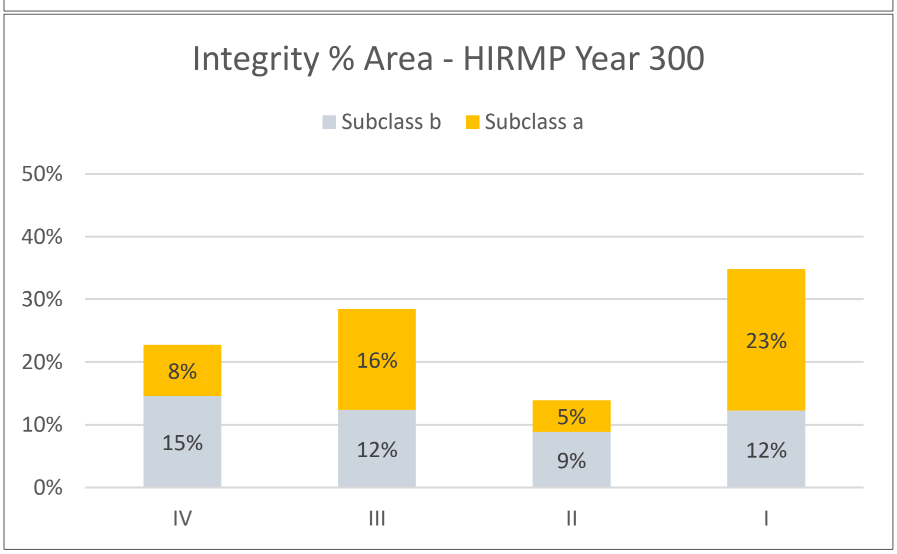
[8] These results are based on a draft scenario used to develop this approach and do not reflect the preferred scenario. The final ecosystem integrity results will be reported out separately in the IRMP.



% Area	**YEAR 0**
Class	Total
IV	44%
III	21%
II	7%
I	28%
Total	100%



% Area	**YEAR 100**
Class	Total
IV	32%
III	29%
II	15%
I	24%
Total	100%



% Area	**YEAR 300**
Class	Total
IV	23%
III	28%
II	14%
I	35%
Total	100%

Figure 29. Hišuk ma cawak IRMP (HIRMP; incl. TFL 44) – Area profiles for each ecosystem integrity class/subclass for year 0 (top), 100 (middle), and 300 (bottom). Class totals provided in small data table to right of each chart.

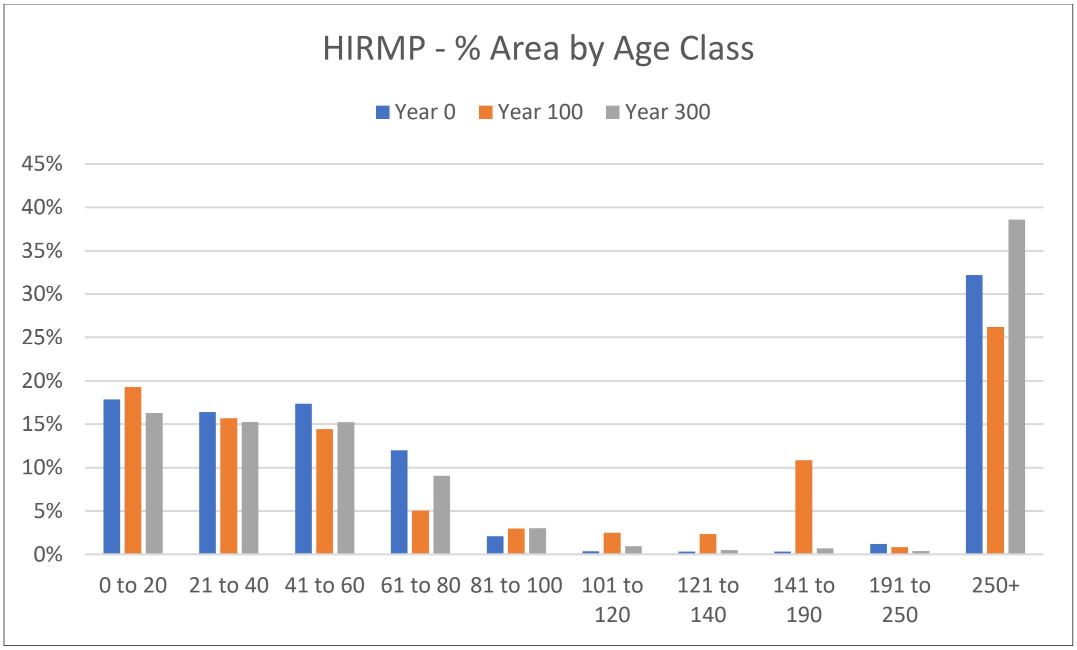


Figure 30. Hišuk ma cảwak IRMP – Area profiles for each age class for year 0, 100, and 300.

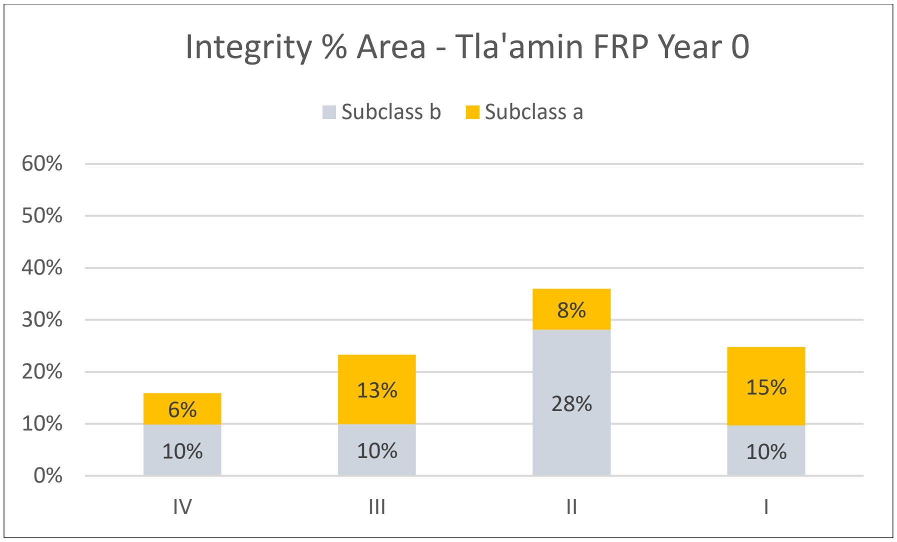
5.1.3 Tla'amin Forest Resource Plan

Ecosystem Integrity area-weighted means for the Tla'amin FRP, including TFL 39-1, for year 0, year 100, and year 300, are as follows: 23.0 – 25.2 – 27.8[9]. There is an increase over time because of aging of the forest and proposed changes in management, including an increase in landscape retention. The change in proportion of ecosystem integrity classes/subclasses over time is shown in Figure 31, and the change in the area by age class is shown in Figure 32.

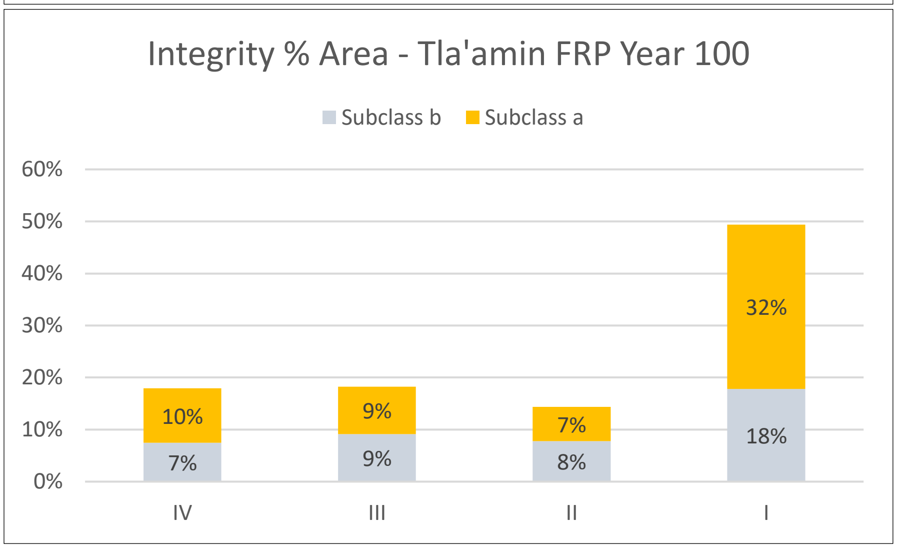
Predicted changes to ecosystem integrity over the 300-year period can be summarized (aspatially) as follows. For year 100, slight decreases in the area occupied by the lower integrity classes III and IV (decrease of 3 % of total scored area; 6,207 ha) are reflected in a 3% increase in the higher EI classes I and II. However, considerable changes are predicted in the proportion of the forest in classes II (a decrease of 22%) and I (an increase of 24%) as mature stands further mature.

By year 300, there is a further decrease in area in integrity classes IV and III, to about 29% of the plan area, and a further increase in the area in the highest integrity subclass Ia. Class I increases from 25% at year 0 to 59% of the area at year 300, an increase of 68,984 ha.

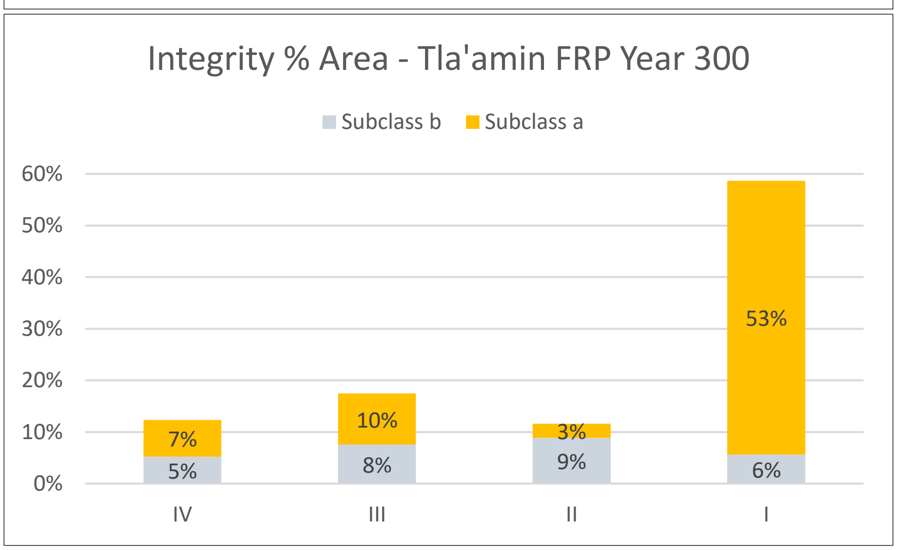
[9] These results are based on a draft scenario used to develop this approach and do not reflect the preferred scenario. The final ecosystem integrity results will be reported out separately in the FRP.



% Area	Year 0
Class	Total
IV	16%
III	23%
II	36%
I	25%
Total	100%



Year 100	
% Area	Year 100
Class	Total
IV	18%
III	18%
II	14%
I	49%
Total	100%



% Area	Year 300
Class	Total
IV	12%
III	17%
II	12%
I	59%
Total	100%

Figure 31. Tla'amin FRP (incl. TFL 39-1) – Area profiles for each ecosystem integrity class/subclass for year 0 (top), 100 (middle), and 300 (bottom). Class totals provided in small data table to right of each chart.

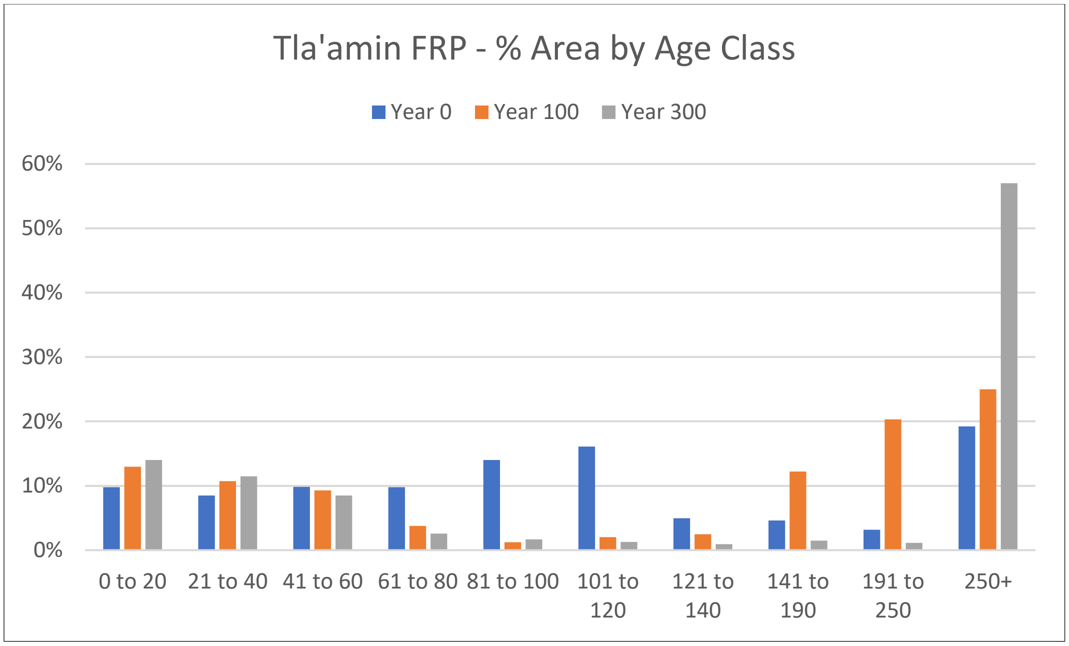


Figure 32. Tla'amin FRP – Area profiles for each age class for year 0, 100, and 300.

This plan area has higher ecosystem integrity than the other plan areas discussed, both at Year 0 and going forward, for several reasons:

- Unlike the TFL 37 FLP and Nanwakolas TFL 64 IRMP, the plan area is not confined to a TFL and includes parks and protected areas, including East Redonda Island, Malaspina Provincial Park, and Inland Lake Provincial Park. These all contribute to the high current integrity numbers (year 0).
- There is a higher proportion of steep terrain that is not able to be harvested. North of Goat Island, there are only narrow corridors along the lakes and valley bottoms that are harvestable, which also contribute to the high current integrity numbers.
- Today, there is relatively little old forest (Figure 32) due to the extensive fires from the early 20th century. So, projecting forward, more than 50% of the plan area will be over 200 years old in 100 years, and old-growth forest in 300 years, which contribute to higher integrity scores through time.

5.1.4 Nanwakolas TFL 64 Integrated Resource Management Plan[10]

[redacted]

[redacted]

[10] This section has been redacted since the IRMP is ongoing at the time of publication and the results reflect a draft scenario.

[redacted]

[redacted]

Figure 33. Nanwakolas TFL 64 IRMP – Area profiles for each ecosystem integrity class/subclass for year 0 (top), 100 (middle), and 300 (bottom). Class totals provided in small data table to right of each chart.

[redacted]

[redacted]

Figure 34. Na̲nwak̲olas TFL 64 IRMP – Area profiles for each age class for year 0, 100, and 300.

5.2 Spatial Reporting of Predicted Changes in Ecosystem Integrity

Changes in the Nimpkish Valley portion of TFL 37 FLP, are shown in Figure 35. Year 0 shows the prevalence of lower integrity classes (IV and III) in the valley, with classes II and I at mid and higher elevations. This reflects the earliest harvesting at the lowest elevations, with more recent harvesting in the mid and upper elevations. Over time, there is projected to be a significant recovery of older forests, with higher ecosystem integrity, in this valley—See Year 100 and 300 images.

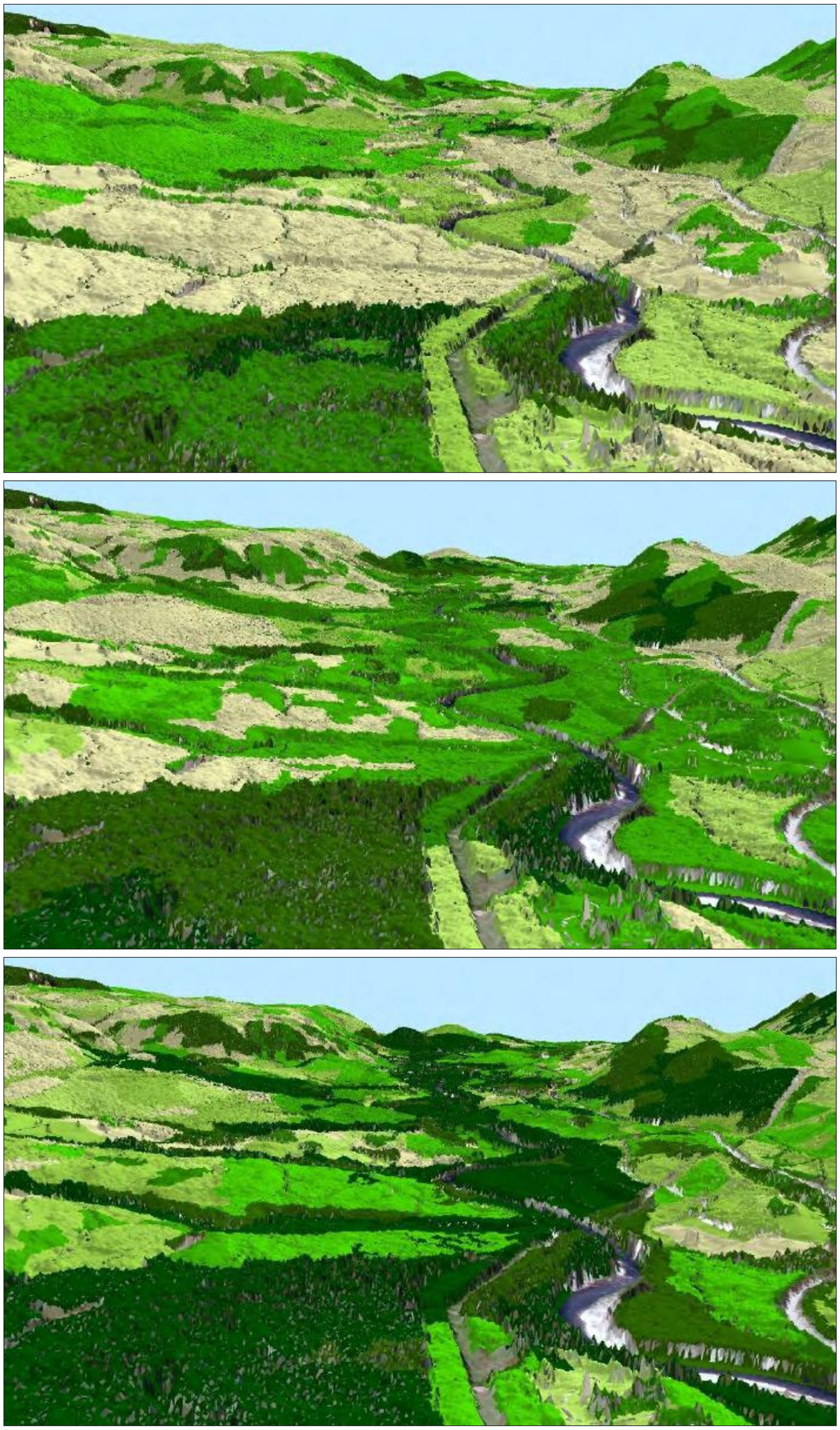


*Figure 35. Distribution of ecosystem integrity classes/subclasses in a portion of the Nimpkish River for **year 0 (top), year 100 (middle)** and **year 300 (bottom)**. Integrity classes defined as in Table 11, with highest subclass (Ia) darkest green, grading lighter green to subclass IVa, with the lowest subclass (IVb) yellow in colour.*

Figures 36 to 38 present the predicted changes in the spatial distribution of ecosystem integrity classes/subclasses throughout a portion of the Tla'amin FRP for years 0, 100, and 300, respectively. While these images are too small a scale to depict fine detail, the increase in darker green colours, i.e., increase in ecosystem integrity, is evident. This is due to the increase in both landscape and stand retention over time, as compared to present time.

The use of variable retention and the associated structural complexity in regenerating forests will have a positive impact on rates of recovery and integrity scores. What results is a continual shift in integrity over time and space in the more managed portions of the land base.

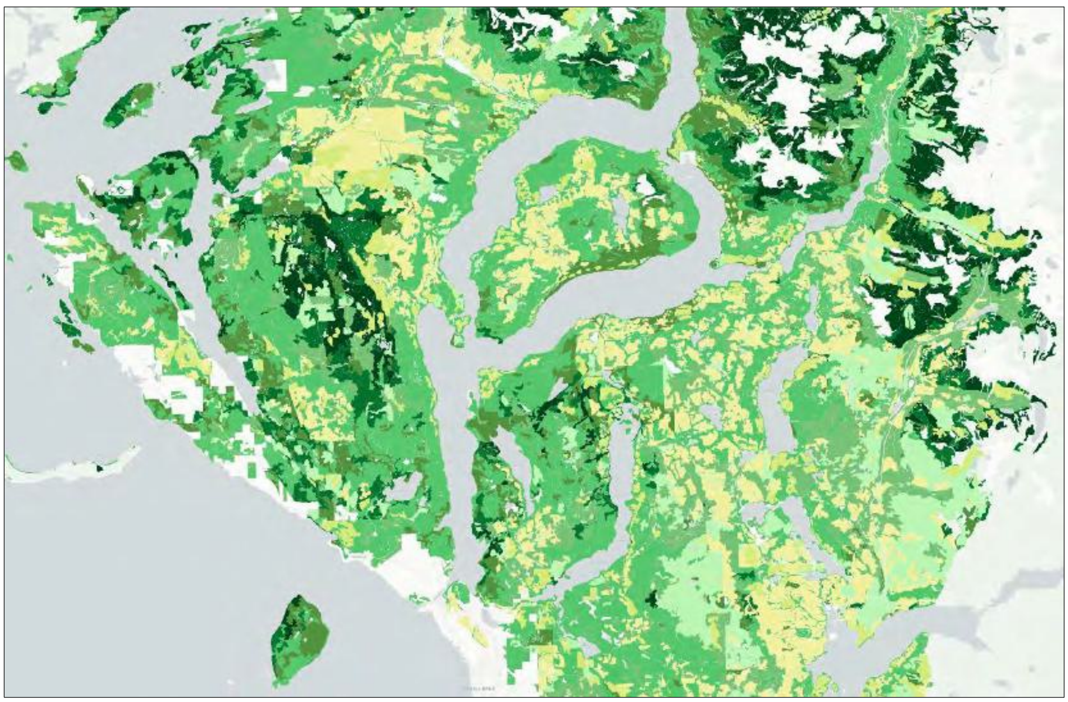


Figure 36. Distribution of ecosystem integrity classes/subclasses in a portion of the Tla'amin FRP area for ***year 0****. Integrity classes defined as in Table 11, with highest subclass (Ia) darkest green, grading lighter green to subclass IVa, with the lowest subclass (IVb) yellow in colour.*

*Figure 37. Predicted distribution of ecosystem integrity classes/subclasses in a portion of the Tla'amin FRP area for **year 100**. Integrity classes defined as in Table 11, with highest subclass (Ia) darkest green, grading lighter green to subclass IVa, with the lowest subclass (IVb) yellow in colour.*

*Figure 38. Predicted distribution of ecosystem integrity classes/subclasses in a portion of the Tla'amin FRP area for **year 300**. Integrity classes defined as in Table 11, with highest subclass (Ia) darkest green, grading lighter green to subclass IVa, with the lowest subclass (IVb) yellow in colour.*

5.3 Stratifying Ecosystem Integrity by Management and Ecological Units

So far, in the plan areas, we have summarized ecosystem integrity for the entire unit. The integrity assessment score can, however, be evaluated in a variety of ways including:

- Various management units
- Specific study areas
- Landscape Units (LU)
- Biogeoclimatic / Ecosystem Units

See TFL 37 report (Banner et al. 2023) for examples.

6 Evaluation and Monitoring

6.1 The Need for Further Field Verification and Refinement

The approach to assessing and mapping ecosystem integrity described in this report has drawn on some previous initiatives by NatureServe/BCCDC as well as the authors (see Sections 2 and 3), including several decades of field studies by the authors related to forest ecology, ecosystem sampling and classification, ecosystem recovery, and rare/at risk ecosystems. More recently, field work related to the development and application of LMH 72 (Banner et al. 2019) over the past seven or so years has helped in better understanding levels of recovery in young and mature forests on the south coast of British Columbia. Canopy complexity is an important component of this lidar-based GIS approach and the LMH 72 work has helped to better understand the relationships between canopy complexity, understory development, and recovery.

The next logical step in this process is ground assessments within the planning areas to further confirm and refine these relationships and the integrity mapping, and to monitor conditions on the ground over time. This will not only serve to monitor the impacts of ongoing management plans and practices but also the impacts of natural disturbances and climate change. It is also important to document important attributes not directly included in the GIS assessment, for example understory and epiphytic vegetation development, snags, coarse woody debris, and forest floor characteristics.

6.2 Using Ecosystem Integrity GIS layer as a Framework for Field Sampling

Now that an ecosystem integrity layer has been generated for several areas, it provides an excellent framework for planning and stratifying for a field sampling program.

During the exploratory phases of this project, we established a series of sample transects (for GIS lidar/FUSION assessment) throughout the three initial study areas (Mt Cain, Woss, and Beaver Cove). A subset of these transects (and additional transects throughout all the planning areas) could be efficiently sampled in the field, by creating georeferenced maps, facilitating accurate location of lidar pixel centroids along sample transects. Field checks can thus be carried out over the full range of age class/stand structure lidar (rumple index) values. This would enable the refinement of lidar assessments of stand canopy characteristics and other ecological attributes.

Assessment procedures in the field should include confirmation of BGC site series (Green and Klinka 1994) and assessment of the forest attribute score (FAS), utilizing the methodology outlined in LMH 72 (Banner et al. 2019). Confirmation of age, tree species composition, and canopy differentiation shouldbe completed for each ground plot. Thought could also be given to concurrently collecting data relevant to other objectives.

Resources available for extensive field sampling do have limits, however, and thus stratification using the ecosystem integrity layer, combined with TEM and other map layers, will help to ensure efficient use of resources. The field program can be augmented by a more extensive GIS evaluation of integrity attributes/scores within forest cover and TEM polygons, using available air photo/satellite imagery and lidar canopy height models. Refinements to improve the assessment of ecosystem integrity, and the broader ecological integrity of the plan areas over time can be developed as part of an adaptive management framework.

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8 Appendices

8.1 Description of Condition, Landscape Context, and Size factors utilized by the BC Conservation Data Centre for assessing Ecosystem Integrity of rare/at risk ecological communities.

Note: The content in this section follows British Columbia Ministry of Environment (2006) and draft materials from CDC but has been edited for clarity and application in forest environments.

8.1.1 Condition

Condition is an assessment of the composition, structure, and ecological function of the ecological community occurrence. Condition can be thought of as the degree of departure from the structure, function, and distribution of late seral ecological communities prior to European settlement. Successional stage, stability, ecological processes, disturbance regimes, alteration of physical or chemical processes, and changes in species composition are all factored in to the assessment of condition.

Changes in natural disturbance regimes and anthropogenic disturbances reduce condition. Intact natural disturbance regimes, particularly for fire-maintained systems and flood systems, are critical to ecological integrity. For wetland ecological communities, alterations in the hydrological regime can be a primary degrader of condition.

A: Excellent condition

- Typically, old-growth stands. May also include mature forest with elements of old-growth structure and some patches or stands of old growth.
    - At least ½ of stand has age > 250 years or multi-cohort stands with significant component of > 250-year-old trees.
- Stands have well-developed vertical structure. Structure is all-aged with multi-layered canopy including larger diameter trees.
- No, or very little, evidence of past forest harvesting is apparent and stand origin is apparently from natural disturbance, typical from gap dynamics and /or low intensity fire, or very old stand replacing disturbance.
- There is a significant component of standing (snags) or fallen (coarse woody debris) dead and decaying wood of all sizes and diameters.
- Understory vegetation is composed of native species and alien species are absent or non-invasive, and present with very low frequency.
- There may be evidence of natural disturbance (i.e., fire, insects, pathogens, wind).
- Typically, there is no mineral soil exposure due to recreation or resource use.
- Little to no internal fragmentation.

B: Good condition

- Typically, mature or nearly mature forest stands.
    - Majority of stands are < 250 and > 140 years of age (stand origins from natural disturbance, e.g. tree-fall gap, windfall, geomorphic event, older stand-replacing disturbance; or little evidence of disturbance from past harvesting); or,

    - Stands > 250 years of age but show evidence of selective logging that has altered their structure.
    - Minor inclusions of early seral forest may exist.
- Stands have moderately well-developed vertical structure. Remnant large diameter trees may be present and increase the condition of otherwise younger (>80 years old) stands.
- Snags or coarse woody debris of large and medium diameter are present.
- Alien species may be present with low to moderate frequency, but have low percent cover of invasive alien species.
- Low fragmentation: e.g. < 25% fragmented and > 75% contiguous patch.

C: Fair condition

- Vertical structure is poorly developed and consists mostly of even aged stands, often with a suppressed regeneration layer in the understory.
- Stand structure is young forest with pole-sapling and limited areas of mature forest.
- Both live trees and snags are of small to medium diameter and small size coarse woody debris predominates.
- Stands regenerated naturally after logging or are young to mature stands with significant history of selective logging disturbance that altered composition or structure.
- Alien invasive species may be uncommon to frequent but do not dominate or co-dominate understory (< 10–20% cover).
- Moderate fragmentation: e.g. > 40% fragmented and < 60% contiguous patch.

D: Poor condition

- Stands are typically regenerated after clearcut harvesting, or dominant trees were planted after harvesting.
- Invasive alien species may be abundant in the understory or invading the upper canopy.
- The ground surface may be very disturbed with major disruptions to vegetation and components of exposed mineral soil.
- Continued resource or recreational use may be evident.
- High fragmentation: e.g. > 75% fragmented and < 25% contiguous patch.

8.1.2 Landscape Context

Landscape context considers both the abiotic and biotic features of the geographic area adjacent to and surrounding the ecological community occurrence. The condition of the landscape is assessed by the integrity of ecological processes, species composition, and structure of the vegetation, including its maturity and stability, and the stability of the abiotic features of the landscape. Patchiness, fragmentation, and connectivity are specific attributes of the landscape.

A: Excellent landscape context

- Highly connected landscape over a large area around the Occurrence with intact natural vegetation. Few small roads in the surrounding landscape.
- Surrounding landscape with native-dominated vegetation, very little to no development or agriculture, and little to no industrial forestry (> 90% natural vegetation).
- Fragmentation by anthropogenic influences (transportation corridors, development, etc., is less than 5% and connectivity to other element occurrences is limited only by natural barriers.

- Natural disturbance regime is within the expected range of variability for the region.
- Islands may have poor connectivity to other element occurrences because of large bodies of open water, but those with greater separation and little to no anthropogenic alteration have higher natural landscape context due to isolation from adjacent disturbances and with higher possibility of uninterrupted natural disturbance dynamics.

B: Good landscape context

- Moderately connected landscape composed primarily of natural or semi-natural vegetation, without any development occurring directly adjacent to the occurrence; or landscape has very little development or agriculture, but may have components of alien vegetation in at least one physiognomic layer and/or includes some area of young tree plantations (< 40 years).
- Surrounding landscape has low fragmentation (> 75% contiguous patch) and natural and semi-natural vegetation dominates the landscape (70-90%).
- There are few non-natural barriers occurring in the surrounding landscape (e.g. major roads, urban areas).
- Connectivity to at least one or more other occurrences of the same ecosystems and connectivity to other adjacent ecosystem types is present.
- There may be some suppression of natural fire, primarily due to rural interface safety issues.

C: Fair landscape context

- Moderately fragmented landscape (25-75%) due to anthropogenic barriers such as urban, industrial, commercial areas and transportation corridors.
- Surrounding vegetation is a mosaic (35-70%) of natural or semi-natural vegetation and/or or the landscape is dominated by very young tree plantations (cut within the last 20 years).
- Connectivity to other occurrences of the same type is largely restricted by non- natural barriers and connectivity to other ecosystem types is also limited.
- Natural disturbance regimes are actively suppressed.

D: Poor landscape context

- Heavily fragmented (< 25% of the landscape occurs in contiguous patch) and the occurrence is surrounded primarily by urban, industrial, commercial, or agricultural areas.
- Less than 35% of the landscape is of natural or semi-natural vegetation.
- No connectivity to other occurrences of the same ecosystem and limited connectivity to occurrences of other ecosystem types.
- Disturbance regimes are outside of expected natural patterns.

8.1.3 Size

As used here, size refers to the area of occupancy of the ecological community occurrence. As noted in the guidance document, total size will often involve multiple stands. If an ecosystem occurs in mosaic with other ecosystems, the area is calculated based on the estimated proportion of occupancy. The importance of size varies based on the type of ecosystem, e.g., size is relatively unimportant in small patch or linear ecosystems but is very important in large patch and matrix type ecosystems—larger occurrences have greater integrity because of reduced edge effects and reduced susceptibility to degradation or extirpation by large scale disturbance events. Smaller occurrences can have high importance, particularly where existing disturbance precludes any remaining matrix occurrences. In these cases, condition is equally or more important than landscape context. Criteria for size are specific to each ecological community at risk but general estimates are shown below:

Size Classes for Spatial Distribution Pattern Groups (defined below)

Distribution Pattern	A rating*	B rating*	C rating*	D rating*	Minimum size*
Matrix	> 2000	200-2000	20-200	< 20	2
Large patch	> 80	30-80	2-30	< 2	0.25
Small patch	> 40	10-40	2-10	< 2	0.05
Linear	> 20	8-20	1-8	< 1	0.25

* All measurements in hectares

Spatial Distribution Pattern Types used by the BC Conservation Data Centre

Spatial Distribution Pattern Type	Definition
Matrix	Ecosystems that form extensive and contiguous cover, occur on the most extensive landforms, and typically have wide ecological tolerances. Disturbance patches typically occupy a relatively small percentage (e.g., < 5%) of the total occurrence. In undisturbed conditions, **typical occurrences range in size from 2,000 to 10,000 ha (100 km^2) or more**.
Large Patch	Ecosystems that form large areas of interrupted cover and typically have narrower ranges of ecological tolerances than matrix types. Individual disturbance events tend to occupy patches that can encompass a large proportion of the overall occurrence (e.g., > 20%). Given common disturbance dynamics, these types may tend to shift somewhat in location within large landscapes over time spans of several hundred years. In undisturbed conditions, **typical occurrences range from 50 to 2,000 ha**.
Small Patch	Ecosystems that form small, discrete areas of vegetation cover, typically limited in distribution by localized environmental features. In undisturbed conditions, **typical occurrences range from 1 to 50 ha**.
Linear	Ecosystems that occur as linear strips. They are often ecotonal between terrestrial and aquatic ecosystems. In undisturbed conditions, **typical occurrences range in linear distance from 0.5 to 100 km**.

8.2 Ecosystem Integrity by Planning Area – Year 0

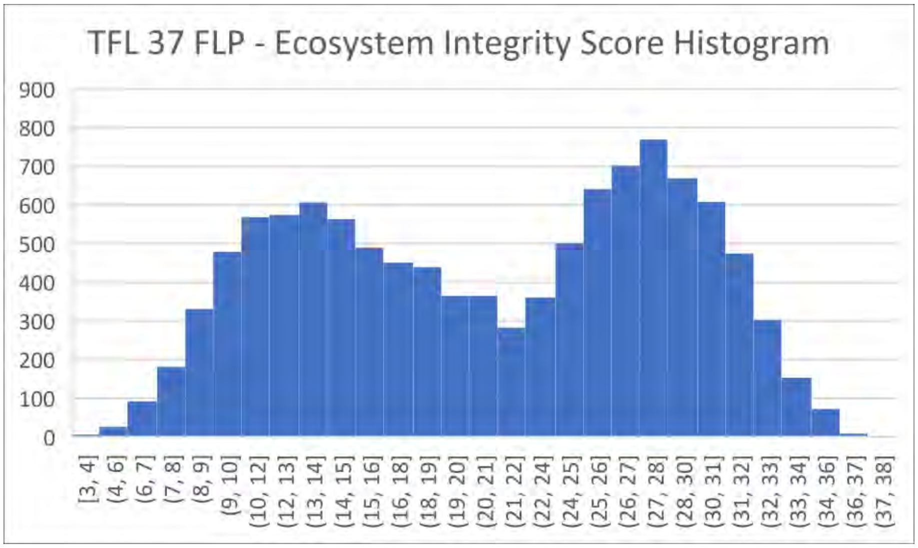

Figure A8.2(a). Histogram of polygon integrity scores for TFL 37 FRP (current conditions - Year 0)

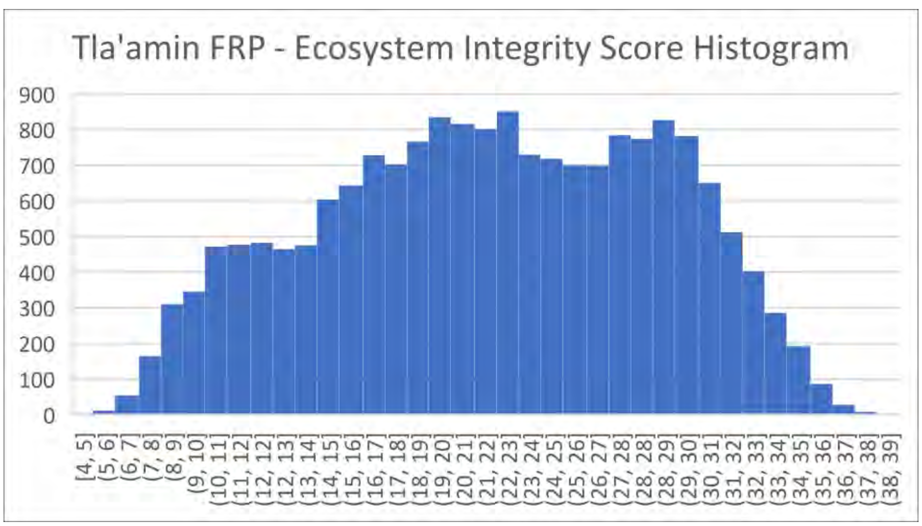

Figure A8.2(b). Histogram of polygon integrity scores for Tla'amin FRP (current conditions - Year 0)

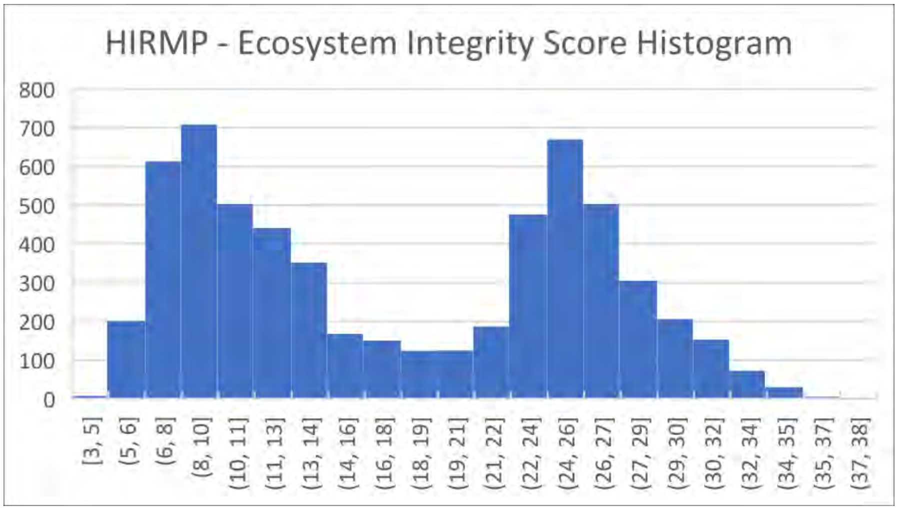

Figure A8.2(c). Histogram of polygon integrity scores for HIRMP (current conditions - Year 0)

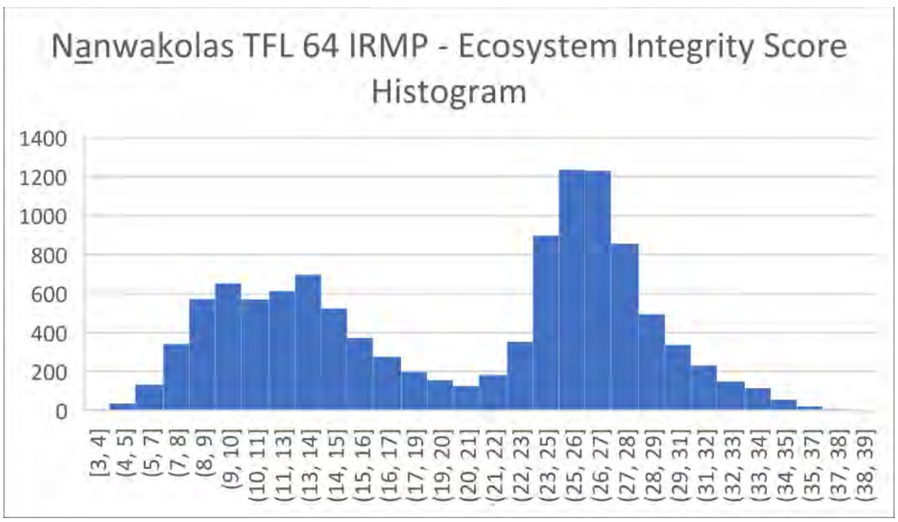

Figure A8.2(d). Histogram of polygon integrity scores for Nanwakolas TFL 64 IRMP (current conditions - Year 0)