Status of BC's Old Forests

THE SITUATION IN 2021

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Executive Summary

In recent years, there has been increasing public interest in British Columbia's old growth forests. This report uses best available data to describe the status of old forests in BC. It aims to answer key questions about the amount, distribution, status, and types of old forests in the province. The data and context information provided in this report can inform meaningful discussions about the management of old forests in BC. Consideration of appropriate representation of old forests, distribution of these forests within ecosystems, and management actions that may be needed to maintain them are important issues for the province to consider as it works to implement the 14 recommendations in "A New Future for Old Forests" (Gorley & Merkel, 2020).

Old Growth Definition

The age-based definitions of old forest found in the Biodiversity Guidebook[1] were used to identify old forest within the provincial forest inventory (>250 years old on the coast and wet portions of the interior, and >140 years old for the rest of the interior). Old forests can look very different across BC, depending on species, location, climate, and natural disturbance patterns that are typical in an ecosystem. The type and frequency of natural disturbances, such as wildfire, will determine how much old growth would occur naturally, and the typical age range of the forest. The significant diversity of BC's forests translates into many different types of old growth stands.

Data and Assumptions

A dataset was compiled to including all of BC's Crown lands (federal and provincial lands – representing over 94% of the forested land in BC). Each forest stand's physical characteristics, elevation, growth potential, biogeoclimatic (ecosystem) label, protected status, and potential for future harvest are described in the data. It includes forest inventory data from all Tree Farm Licenses in the province. Stand attributes, including age, have been updated in the forest inventory to reflect forest harvesting and any stands impacted by mountain pine beetle or fire as of early 2021. It should be noted that the vast majority of forest inventory data in BC is collected through manual interpretation of 3D aerial photography, and has limitations for describing old forests. The older a stand is on the ground, the harder it is to estimate its age from photography – meaning inventory ages are not very reliable for old stands. Inventory site productivity estimates are also not reliable for old stands, largely because they are derived using these inaccurate ages.

Results

Using best available data, BC's 55.4 million ha of Crown forested land contains 11.4 million ha of old forest (21%) (Table 1). Previous reports released in the last 2 years have indicated that 13.2-13.7 million ha of old growth existed in BC. The lower numbers reported here are due to the exclusion of private land, use of more current data, less reliance on basemap thematic mapping, and improved recognizaton of historic fire and mountain pine beetle mortality. When assessed regionally, **the coast has a higher proportion of old forest (43%) than the interior (13-19%, Avg 17%).**

Approximately 75% (8.5 million ha) of BC's old forest is considered protected or not within the Timber Harvesting Land Base, with this proportion being significantly higher on the coast (88%) versus the interior (66-76%). This is due to the coast region's significant areas of parks / protected areas, steep/inaccessible terrain, and the protections found under the Great Bear Rainforest Land Use Order (2016).

[1] BC Environment. (1995). *Biodiversity Guidebook. Forest Practices Code of British Columbia.* Retrieved from: https://www.for.gov.bc.ca/hfd/library/documents/bib19715.pdf

Table 1. Summary statistics for BC's old forests in 2021 (provincial and federal lands only – excludes private lands).

Region	Forested Area (ha)	Old Forest (ha)	% Old	Area of Old Protected or in Non-THLB	% of Old Protected or in Non-THLB
Coast	8,039,880	3,435,752	**43%**	3,024,624	88%
Northern Interior	30,955,591	5,797,732	**19%**	3,833,067	66%
Southern Interior	16,418,510	2,184,422	**13%**	1,652,773	76%
Province	55,413,980	11,417,906	**21%**	8,510,464	75%
Vancouver Island (subset of Coast)	1,997,047	770,172	**39%**	618,801	80%

Non-THLB = Non-Timber Harvesting Landbase

BC's range of climate, topography, and soils means that the 11.4 million ha of old forests span a wide range of tree species and tree sizes, from short stands growing in less productive conditions to very tall stands growing in highly productive conditions. While all old forests contribute to biodiversity, ensuring representation of forest stands with larger trees is also important. Forest inventory (VRI) estimates of site productivity for old forests are innaccurate and thus are not a good means to identify 'big tree' old growth. The BC government's Provincal Site Productivity Layer (PSPL) has a significantly better correlation with the presense of big trees than VRI site index data. When old forests are characterized using PSPL data, the percentage of old forest is relatively consistent across site productivity classes and **approximately 3.34 million ha of old forest is growing on sites where the expected site index is greater than 20m (29.3% of all old forest in the province).** It is recognized that using SI>20 to denote good growing sites in the province is a vast simplification of reality, as SI 20 would be considered lower productivity in some ecosystems (portions of the coast) and high in others (dry interior), but is used here only to provide a comparable number to past reporting. If the goal is to ensure old forests are present across the range of productivity classes in an ecosystem, site index thresholds would need to be developed specific to tree species and ecosystem groups across BC. This is a substantive piece of work that will require input from a range of professionals and was thus not attempted here. Blanket provincial approaches are not appropriate.

Limitations of the Forest Inventory Data

BC's age-based definitions for old forest combined with the inaccuracies of photo interpreted ages in the provincial forest inventory have resulted in several challenges with identifying the presence and quality of old growth stands. It is very likely that the area of old forest in BC is underestimated by the current inventory, but circumstances will vary across the province. Investing in more detailed inventories supported by LiDAR data would help in the identification of high value old growth stands.

Relying on simple statistics from the provincial inventory to identify ecosystems in need of additional old growth deferrals is not recommended as local context and data limitations are not addressed. It is recommended that more detailed assessments of old growth conditions be completed regionally in conjunction with local experts, including First Nations, to ensure sufficient context is available when interpreting the data and developing management strategies. Examples of this work are already occurring in the province's Forest Landscape Planning pilot projects. Provincial datasets can be helpful to identify large scale trends and potential issues of concern, but are not appropriate to establish detailed forest management direction. For example, ecosystem restoration treatments may be more beneficial than harvesting deferrals in very dry stands where active management can help to maintain or improve ecosystem integrity (e.g. drybelt Douglas-fir stands).

Acknowledgments

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Cam Brown, RPF holds an undergraduate degree (BSF) from UBC and a Master's in Forestry from Oregon State University. He obtained his BC RPF in 1996 and has worked in the Canadian forest sector for over 25 years – mostly in consulting roles. Cam has extensive experience in resource analysis and modeling, strategic planning, forest inventory, forest carbon analysis, and the use of LiDAR data in the forest sector. He has been working with BC data and old growth requirements for most of his career, including supporting the development of the old growth retention strategies found in the Great Bear Rainforest Land Use Order, selecting specific stands to meet legal old growth target areas in Landscape Units in the BC Interior, and modeling the achievement of old seral targets over time in timber supply review processes.

Spruce/Balsam old growth near Clearwater, BC (Photo Ken Zielke)

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List of Acronyms

BC	British Columbia	NDT	Natural Disturbance Types
BCTS	British Columbia Timber Sales	OGMA	Old Growth Management Areas
BEC	Biogeoclimatic Ecosystem Classification System	PP	Ponderosa Pine
BEO	Biodiversity Emphasis Option	PSPL	Provincial Site Productivity Layer
BGB	Biodiversity Guidebook (1995)	RoNV	Range of Natural Variation
BMTA	Biodiversity Management and Tourism Areas	RPF	Registered Professional Forester
BWBS	Boreal White and Black Spruce	SBPS	Sub-Boreal Pine-Spruce
CDF	Coastal Douglas-fir	SBS	Sub-Boreal Spruce
COFI	BC Council of Forest Industries	SI	Site Index
CWH	Coastal Western Hemlock	SWB	Spruce-Willow-Birch
DBH	Diameter at Breast Height	THLB	Timber Harvesting Land Base
EBM	Ecosystem-based Management	TSA	Timber Supply Area
ESSF	Engelmann Spruce-Subalpine Fir	UBC	University of British Columbia
GBR	Great Bear Rainforest	UWR	Ungulate Winter Ranges
ICH	Interior Cedar-Hemlock	VDYP	Variable Density Yield Projection
IDF	Interior Douglas-fir	VRI	Vegetation Resource Inventory
LU	Landscape Unit	WHA	Wildlife Habitat Area
LVI	Landscape Vegetation Inventory	WMA	Wildlife Management Areas
MH	Mountain Hemlock		
MPB	Mountain Pine Beetle		
MS	Montane Spruce		

1 Introduction

In 2019, the Government of British Columbia commissioned an independent strategic review of old growth forest management to help address public concerns. The resulting report, "A New Future for Old Forests", completed by Al Gorley, RPF and Garry Merkel, RPF ("the Review"), summarized findings from scientific studies, policy reviews, and discussions with British Columbians[2] but had limited analytical support to describe the current conditions in the province. The final report contained 9 key observations and made 14 recommendations that address conditions required for change, areas of immediate response, improving forest management, and an orderly transition. In September 2020, the BC government committed to implementing all 14 recommendations from the Review and is currently working on addressing several of the recommendations. Gorley and Merkel, among others[3], have highlighted that the recommendations in the Review will not happen overnight as they require a paradigm shift in forest management in BC.

In the Review, Gorley and Merkel heard numerous definitions of old growth from different perspectives, interests, and beliefs; and a wide range of opinions on the status of old growth (and forest management in general). Two common themes emerged from discussions with British Columbians:

- Managing old growth effectively is beneficial; and
- There is a common loss of trust in the information, statistics, and interpretation thereof being shared on old growth and forest management from all sources.

The lack of publicly available data on the state of old growth in the province led to the development of "BC's Old Growth Forests – A Last Stand for Biodiversity" in April 2020[4]. While this report advanced the conversation about old growth, it also led to several inaccurate conclusions about the current state of old growth in BC. The authors of this report are now part of the Old Growth Technical Advisory Panel[5] which is advising the BC government on developing a summary of old forest ecosystems and identifying candidate deferral areas.

2 Objectives

The purpose of this report is to provide an assessment of BC's old forests, suitable to support meaningful discussions about the amount, distribution, status, and type of these forests provincially. The report synthesizes information from multiple sources to describe the current status of old growth forests and provide context to the numbers that will support meaningful dialogue on old forest management now and into the future. This report is designed to:

- Describe old forests and their variability across BC;
- Describe and map the extent of old forests in BC;
- Describe and map the protection status of old forests in BC;

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[2] Gorley, A. & Merkel, G. (2020). *A new future for old forests: A strategic review of how British Columbia manages for old forests within its ancient ecosystems*. Retrieved from: https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/old-growth-forests

[3] Innes, J. (2021). *July 2, 2021 news release: A personal message from the Dean to the UBC forestry community on the subject of old-growth forests*. Retrieved from https://forestry.ubc.ca/news/message-on-old-growth-forests/

[4] Price, K., Holt, R. Daust, D. (2020). *BC's Old Growth Forests - A Last Stand for Biodiversity*. https://veridianecological.files.wordpress.com/2020/05/bcs-old-growth-forest-report-web.pdf

[5] BC. (2021). *June 24, 2021 news release*: *Science to help drive old growth deferrals*. https://news.gov.bc.ca/releases/2021FLNRO0043-001225

- Explore the issues with identifying and quantifying old forests with BC's current datasets; and
- Distinguish regional differences in old forest representation in BC.

3 What is Old Growth?

Old growth has become a generic term to describe forests with old and/or big trees.[6] In this report, the terms "old forests" and "old growth" are used interchangeably; however, the term "old forests" will generally refer to older forests in an ecological sense, and "old growth" in a management and policy sense. **Within BC's diverse ecosystems, old forests can look very different depending on the site conditions, climate, and type and frequency of natural disturbances typical to a given ecosystem.** The sections below describe the diversity of old forest types in BC.

3.1 OLD FOREST DEVELOPMENT

Ecosystems are not static. Given adequate time between significant disturbance events, ecosystems evolve in a process called succession (Figure 1) but many follow complex pathways as a result of mixed disturbance impacts (partial mortality resulting from fire, insects, disease, etc.). When stand replacing disturbances occur, pioneer species colonize the site and surviving seeds or saplings start to grow. Stand initiation can last up to a few decades in the early phases of forest succession. Sites initially experience rapid changes as they are taken over by herbs, shrubs, and then trees. As the tree canopy closes and provides increased shade, shade intolerant species are incrementally excluded and die in the stem exclusion phase. The forest then enters a phase where changes happen gradually and can vary significantly among ecosystems. This phase usually involves the introduction of gaps from mortality and new growth occurring in the understory – leading to old growth conditions. The type and severity of disturbances may cause stands to vary from this simple pathway and experience mixed successional pathways.

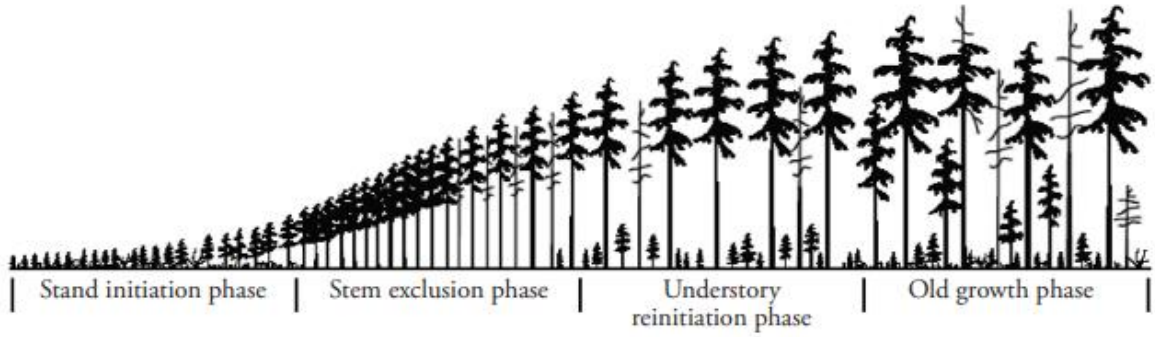


Figure 1. Graphical representation of forest succession (by J.P. Kimmins)

Ecosystems that are rarely disturbed by fire, wind, insects, etc., can remain in the old growth phase for hundreds to thousands of years as individual trees die and create gaps for younger trees to regenerate in. This type of gap regeneration occurs in BC's wet coastal and temperate inland rainforests; however, the majority of BC's forested ecosystems are naturally adapted to large-scale disturbances that initiate new stands on a regular basis (see Figure 2). Disturbances such as wildfires, windstorms, and significant insect infestations act like a reset button on

[6] Gorley, A. & Merkel, G. (2020). *A new future for old forests: A strategic review of how British Columbia manages for old forests within its ancient ecosystems*. Retrieved from: https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/old-growth-forests

succession. With an ecosystem, the disturbance frequency and severity is key to determining how much old growth would exist naturally. Where disturbances occur frequently, the oldest forest in an ecosystem will be far younger than if disturbances are rare or happen only at small scales.

Figure 2. Example of stand initiation following a wildfire (photo by Ron Otsu)

BC has incredibly diverse landscapes and ecosystems, yet coastal old growth forests are among its most iconic. To the general public, the term "old growth" typically evokes images like the stand in Figure 3.

Figure 3. Old growth covered in moss (photo by Ron Otsu)

It is important to recognize that old forests do not simply appear at a precise age, but rather they develop key attributes over time as stands mature into old growth. Attributes that have been found to describe or indicate old forests on the BC coast include:[7] [8] [9]

- Multi-layered canopy – a mix of different aged trees (often reflected in various heights and diameters);
- Species diversity – a mix of shade tolerant and intolerant species;
- Larger dead trees on the ground and standing as snags;
- Canopy gaps where understory plants are able to grow; and
- Presence of large trees

Stand attributes offer a means to identify old growth based on functional, ecological characteristics. This approach is preferable to using simple age-based definitions that fail to recognize that attributes can develop at different rates depending on the productivity of growing sites. This issue was scrutinized[10] as part of planning for the Great Bear Rainforest Land Use Order and, despite its inaccuracies, the recommendation was to use age to define old growth because it was the only attribute consistently available across the land base. At the time, ecological attribute score cards were seen as a preferred option, but the effort required to compile them for the land base as a whole was not practical. For the Great Bear, it was accepted that if a younger stand was field-verified with an ecological score card and found to express old growth characteristics, then it could be considered old growth. However, this is a question that requires more scrutiny.

Figure 4. An unusually large tree in the IDF BEC zone near Williams Lake, BC (UBC Alex Fraser Research Forest)

The current age-based definitions for old growth vary by ecosystem and natural disturbance frequency (details in Appendix B). In general:

- Ecosystems with more frequent natural disturbance, and thus naturally younger age class distributions, recognize old forest as stands greater than 140 years old for conifer-leading stands or 100 years old for deciduous-leading stands. These stands occur across the interior of BC.

[7] Banner, A., et al. (2019). *Guidelines to support implementation of the Great Bear Rainforest Order with respect to old forest and listed plant communities*. Prov. B.C., Victoria, B.C. LMH 72. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/LMH72.htm

[8] Holt, R. (2000). *Inventory and tracking of old growth conservation values for landscape planning*. Prepared for BC Ministry of Environment, Lands and Parks: Habitat Program. Retrieved from: http://a100.gov.bc.ca/pub/eirs/lookupDocument.do?fromStatic=true&repository=BDP&documentId=3277

[9] Van Pelt, R. (2007). *Identifying mature and old forests in western Washington*. Washington State Department of Natural Resources. Retrieved from: https://www.dnr.wa.gov/publications/lm_hcp_west_oldgrowth_guide_full_lowres.pdf

[10] Holt, R., et al. (2008). *Defining old growth and recovering old growth on the coast: discussion of options.* Ecosystem Based Management Working Group. Retrieved from: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/land-use-plans-and-objectives/westcoast-region/great-bear-rainforest/ei01b_old_growth_definitions.pdf

- Ecosystems with infrequent stand-replacing disturbances, and thus naturally older age class distributions, recognize old forest as stands greater than 250 years old. These stands occur on the BC coast and in limited (wetter or very dry) areas of the BC interior.

Forest managers are well-aware that forest inventory ages are not very accurate for older stands, and that stands on either side of the old age thresholds are not significantly different. Thus, when selecting stands for old forest retention objectives, there are times when mature forests are seen as preferable for meeting biodiversity objectives. Old forests are continuously being created as stands become older and cross old-age definition thresholds.

The ages found in the province's forest inventory data (VRI) are currently the best option for assessing old forests at large spatial scales. At smaller scales, it may be possible to work with better data that can assess ecological attributes associated with old stands.

3.2 ECOSYSTEMS, DISTURBANCE AND OLD GROWTH

BC has developed a hierarchical ecosystem classification system that uses vegetation, soils, and topography to identify geographic areas that have relatively uniform climate. These areas are the foundation of BC's Biogeoclimatic Ecosystem Classification (BEC) system.[11] The BEC system provides a common language for landscape ecology in BC and allows multiple professions to communicate and support sustainable ecosystem management.

BC is divided into 14 BEC zones named for the dominant old forest species and general geographic location (e.g. Coastal Western Hemlock or CWH). The zones are further divided into subzones and variants (indicated by letters and numbers respectively at the end of the BEC zone acronyms [e.g. CWHvh1 or ICHmw]), further characterizing specific climates (e.g. moist, warm). **The variation in climate and growing conditions is a fundamental reason that old growth forests do not develop and look the same across the province**. Even within a BEC variant, site conditions and moisture regimes can result in different plant communities and growth potential – from smaller trees on rocky, thin soils to larger trees on moisture-receiving sites with deep soils.

As previously discussed, the old forest present in an ecosystem is linked to the frequency and extent of disturbances that occur in that ecosystem. In BC, the mapped BEC variants are each assigned to one of the five Natural Disturbance Types (NDTs) mapped in Figure 5[12] and Figure 6[13]. NDTs were first described in the Biodiversity Guidebook developed to support the Forest Practices Code of BC[14] and are still largely used for describing desired forest conditions (including old forest definitions and retention targets) that strive to mimic the range of natural disturbance patterns inherent to each ecosystem.

The five NDT's in BC are:

- NDT1: Rare stand-initiating events
- NDT2: Infrequent stand-initiating events
- NDT3: Frequent stand-initiating events
- NDT4: Frequent stand-maintaining events
- NDT5: Alpine tundra and subalpine parkland (non-forested)

The sections below describe each NDT and illustrate the variation of old forest types that occur within them.

[11] Meidinger, D & Pojar, J. (1991). *Ecosystems of British Columbia*. BC Ministry of Forests. https://www.for.gov.bc.ca/hfd/pubs/Docs/Srs/Srs06.pdf
[12] Biogeoclimatic Zones of British Columbia. https://www.for.gov.bc.ca/hre/becweb/resources/maps/ProvinceWideMaps.html
[13] Natural Disturbance Types of British Columbia. https://www.for.gov.bc.ca/hre/becweb/resources/maps/ProvinceWideMaps.html
[14] BC. (1995). Biodiversity guidebook. Forest practices code of BC. https://www.for.gov.bc.ca/hfd/library/documents/bib19715.pdf

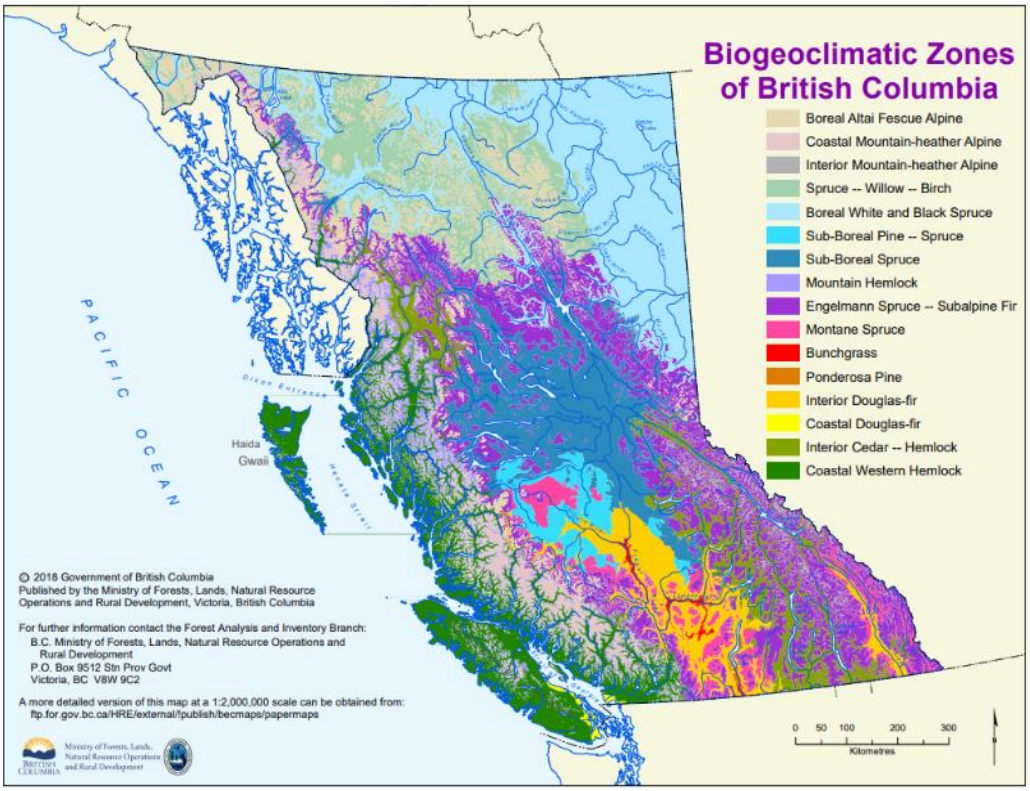


Figure 5. Biogeoclimatic Zones of British Columbia

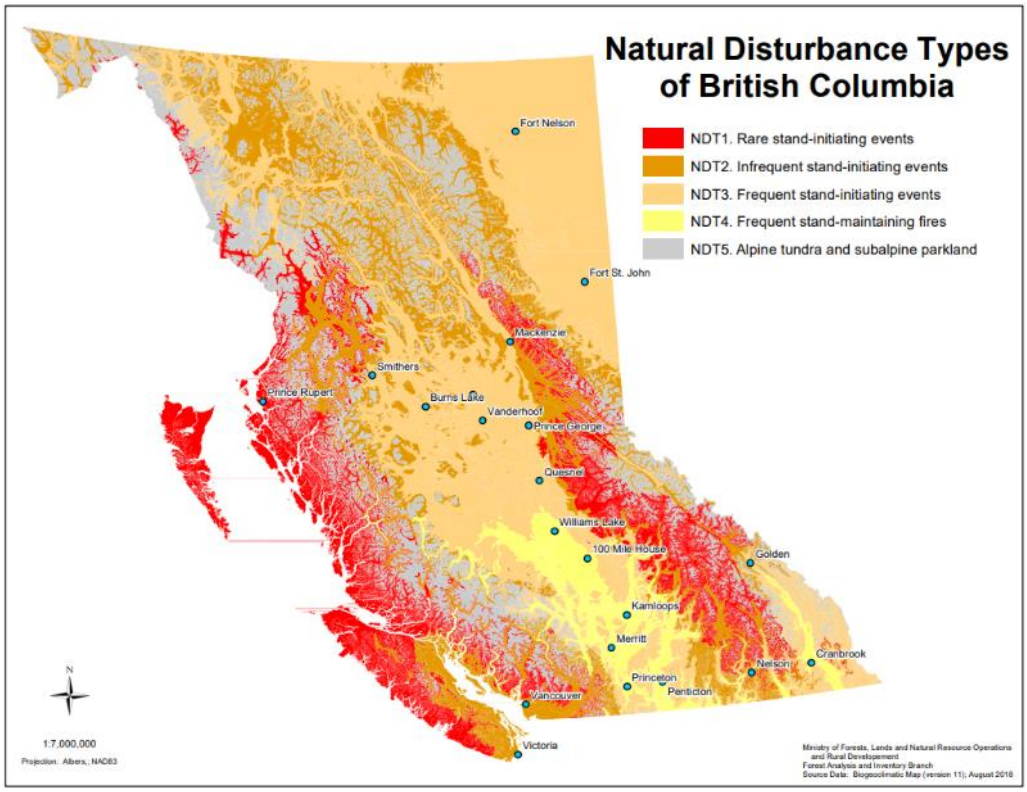


Figure 6. Natural Disturbance Types of British Columbia

3.2.1 Natural Disturbance Type 1 (NDT1)

NDT1 is associated with wet ecosystems where large-scale disturbance is very rare and stands/trees can live to very old ages. The typical natural disturbance agent in these ecosystems tend to be small gaps created by the death of individual trees or small patches due to localized fire, windthrow, or insects into which new trees grow, creating a multi-layered canopy forest (Figure 7). Key attributes of these forests are (see Appendix B for more detail):

- Tree ages: 0 to >1,000 years old (often multi-aged, complex stands)
- Disturbance return interval: 250 to > 1,000 years
- Old growth defined as >250 years old
- Historically natural amounts of old forest from 37% to over 80% based on localized disturbance return intervals
- Examples of NDT1 forests: wet coastal forest types (CWH, MH) and interior wetbelt areas (ICH, ESSF) such as near Revelstoke, BC.

Figure 7. Examples of NDT1 old growth: a) CWH Cedar (photo by TJ Watt); b) CWH Douglas-fir (photo by Ron Otsu); c) MHmm Hemlock – Strathcona Park (photo by Catherine Fleury); d) ICHwk3 near McBride (photo by Ryan Gray)

Old forests in NDT1 typically exhibit complex stand structure, including a variety of species and a range of tree sizes mixed together. There are dead trees standing and on the ground, often acting as nurse logs as they decompose. There is a thriving plant understory often characterized by ferns, mosses, and lichen. NDT1 – especially CWH – has limited disturbances and areas of high productivity, thus containing the biggest trees relative to other NDTs. The biggest trees in the CWH can reach more than 80m in height and greater than 2m in diameter. However, this NDT has harsh as well as lush climates defined by the different BEC variants within it across the province – each with different expressions of old trees.

3.2.2 Natural Disturbance Type 2 (NDT2)

NDT2 is associated with moderately wet ecosystems where infrequent fires occur over moderate-sized areas (20-1,000 ha) and result in even-aged stands experiencing some small gap openings mixed with older patches which did not burn (Figure 8). Key attributes of these forests are (see Appendix B for more detail):

- Tree ages: 0 to >500 years old (primarily even aged stands)
- Disturbance interval: 200 to >1,000 years
- Old growth defined as >250 years
- Historically natural amounts of old forest from 29% to over 80% based on localized disturbance return intervals
- Examples of NDT2 forests: drier coastal forests (CDF) like those on the Gulf Islands or the eastern side of Vancouver Island (CWHmm/xm1), or moist Interior Cedar Hemlock (ICH mw) forests in the Shuswap.

Old forests in the NDT2 are highly variable, as demonstrated by Figure 8, where the BEC zones and variants within NDT2 can result in very different forest ecosystems. Portions of NDT2 also have the ability to grow big trees because of the lower rate of disturbance and moist rich sites present in some locations.

Figure 8. Examples of NDT2 old growth: a) ESSFmw2 in Whistler (photo by Ken Zielke); b) CDFmm on Saltspring Island (photo by Cam Brown); c) CDFmm in Qualicum Beach (photo by Mike Parlow); d) CWHmm in Strathcona (photo by Catherine Fleury)

3.2.3 Natural Disturbance Type 3 (NDT3)

NDT3 is associated with ecosystems that experience frequent and large-scale stand-replacing disturbance. Fires, one of the most common disturbance agents, can reach well over 100,000 ha in size, creating very large patches of even-aged forest with islands of unburnt trees. This NDT covers the greatest area in the province and represents the majority of the interior of BC and the boreal forest. Key attributes of these forests are (see Appendix B for more detail):

- Tree ages: 0 to >250 years old (even-aged stands)
- Disturbance interval: 100 to 150 years
- Old seral defined as >140 years old (>100 years for deciduous stands)
- Historically natural amounts of old forest from 25% to over 39% based on localized disturbance return intervals
- Examples of NDT3 forests: northern boreal forests (Ft St John), spruce/pine forests (Prince George, Chilcotin Plateau), and southern Douglas fir/pine forests (Merritt, Kelowna, Cranbrook).

Old forests in the NDT3 are the most consistent among the NDTs. Species diversity is reduced because fewer tree species are compatible with large-scale, frequent disturbance and the relatively drier climate. Due to frequent disturbance and lower productivity, stands in NDT3 ecosystems do not tend to reach the same sizes as in other NDTs.

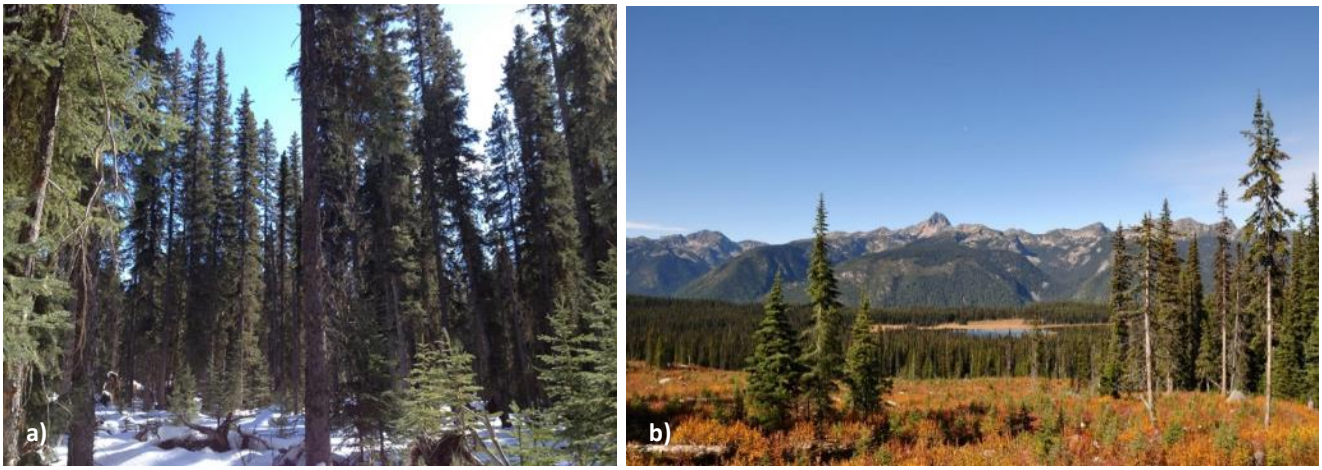


Figure 9. Examples of NDT3 old growth: a) BWBS in Fort St. John (photo by Chelsea Heyer); b) ESSF in Robson Valley (photo by Ken Zielke)

3.2.4 Natural Disturbance Type 4 (NDT4)

NDT4 is associated with hot and dry ecosystems that experience frequent low-severity fire, which typically does not kill mature trees due to their thick bark. This can result in older and more structurally complex forests than those in NDT3. These forests were often open with a grassy understory (Figure 10) but years of fire suppression has allowed many of these stands to become far denser than they would have been historically.[15] Because these stands are typically located in valley bottoms near population centers, they have also seen a long history of logging which removed large trees (settlers, railways construction, etc.). Key attributes of these forests are (see Appendix B for more detail):

- Tree ages: 0 to >300 years old (complex, multi-aged stands)
- Disturbance interval: 250 years
- Old seral defined as >250 years
- Historically natural amounts of old forest are 37% based on localized disturbance return intervals
- Examples of NDT4 forests: dry belt Douglas-fir and ponderosa pine forests (IDF and PP) near Kamloops and the East Kootenays (Cranbrook).

NDT4 forests tend to have limited tree species variation because only certain species are fire and drought tolerant. Trees are often in multi-layered canopies, with large veteran Douglas-fir and ponderosa pine which survived multiple low intensity fires. The largest of these trees can be 40m in height and over a meter in diameter.

[15] Evidence for widespread changes in the structure, composition, and fire regimes of western North American forests. R. K. Hagmann, P. F. Hessburg, S. J. Prichard, et all., August 2021 https://doi.org/10.1002/eap.2431

Figure 10. Examples of NDT4 old growth: a) IDFdk in the Logan Lake Community Forest (photo by Garnet Mierau); b) IDF Williams Lake (photo by Ken Zielke); c) ponderosa pine stand (photo by Kari Stuart-Smith); d) IDFdk in the Logan Lake Community Forest (photo by Garnet Mierau)

4 Why is Old Growth Important?

Old growth forests in BC vary considerably in their character and appearance, but all provide values desired by society. Examples of these values include, but are not limited to:

1. Unique ecosystem conditions that are important for maintaining biodiversity,
2. Opportunities for cultural and spiritual practices,
3. Habitat conditions for specific fish and wildlife species,
4. Areas for recreation, tourism, and intrinsic enjoyment,
5. Stores of carbon,
6. Source of timber and non-timber products, and
7. Source of significant provincial revenues and jobs.

The creation of 'An Old Growth Strategy for British Columbia' (1992)[16] - and later the Biodiversity Guidebook (1995)[17] and the Landscape Unit Planning Guide (1999)[18] - focused forest management on maintaining forest conditions that are consistent with natural landscapes, under the assumption this is the best strategy to conserve biodiversity. **Maintaining representative areas of old forest to meet biodiversity objectives is the primary reason behind old growth management today, but a wide range of other co-benefits aligned with old growth is well-recognized.**

In addition to the biodiversity values that are applicable to all types of old forests and ecosystems, BC's very large old growth stands are valued because they are relatively rare among the world's forests and are difficult to replace in any meaningful timeframe. When we evaluate the condition of old growth, it is very helpful to be clear about whether we are concerned about maintaining old growth for biodiversity reasons or to ensure special rare stand types are conserved for the future. Managing biodiversity can and should be addressed over large areas (i.e. the province), while conservation of special stand types is best addressed at management unit planning scales (e.g. local land use plans).

5 How is Old Growth Protected?

There are many ways that old growth is protected in the province of British Columbia. This section details the different mechanisms available for old forest protection currently under policy or legislation in BC for Crown land. When describing 'protected' old growth in Section 7, it is the items below that are represented.

5.1 PARKS AND PROTECTED AREAS

National and Provincial Parks provide significant areas of protected old forests within their boundaries. BC has the largest provincial park system in Canada with a total of 644 parks.[19] Within the province, there are an additional three National Park Reserves, four National Parks, six National Wildlife Areas, and other National Protected Areas.

In addition, BC has a number of mechanisms to conserve lands outside of parks, such as: ecological reserves (148 across the province), recreation areas (2), protected areas (84), and conservancies (158). Under the *Ecological Reserve Act, Protected Areas of British Columbia Act and Environment* and *Land Use Act*, important ecosystems are reserved from natural resource use, including forestry.

5.2 OLD GROWTH ORDER AND OLD GROWTH MANAGEMENT AREAS

BC's 'Non-Spatial Old Growth Order' sets the broad framework for managing old growth when local Land Use Plan Orders have not done so already.[20] These Orders establish old growth targets for each Landscape Unit (LU) and BEC variant combination across the province to ensure old growth is represented in all ecosystems. Maintaining old forest to meet the targets can be done in two ways:

[16] BC Ministry of Forests, 1992. https://www.for.gov.bc.ca/hfd/library/documents/Bib1569.pdf

[17] BC Ministry of Forests, 1995. https://testwww.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/biodiv/biotoc.htm

[18] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/land-use-plans-and-objectives/policies-guides/lup_guide.pdf

[19] BC. (2021). *Summary of the parks and protected areas* system. https://bcparks.ca/about/park-designations.html#ClassA

[20] BC. (2004). *Order establishing provincial non-spatial old growth objectives.* Forest Practices Code of British Columbia. Retrieved from: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/land-use-plans-and-objectives/bc-biodiversity-mngt/bc_non-spatial_old_growth_fpc_30jun2004.pdf

- Spatially selecting specific stands (referred to as Old Growth Management Areas or OGMAs) to be preserved from harvesting. In some cases, these OGMA locations are made legally binding, while in others they are placeholders to illustrate which stands are to be retained to address old forest area targets. Legally established OGMAs cannot be moved without significant administrative effort. This becomes an issue when a natural disturbance such as insect infestations or wildfires causes mortality inside an OGMA; or
- Assessing the percent of old forest in each LU / BEC variant combination to provide annual statistics on how much old forest currently exists, and identify if an area can be logged and still remain in compliance with the old growth objective. This approach is flexible but more complex than simply mapping out the stands to be protected. It is also less able to consider issues like recruitment, connectivity, patch size, or patch shape.

5.3 OLD GROWTH DESIGNATED AREAS

Since September 2020, BC has designated 11 areas in the province where old growth harvesting is deferred for up to 4 years.[21] These deferrals have been made for specific locations (Figure 11) while BC consults with First Nations on how best to implement the 14 recommendations from the Gorley & Merkel (2020) Review. These deferrals are incremental to areas that are already protected for other reasons.

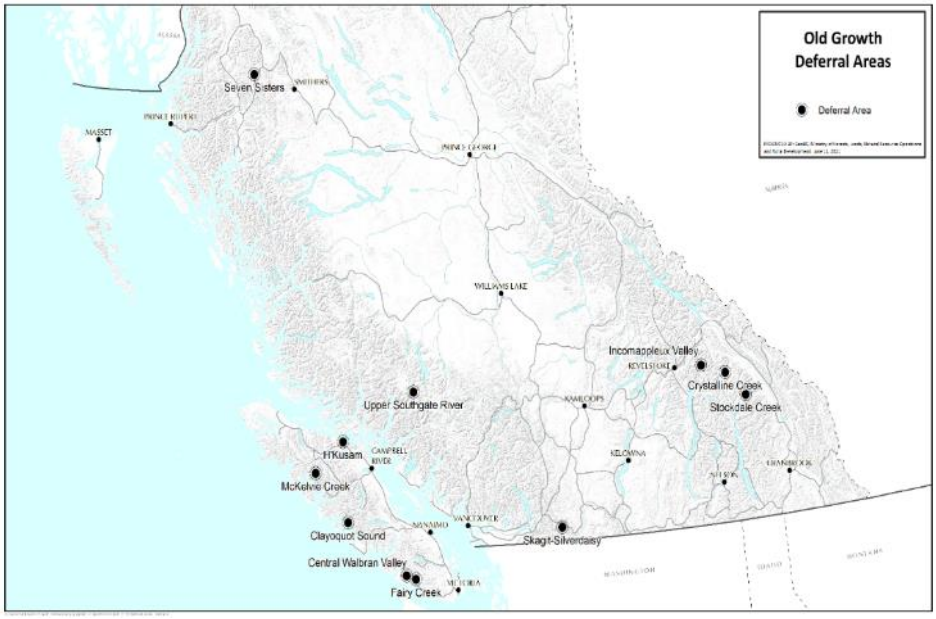


Figure 11. Old growth deferral areas, generated by BC FLRNORD on June 11, 2021

5.4 SPECIAL TREE PROTECTION REGULATION

BC's Special Tree Protection Regulation came into effect in September 2020.[22] This regulation prohibits the cutting (i.e., felling, limbing, pruning, topping, or otherwise cutting), damaging or destroying standing trees that are of certain species and diameter (i.e. very big trees) as outlined in the regulation. It also protects the trees within a 56m radius of a specified tree. Special trees are defined by the diameters shown in Table 2.

[21] BC. (2021). *Ministerial orders for old growth designated areas*. https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/old-growth-forests/deferral-areas#MO

[22] BC. (2020). *Special Tree Protection Regulation*. Forest and Range Practices Act. Retrieved from: https://www.bclaws.gov.bc.ca/civix/document/id/oic/oic_cur/0501_2020

Table 2. Special Tree Definitions (minimum diameter by species)

Species	Diameter at Breast Height (cm)
Yellow Cedar (Cyprus)	265
Douglas-fir (coastal)	270
Douglas-fir (interior)	160
Ponderosa Pine	119
Western Red Cedar (coast)	385
Western Red Cedar (interior)	290
Sitka Spruce	283

5.5 GREAT BEAR RAINFOREST

The Great Bear Rainforest (GBR) is a temperate rain forest comprising of 6.4 million hectares along the north and central coasts of BC where management is guided by the Great Bear Rainforest Land Use Order (2016) and the principles of ecosystem-based management (EBM).[23] The GBR agreement was created through collaboration between First Nations, the provincial government, industry, and local communities balancing cultural, social, economic, and environmental objectives. One of the objectives of the GBR was to conserve 85% of the forested land base (3,108,876 ha) in the form of Biodiversity Management and Tourism Areas (BMTAs) and stand-level reserves for wildlife (e.g. grizzly bears) as well as Red and Blue listed ecosystems. These measures collectively leave 15% or approximately 550,000 ha of the forested land base available to practice sustainable forestry. The GBR is a significant old forest protection mechanism using both large protected areas and old seral retention targets within each LU/ecosystem group. It was a unique solution developed for a specific area of the province.

5.6 OLD FORESTS PROTECTED BY OTHER VALUES

In addition to the mechanisms listed above, BC has designated areas where timber harvesting is limited or restricted. These areas protected by other values also serve to protect old forests. Below are the additional conservation efforts that also benefit old forests.

Under the *Wildlife Act*, BC has approximately 260,000 ha of Wildlife Management Areas (WMAs), which provide habitat protection for regionally and internationally significant fish and wildlife species. Old forests within WMAs are also protected.

Under the *Forest and Range Practices Act*, Ungulate Winter Ranges (UWRs) were established to provide habitat requirements for ungulate species during the winter. Each UWR has its own Order in Council that outlines the exact management objectives for the area, some of which are established no-harvest zones. UWRs where no timber harvesting is allowed are areas where old forest protection exists.

As part of the Canada-BC Agreement on Species at Risk, BC has developed Provincial Recovery Programs and/or Identified Wildlife Management Strategies for the purpose of reversing the decline of species at risk in BC such as the woodland caribou, grizzly bear, marbled murrelet, northern goshawk, spotted owl, and many other species. **Under regulation issued under the *Forest Range and Practices Act*,** BC has also created Wildlife Habitat Areas (WHAs). WHAs are defined by their own Orders in Council that spatially identify where critical habitat for the species is located, and how it should be managed to limit impacts from human beings (i.e. forestry activities are

[23] BC. (2016). *Great Bear Rainforest Land Use Order.* https://www2.gov.bc.ca/gov/content/industry/crown-land-water/land-use-planning/regions/west-coast/great-bear-rainforest/great-bear-rainforest-legal-direction-agreements

usually prohibited from removing forest cover in forested habitat). BC has established 2,778,706 ha of WHAs, where harvesting is not allowed and therefore old forest protection exists.

Within Visual Landscape Polygons, Preservation and Retention Objectives are specific areas around communities and travel corridors where the goal of forest management is to maintain visual quality/scenic beauty. The old forests in these visually sensitive areas are expected to have very limited impacts from forest harvesting.

Overall, BC has many forest protection mechanisms that contribute to maintaining old forest on the landscape (riparian area retention is another example). In addition to these protections, there are large areas of the province that have no expectation of logging activity because of economic and physical constraints.

6 How Do We Track Old Growth?

BC's forest inventory data – known as the Vegetation Resource Inventory (VRI) – is the foundation for mapping and assessing forested attributes over large areas. **Despite well-known limitations, VRI data remains the best available information to identify old forests at the scale required for this report. But it is important to be aware of the VRI's limitations when interpreting the results presented here (explored in more detail below).**

6.1 VEGETATION RESOURCE INVENTORY (VRI) STRUCTURE

VRI data is created by certified forest inventory professionals to provincial standards.[24] These professionals use 3D (stereo) imagery to assess the forest and delineate polygons that capture relatively homogenous forest and non-forested areas. Once polygons are established, they assign specific attributes for species, height, basal area, crown cover percent, trees per hectare, and age using the stereo imagery. Field checks are completed in several stands in each map sheet to support the interpretation process. Younger stand data from silviculture surveys is also incorporated into the inventory attributes. Additional attributes (e.g., site index, average stand diameter at breast height, merchantable volume) are then calculated for each polygon using the photo interpreted values, and polygons are then classified according to BC's land classification scheme (Figure 12).

[24] BC. (2021). *Forest cover inventory photo interpretation standards*. Retrieved from: https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-inventory/forest-cover-inventories/photo-interpretation/standards

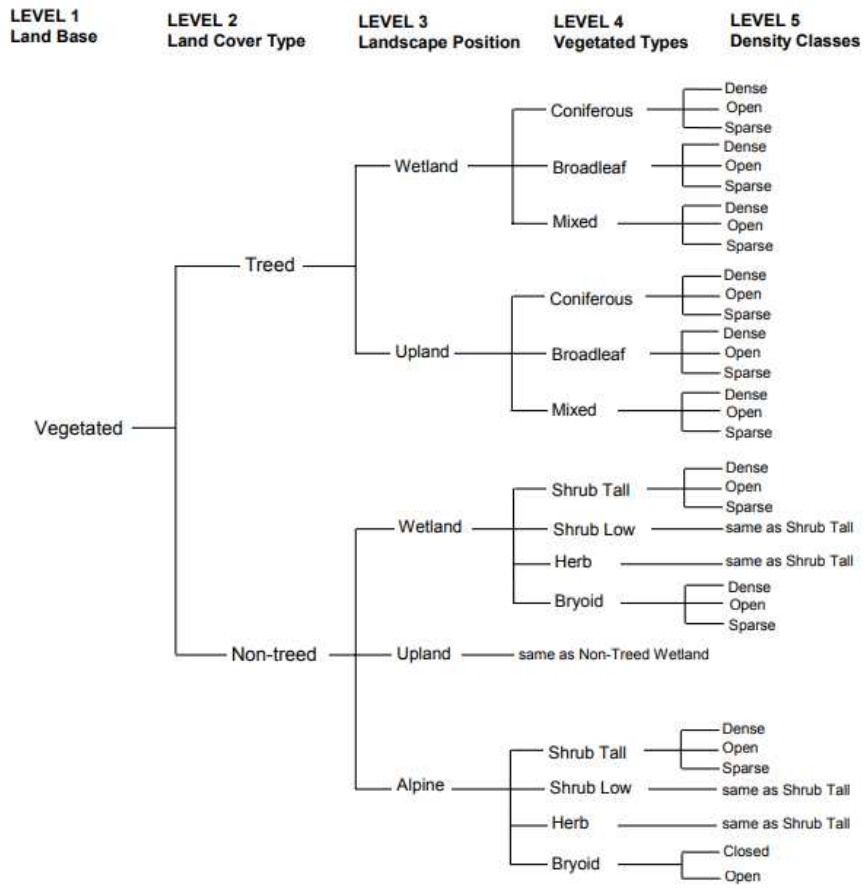


Figure 12. BC's Land Classification Scheme overview

It should be noted that not all areas of the province have VRI data created as described above:

- Several areas of the province have no VRI data available. These are typically parks that have never been inventoried to the VRI standard. The Kitlope Heritage Conservancy is the largest example of this in the province (located between Kitimat and Bella Coola). Older (1995) Basemap Thematic Mapping exists for these areas and was used in this project to fill gaps in the VRI.
- Several areas of the province (Cassiar, Williams Lake, Quesnel West) have had Landscape Vegetation Inventories (LVI) completed using a combination of Landsat imagery and photo interpretation.[25] Image analysis is used to segment homogeneous polygons, selected samples of these polygons are photo interpreted for attributes, and then algorithms are used to assign attributes to all remaining polygons. These cost-efficient datasets have lower attribute accuracy at the stand-level but have been designed to be statistically accurate at the class/stratum and population levels.

Inventory Updates

The provincial forest inventory is updated annually by government (FLNRORD Forest Analysis and Inventory Branch) using largely automated processes. This process includes incrementing stand ages by 1 year and then using the province's growth and yield model (VDYP[26]) to 'grow' each stand's attributes. Depletions (harvesting and

[25] LVI Presentation by BC Gov't https://slideplayer.com/slide/13398354/

[26] Variable Density Yield Projection (VDYP7) model. https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-inventory/growth-and-yield-modelling/variable-density-yield-projection-vdyp

some natural disturbances) are then included along with any new free-growing silviculture survey data for previously harvested areas.

The province has mapped fire severity within fire perimeters > 100 ha in size for fires back to 2015. This data is used to adjust the basal area and stems per hectare in the inventory update process, but ages are not altered. For the purpose of this report, all areas that exhibited medium or high burn severity were considered stand-replacing and had their ages reset to 0 years as of the fire year. In addition, stands with > 50% mortality from mountain pine beetle also had their age set to 0 years as of the year of attack.

6.2 FOREST DEFINITION

In order to identify old forest, we must first define what is considered forest. The definition of "forested land" used by the province (and in this report) is based on VRI data and is as follows:

- Vegetated Treed polygons as well as Vegetated-Non-Treed polygons that are regenerating from past logging (have an opening ID or logging history); and
- Site Index > 5m (capable of growing to 5m tall in 50 years of age at breast height).

This effectively defines "forest" as those sites capable of growing >5m tall in 50 years (breast height age) and containing at least 10% tree cover.

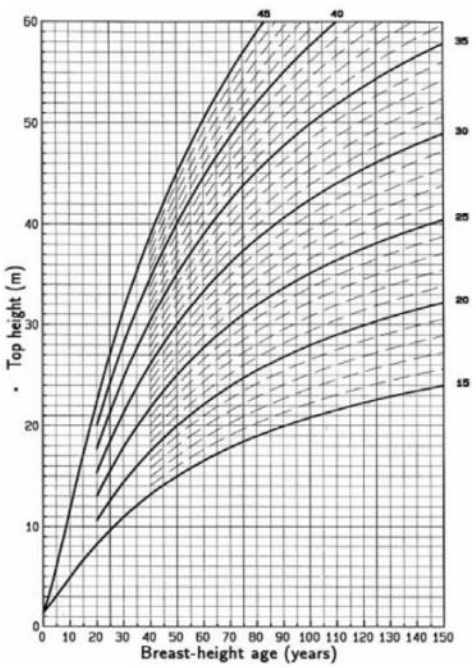
6.3 SITE PRODUCTIVITY DATA AND OLD GROWTH

Site productivity estimates in BC's forest inventory (VRI) have been used to describe the amount of area capable of supporting high quality ('big tree') old growth in BC. For example, in 'BC's Old Growth Forest – A Last Stand for Biodiversity' it was stated that there is only 415,000 ha of old growth existing on good quality sites (site index >20m) in the province, leading to the false conclusion that only 3% of BC's old forest is good quality ('big tree') old growth. **Site index data currently available in the provincial VRI data is not well-suited to describe the presence of 'big tree' old growth.** The text below provides context around BC's site index estimates for old stands.

Site index values provide a measure of productivity for a specific species on a given site, and indicates how tall a site tree will be at age 50 years (measured at breast height).[27] A site index value represents the 'growth potential' for a specific tree species on a site, but the actual expression of height growth will vary based on tree genetics and damage from pests, disease, wind, etc. For example, a site index 30 Douglas-fir site would suggest that the best Douglas-fir trees on a given site would be 30 meters tall when they are 50 years old (measured at breast height) assuming no impacts from wind, pests, or disease.

[27] Stearns-Smith, S. (2002). Making sense of site index estimates in British Columbia: A quick look at the big picture. Journal of Ecosystems and Management, 1(2). Retrieved from: https://jem-online.org/index.php/jem/article/viewFile/237/156

When assigning site index values in BC's forest inventory (VRI), a professional photo interpreter looking at stereo (3D) photography will estimate the height and stand age for a mapped polygon, then use published site index curves (example image to right) to estimate the site index for the stand. This is challenging because estimating age from photography is very difficult for old stands and thus the age of old growth stands is often very simplified (e.g., 250, 300, 350, etc.) and not particularly accurate. In addition, the interpreter is not focusing on site trees to complete the task, but instead describing the average dominant tree height in a polygon. Thus, the **VRI site index values for old stands often substantially underestimate actual site productivity**. The values are still retained in the VRI because they are useful for growing old stands in the province's VDYP yield model. Stand heights in old stands are already at or near their maximum and VDYP volume predictions are tied to empirical relationships with height, basal area, and stems per ha. As a general rule, VRI site index values are underestimated for old stands across the province but more significantly in coastal ecosystems where sites are often very productive and trees can live to very old ages.



BC Coastal Douglas-fir site index curve[1]

Based on this known issue with VRI site index values, significant research has been completed to derive improved estimates of site productivity for the province's old stands.[28] These improved estimates are based on ground sampling of site index (for specific species) within specific ecosystem strata (BEC variant – site series). The province has published this data as the Provincial Site Productivity Layer (PSPL) with supporting validation[29] and is now the preferred method of describing the growing potential for sites currently occupied by old forest. While this may be a less direct reflection of the trees currently on a given site because it represents average productivity by ecosite/tree species, it does appear to correlate better with the presence of larger trees relative to VRI site index.

To illustrate this point, a total of 533 verified Big Trees on BC's coast were compiled: 65 from UBC's Big Tree Registry, 122 from BCTS's Legacy Tree dataset, 108 from Western Forest Products Big Tree Dataset on the BC coast, and an additional 238 coastal trees with LiDAR confirmed heights >= 80m tall. All trees were at least 250 years old or in VRI polygons >= 250 years old. Each tree was assigned a site index value from the provincial VRI data and from the provincial PSPL data. Because these are all confirmed Big Trees, it could be expected that they will be growing on high productivity sites. Figure 13 shows that a large portion of these Big Trees have VRI site indexes <20m, while PSPL site index values indicates they are almost all >20m. The PSPL data shows a much stronger relationship between the presence of big old trees and higher site productivity.

[28] SIBEC Site Index Estimates in Support of Forest Management in British Columbia (Shirley Mah and Gordon Nigh, 2003) https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/ecosystems/sibec_tech_report_tr004.pdf

[29] Validating the site productivity layer for British Columbia with equivalence testing (G.D. Nigh and J. de Jong, 2015) https://www.for.gov.bc.ca/hfd/pubs/docs/tr/TR085.pdf

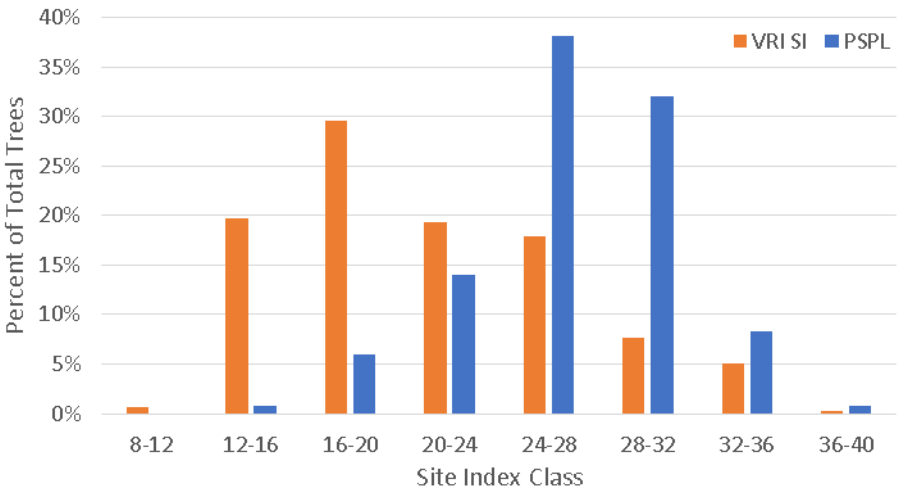


Figure 13. Verified Big Trees and associated site index values assigned by VRI data versus PSPL data

To investigate a specific example, Figure 14 shows the location of a UBC verified Big Tree (66m tall, 347 cm diameter Sitka Spruce) on Haida Gwaii located in a VRI polygon with a site index of only 15.6m (VRI age 353 years, height 40m).

Figure 14. UBC Verified Big Tree location and attributes in pink (Ss 347 cm, 66m tall) with VRI values (white) on Haida Gwaii. Younger stands all have higher VRI site index values because they can be more accurately measured.

The VRI stand attributes indicate a relatively tall stand with a low site index – yet it has the capacity to produce very big trees. Due to the inaccuracies of older stand ages, VRI site index is simply not a good means to identify actual areas of big tree old growth

An alternative way to gauge the usefulness of 'site index > 20m' as means to identify 'quality/big tree' old growth is to examine the stands in the Fairy Creek watershed. This high-profile old growth area has attracted significant attention for preservation in the past year and is thus assumed to be high-value old growth. The upper 80% of the watershed contains stands between 199 and 319 years (VRI ages) with VRI site indexes generally under 20m (Figure 15), while the bottom of the watershed has higher site index values but younger stands at 30-70 years. Thus, if stands must be 250 years old with site indices of at least 20m to be considered good quality old growth, a small fraction of this valley would meet that definition. **Fairy Creek is thus largely excluded from what the "Last Stand for Biodiversity" report defined as quality old growth (i.e. the 415,000 ha or 3% of all old forest) and is a good example of why that report caused the confusion it did around the state of old growth in the province.**

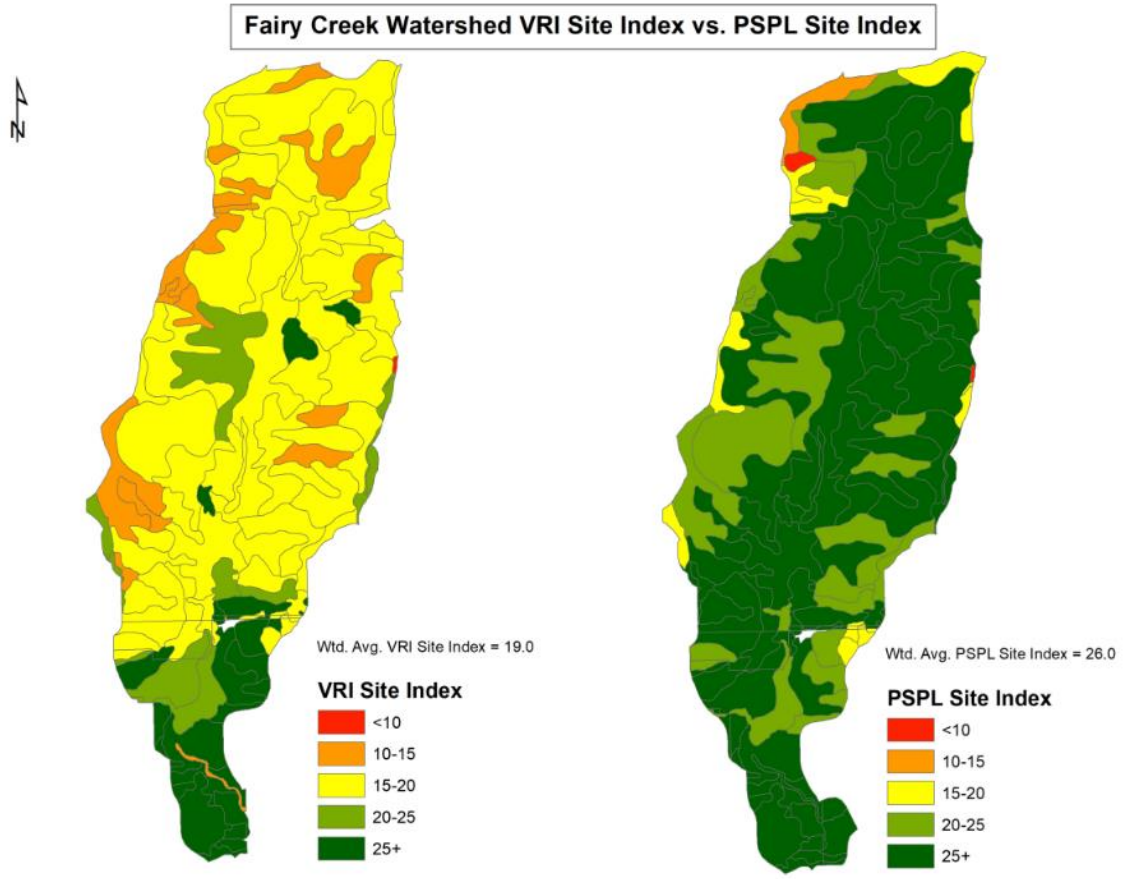


Figure 15. Fairy Creek watershed themed by VRI site index and PSPL site index. Note that the high site index areas in the left image (VRI) occurs almost exclusively where stand ages are young and measured more accurately.

7 How Much Old Growth is in BC?

7.1 AREA BY SERAL STAGE

Using BC's age-based definitions for old forests by ecosystem (see Appendix B) there is currently **11.4 million ha of old forest on the forested Crown lands in BC** (55.4 million ha of provincal and federal lands).[30] This represents 21% of the Crown forested land base with some variation by region in BC (Figure 16 and Table 3).

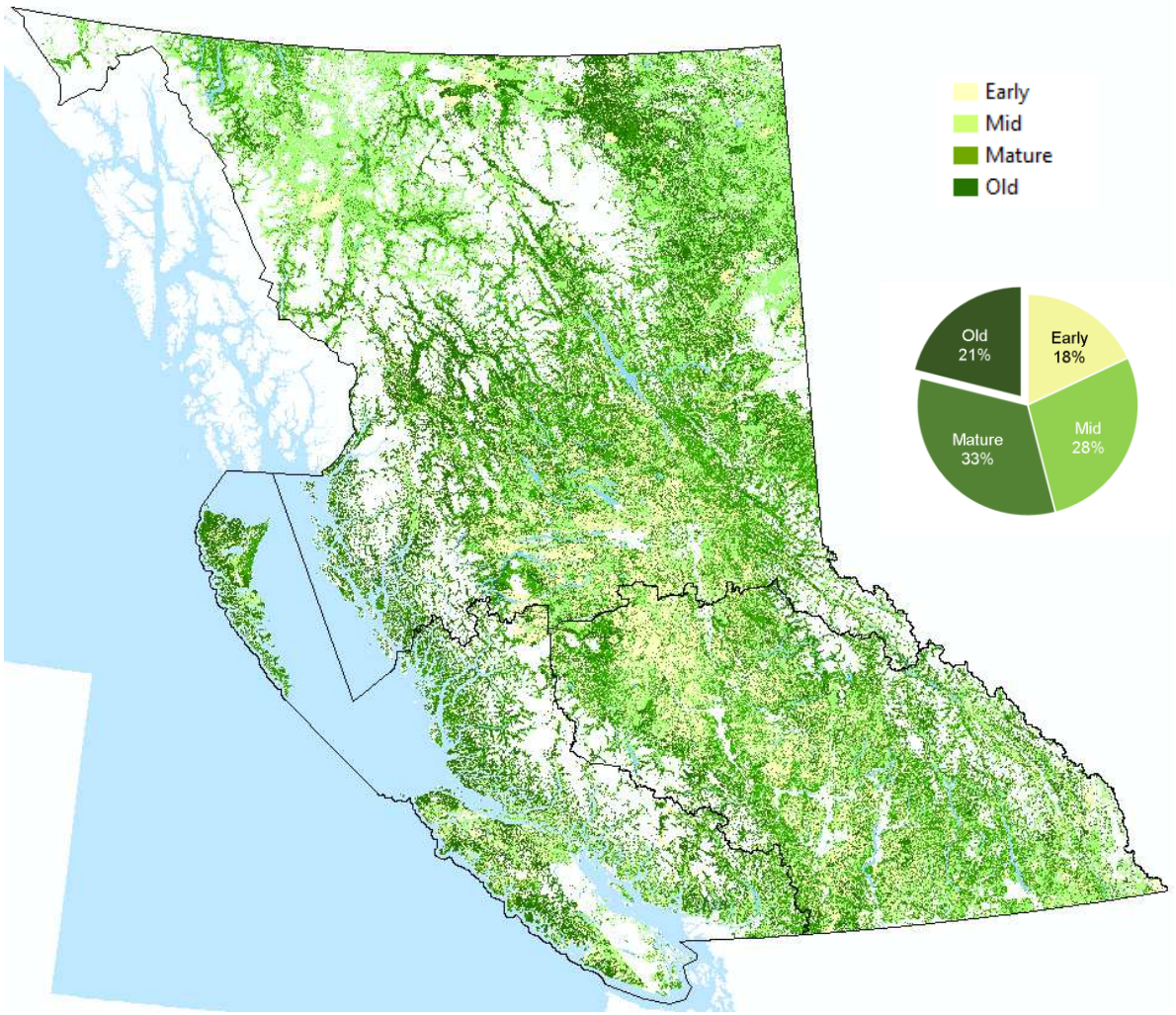


Figure 16. Distribution of early, mid, mature, and old seral forests in BC as of January 2021

Current to January 2021, Figure 17 illustrates the Crown forested area in ten year age classes broken down by the Timber Harvesting Landbase (THLB) and Non-Timber Harvesting Landbase (non-THLB or NTHLB). Overall, the THLB is younger than the NTHLB - which includes protected old stands. It is worth noting that neither THLB or non-THLB lands (where no harvesting is expected) contain forest mapped over 430 years old. We know that old forests well

[30] Other estimates of BC's old forest published in the last two years have indicated 13.2 to 13.7 million hectares exist in BC. These values included private lands not included here (e.g. Mosaic on Vancouver Island, Darkwoods near Nelson, Canwell in East Kootenays)and were produced with 1) older (2018) datasets that 2) treated historic fire and mountain pine beetle mortality differently, and 3) had several other structural differences. The dataset used here included more detailed forest cover mapping in several Tree Farm Licences (VRI instead of BTM mapping) and a newer LVI created for the Cassiar TSA which shifted over 900,000 hectares of forest from old to mature ages. Government inventory staff believe the older inventory more correctly reflected the amount of old forest.

over 500 years old currently exist on the land base but they are poorly described in the forest inventory because of the challenges with estimating accurate ages from stereo photography.

Table 3. Crown forested area by seral stage for Natural Resource Operations Regions in BC

Region	Early	Mid	Mature	Old	Total	Percent Old
Coast	1,257,514	1,208,089	2,138,524	3,435,752	8,039,880	43%
Northern Interior	5,300,897	9,934,680	9,922,282	5,797,732	30,955,591	19%
Southern Interior	4,894,883	3,949,598	5,389,607	2,184,422	16,418,510	13%
Province	**11,453,294**	**15,092,367**	**17,450,413**	**11,417,906**	**55,413,980**	**21%**
Vancouver Island (subset of Coast)	501,049	423,873	301,953	770,172	1,997,047	39%

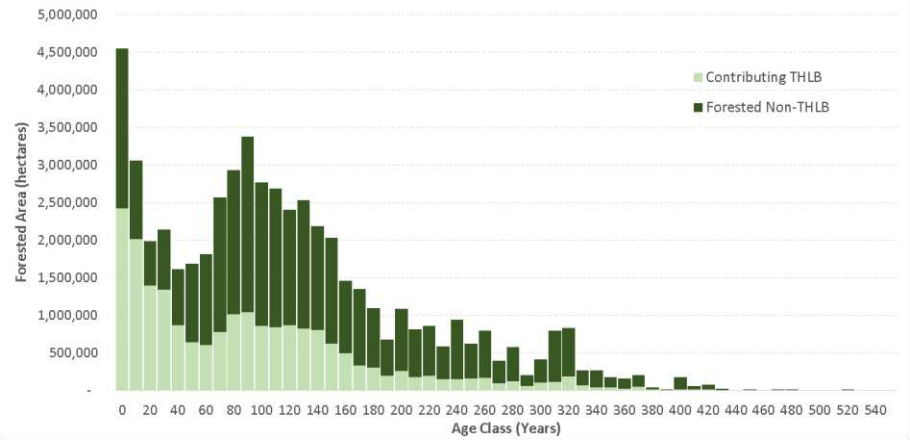


Figure 17. Provincial Crown forested area by 10 year age class

7.2 AREA BY PROTECTED STATUS

To examine the status of old forests in the province, all old stands were assigned to one of three categories: 1) Protected (see Section 5), 2) Non-Timber Harvesting Landbase[31], and 3) THLB or Harvestable areas (subject to meeting local/provincial planning requirements). **At the provincial scale, 75% of the old forest is Protected or outside the Timber Harvesting Landbase**. A full summary of these areas is provided in Table 4 and Figure 18. Old forest area on the Crown land base by protection status for each region and the province, and mapped in Figure 19.

Table 4. Old forest on Crown lands by protection status

Region	Protected	Non-Timber Harvesting Landbase	Harvestable	Total	% Not Harvestable
Coast	2,228,126	796,498	411,128	3,435,752	88%
Northern Interior	1,194,009	2,639,059	1,964,665	5,797,732	66%
Southern Interior	1,015,252	637,522	531,649	2,184,422	76%
Province	**4,437,386**	**4,073,078**	**2,907,442**	**11,417,906**	**75%**
Vancouver Island (subset of Coast)	313,640	305,161	151,371	770,172	80%

[31] Harvest is possible but unlikely due to non-timber values, economic and/or physical limitations.

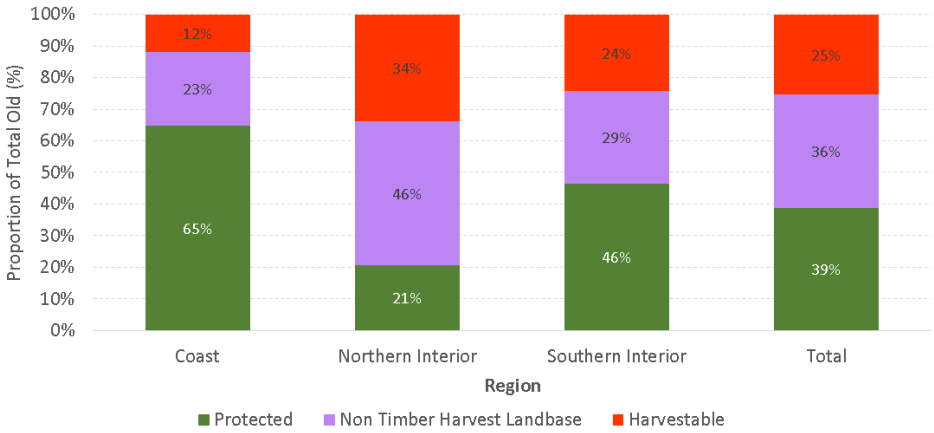


Figure 18. Old forest area on the Crown land base by protection status for each region and the province

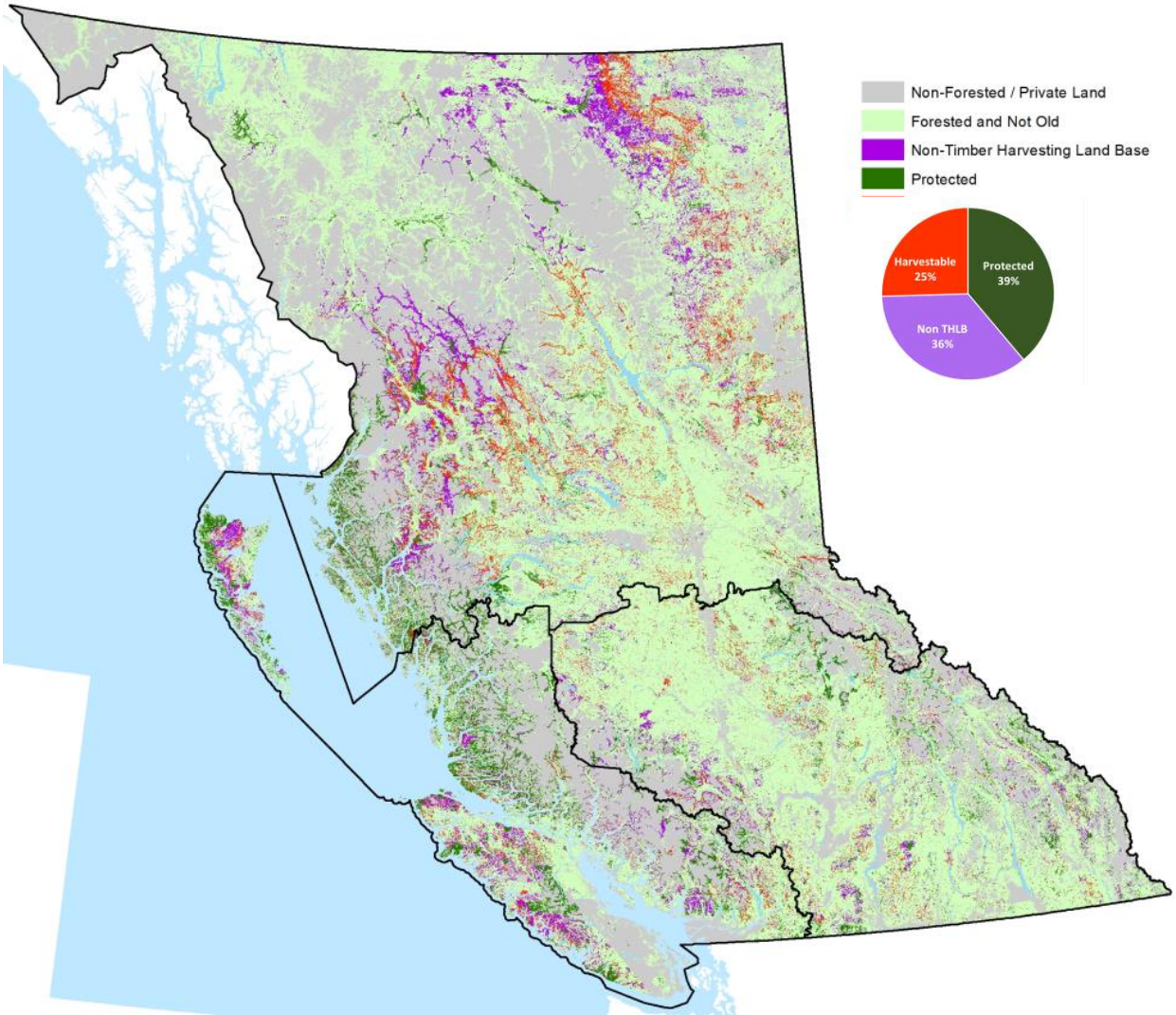


Figure 19. Old forest by protected status across the province

7.3 AREA BY SITE INDEX

As discussed in Section 6.3, there are two different sources of site productivity available at the provincial scale. The estimates in BC's forest inventory (VRI) data significantly underestimate true site potential and show poor correlation with old growth stand height or diameter due largely to inaccuracies in old stand ages. The PSPL provides a better approximation of site productivity based on correlations with ecosystem characteristics, and appears to correlate better with the presence of big trees.

A comparison of the two sources illustrates that VRI site index values are significantly lower than the PSPL data, and high productivity sites (>25m) are not common at the provincial scale (Figure 20) as they are largely located only on the coast. Figure 21 and Figure 22 breakdown the province by seral stage and PSPL site index classes. Figure 21 shows that **when PSPL data is used, the percentage of old forest is relatively consistent across productivity classes**.

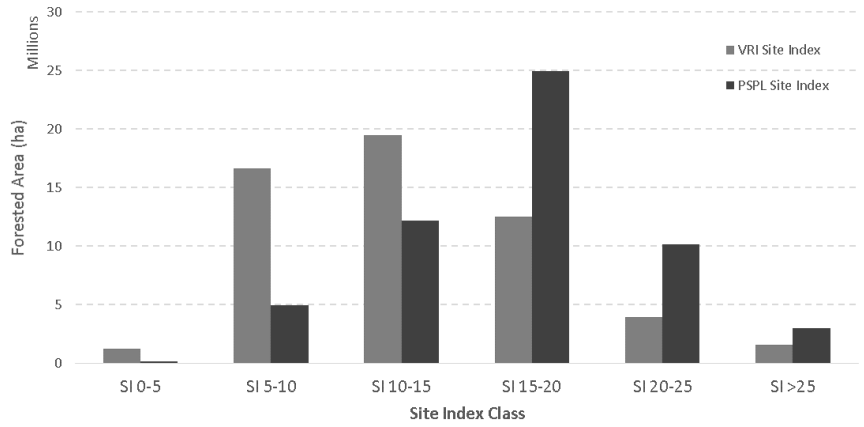


Figure 20. Provincial Crown forest by site index class – VRI versus Provincial Site Productivity Class

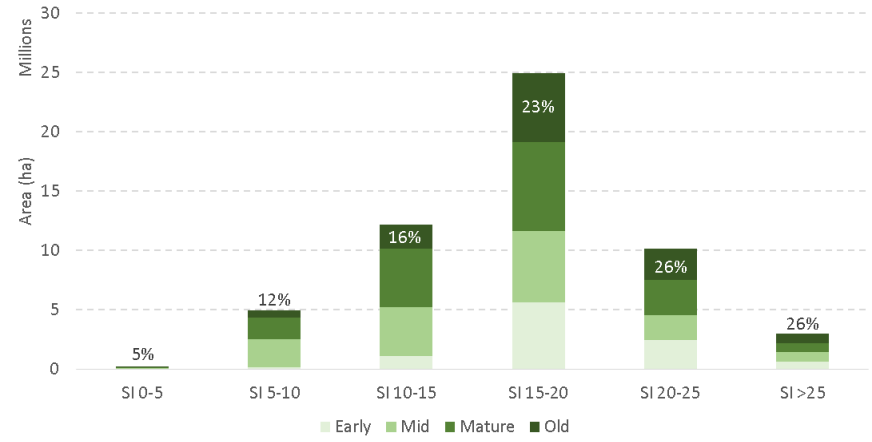


Figure 21. Provincial level Crown forest area by PSPL site index and seral class with current percent old growth

Table 6 indicates that there are 3.34 million ha of old forest growing on sites where the expected site index is greater than 20m (29.3% of all old forest in the province). It is recognized that using SI>20 to denote good growing sites in the province is a vast simplification of reality, as SI 20 would be considered lower productivity in some ecosystems (portions of the coast) and high in others (dry interior), but is used here only to provide a comparable number to past reporting. If the goal is to ensure old forests are present across the range of

productivity classes in an ecosystem, site index thresholds would need to be developed specific to tree species and ecosystem groups across BC. This is a substantive piece of work that will require input from a range of professionals and was thus not attempted here. Blanket provincial approaches are not appropriate.

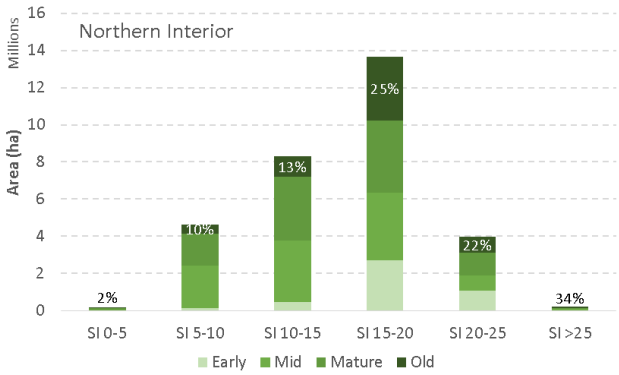
Table 5. Provincial level Crown forest area by seral stage and VRI site index (SI class)

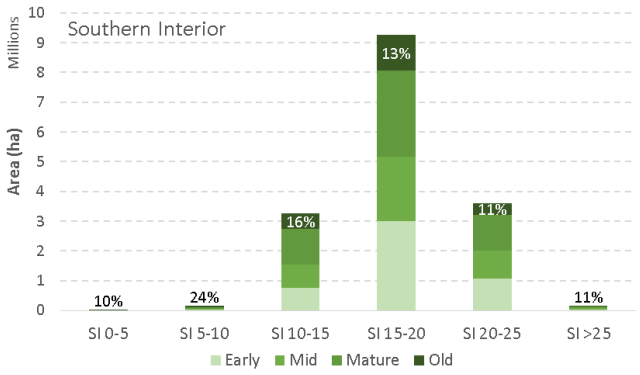
SI_CLASS	Early	Mid	Mature	Old	Total	% of Total	% Old
SI 0-5	719,970	164,585	212,791	167,034	**1,264,382**	2%	13%
SI 5-10	1,174,542	4,431,912	6,990,356	4,033,965	**16,630,775**	30%	24%
SI 10-15	3,358,147	5,279,557	6,220,982	4,607,245	**19,465,932**	35%	24%
SI 15-20	3,886,681	3,316,112	3,152,213	2,170,980	**12,525,987**	23%	17%
SI 20-25	1,757,434	1,174,801	600,142	*393,584*	**3,925,962**	7%	10%
SI >25	556,519	725,399	273,928	*45,097*	**1,600,943**	3%	3%
Total	**11,453,294**	**15,092,367**	**17,450,413**	**11,417,906**	**55,413,980**	100%	21%
% of Total	21%	27%	31%	21%	100%		

Table 6. Provincial level Crown forest area by seral stage and PSPL site index (SI class)

SI_CLASS	Early	Mid	Mature	Old	Total	% of Total	% Old
SI 0-5	32,739	29,826	88,709	19,319	**170,594**	0%	11%
SI 5-10	224,218	2,352,451	1,789,584	593,663	**4,959,916**	9%	12%
SI 10-15	1,388,824	4,105,014	4,732,101	1,951,041	**12,176,979**	22%	16%
SI 15-20	6,578,075	5,739,434	7,117,718	5,513,259	**24,948,487**	45%	22%
SI 20-25	2,587,609	2,062,138	2,951,540	*2,546,928*	**10,148,216**	18%	25%
SI >25	641,828	803,504	770,761	*793,696*	**3,009,789**	5%	26%
Total	**11,453,294**	**15,092,367**	**17,450,413**	**11,417,906**	**55,413,980**	**100%**	**21%**
% of Total	21%	27%	31%	21%	100%		

When the PSPL site index data is evaluated at the regional level, the coast can be seen to have significantly higher site index values (majority >20m) relative to the interior (majority <20m), and significantly higher percentages of old forest (average 43%) relative to the interior (average 13% in the south and 19% in the north). The coast exhibits a trend of declining old seral representation in the highest site productivity class, whereas this is less evident in the interior.





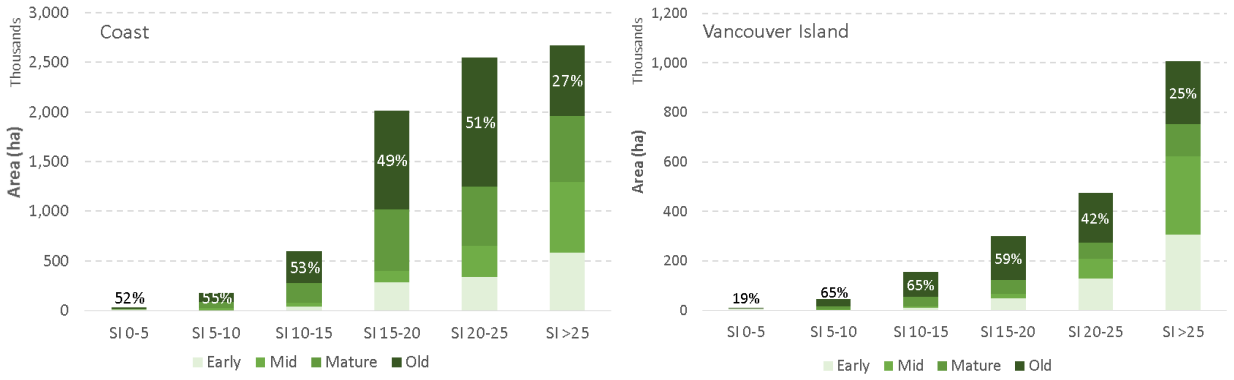


Figure 22. BC Regions: Crown forest area by PSPL site index and seral class with current percent old growth (note: Vancouver Island is a subset of the Coast region)

7.4 AREA BY ECOSYSTEM

When old seral percentages are summarized at the NDT/BEC zone level, it is possible to compare the current old percentage on the land base to an expected old percentage derived from each ecosystem's disturbance interval (average time between natural stand replacing disturbance events). Ecosystems with frequent natural stand replacing disturbances will inherently have less old growth than ecosystems where disturbances are rare. The 'natural old %" assessed for a given ecosystem represents an average condition around which variation would occur over time. Deviation around this average amount of old forest is normal, but as deviation levels get larger, there is an increasing risk to biodiversity. Figure 23 and Table 7 show current old and mature percentages by NDT and BEC zone and include quartile markers (25%/50%/75%) as reference points to indicate the level of deviation from 'natural old'. See Appendix B for detailed descriptions of disturbance intervals and expected 'natural old' seral percentages. **The question of how much old forest should be present in a given area is not addressed here, as it should be examined at the regional level by local experts with more detailed information.**

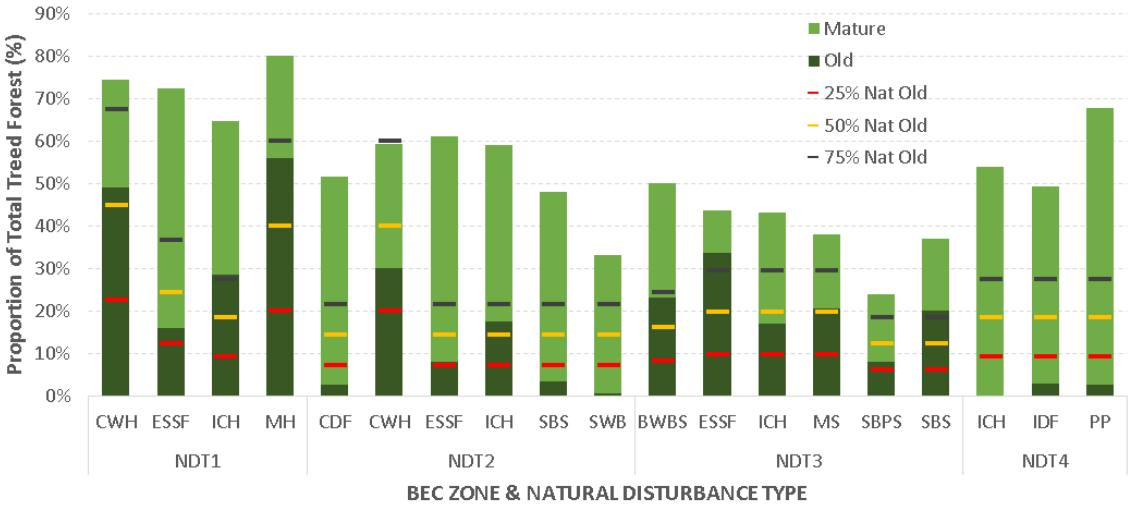


Figure 23. Old and mature areas expressed as a percent of forested area.

Results show that 13 of 19 NDT/BEC combinations in the province contain enough old forest to exceed the '25% of natural' level, while only 3 of 19 meet the '75% of natural' level. Due to the known issues with VRI age estimates

for older and/or complex stands, mature stands are also shown in the graph. It is likely that some portion of the mature stands in SWB, SBS, ESSF, and all NDT4 BECs would be considered old if field-verified. Many of these areas have extensive areas mapped with ages just below the old age, and are thus called mature in the analysis. For example:

- The PP and IDF ecosystems (all of which are < 10% old) tend to have complex stand structures (trees of many different aged in a single stand) which have resulted in most older stands being assigned ages in the 200-250 year range, just under the old age threshold of 250 years. However, many of these mature stands can contain old trees. Irrespective of age classifications, many of these stands were impacted by partial harvesting of larger trees in the past (1900-1970). Long periods of fire suppression have also left these stands far denser than they would have been historically, and will require restoration treatments to ensure quality old forest stands exist into the future. Deferral strategies would ideally not to prevent ecologically appropriate management from occurring, as these stands rely on disturbances to maintain their natural structures.[32]
- The Spruce-Willow-Birch (SWB) ecosystems (northwest corner of the province) are largely described by new satellite based LVI inventory data that has lowered stand ages across the board (140-150 years old stands now labeled as 100-140 years old). Government staff believe that the ages in this new inventory are less reliable than the older inventory. It is highly likely this largely natural landscape has extensive areas of old forest not reflected by the current inventory. See Figure 23 to understand the large amount of mature forest mapped in this BEC zone.
- The BWBS, CDF and portions of the ESSF also have potential issues with not recognizing old stands in the inventory. See Figure 23 to understand the large amount of mature forest mapped in these BEC zones.

[32] Wildfire and climate change adaptation of western North American forests: a case for intentional management. Paul F. Hessburg, Susan J. Prichard, R. Keala Hagmann, Nicholas A. Pova, Frank K. Lake. August 2021 https://doi.org/10.1002/eap.2432

Table 7. Current old and mature forest area summarized by NDT and BEC zone

Natural Disturbance Type	BEC Zone	Forest Area (ha)	Old Forest (ha)	% Old	% Mature	% Mature + Old	25% of Natural Old	50% of Natural Old	75% of Natural Old
NDT1	CWH	5,461,777	2,681,850	**49%**	25%	75%	23%	45%	68%
	ESSF	3,608,321	573,565	**16%**	57%	73%	12%	24%	37%
	ICH	1,332,813	380,070	**29%**	36%	65%	9%	18%	28%
	MH	1,167,556	655,339	**56%**	24%	80%	20%	40%	60%
NDT2	CDF	41,108	1,019	**2%**	49%	52%	7%	14%	21%
	CWH	2,215,431	668,072	**30%**	29%	59%	20%	40%	60%
	ESSF	4,980,627	399,729	**8%**	53%	61%	7%	14%	21%
	ICH	2,113,252	367,766	**17%**	42%	59%	7%	14%	21%
	SBS	1,609,617	55,448	**3%**	45%	48%	7%	14%	21%
	SWB	3,612,815	19,018	**1%**	33%	33%	7%	14%	21%
NDT3	BWBS	11,965,654	2,756,873	**23%**	27%	50%	8%	16%	24%
	ESSF	1,656,999	559,082	**34%**	10%	44%	10%	20%	29%
	ICH	972,138	165,938	**17%**	26%	43%	10%	20%	29%
	MS	2,572,365	527,728	**21%**	18%	38%	10%	20%	29%
	SBPS	1,992,608	158,485	**8%**	16%	24%	6%	12%	18%
	SBS	6,718,356	1,354,621	**20%**	17%	37%	6%	12%	18%
NDT4	ICH	48,592	28	**0%**	54%	54%	9%	18%	28%
	IDF	3,246,549	90,845	**3%**	46%	49%	9%	18%	28%
	PP	97,401	2,430	**2%**	65%	68%	9%	18%	28%
Total		55,413,980	11,417,906	**21%**	31%	52%			

8 Conclusions

As of early 2021, BC's 55.4 million ha of provincal and federal forested lands contained 11.4 million ha of old forest. This represents 21% of the Crown forested land base existing as old forests, with approximately 29% (3.3 million ha) of these old forests growing on sites with an expected productivity (site index) of > 20m. It is recognized that using SI>20 to denote good growing sites in the province is a vast simplification of reality, as SI 20 would be considered lower productivity in some ecosystems (portions of the coast) and high in others (dry interior), but is used here only to provide a comparable number to past reporting that suggested only 3% of BC's old forests were on sites capable of growing big trees. If the goal is to ensure old forests are present across the range of productivity classes in an ecosystem, site index thresholds would need to be developed specific to tree species and ecosystem groups across BC. This is a substantive piece of work that will require input from a range of professionals and was thus not attempted here. Blanket provincial approaches are not appropriate.

At a regional level, the coast has a higher proportion of old forest (43%) than does the BC interior (13 to 19%).

Overall, approximately 75% of BC's old forest is considered protected or outside the Timber Harvesting Landbase, with this proportion being significantly higher on the coast (88%) than the interior (66 to 76%). This is due to the coast region's significant areas of Parks and Protected Areas, steep/inaccessible terrain, and protections found under the Great Bear Rainforest Land Use Order.

Key statistics describing BC's old forests are provided in Table 8.

Table 8. Summary statistics for BC's old forests in 2021 (provincial and federal lands)

Region	Forested Area (ha)	Old Forest (ha)	% Old	Area of Old Protected or Non-THLB	% of Old Protected or Non-THLB
Coast	8,039,880	3,435,752	43%	3,024,624	88%
Northern Interior	30,955,591	5,797,732	19%	3,833,067	66%
Southern Interior	16,418,510	2,184,422	13%	1,652,773	76%
Province	55,413,980	11,417,906	21%	8,510,464	75%
Vancouver Island (subset of Coast)	1,997,047	770,172	39%	618,801	80%

Non-THLB = Non-Timber Harvesting Landbase (harvest unlikely)

BC's age-based definitions for old forest combined with the inaccuracies of photo interpreted ages in the provincial forest inventory have resulted in several challenges to identifying the presence and quality of old growth stands. It is very likely that the area of old forest in BC is underestimated by the current inventory, however circumstances will vary across the province.

Relying on simple statistics from the provincial inventory data to identify "ecosystems at very high and near-term risk of irreversible biodiversity loss" is not recommended as local context and data limitations are not addressed. It is recommended that detailed assessments of old growth conditions be completed regionally in conjunction with local experts, including First Nations, to ensure sufficient context is available to support management decisions. Examples of this work are already occurring in the province's Forest Landscape Planning pilot projects. Provincial datasets can be helpful to identify large scale trends and potential issues of concern, but are not appropriate to establish detailed forest management direction.

BC's current approach to managing old growth maintains representation within Landscape Units and BEC variants (ecosystems). Based on this solid foundation, assessment of the appropriate amounts of retention, how this retention is distributed by stand types, and what management actions such as Variable Retention may be utilized to maintain healthy old stands in some ecosystems are worthwhile issues for the province to consider while working to implement the 14 Recommendations found in "A New Future for Old Forests" (Gorley & Merkel, 2020).

Appendix A - Detailed Data Sources

DATA	SOURCE	FEATURE NAME	DATE
BASELINE THEMATIC MAPPING	DataBC	BTM_PRESENT_LAND_USE_V1_SVW.gdb\WHSE_BASEMAPPING_BTM_PRESENT_LAND_USE_V1_SVW	1995
BIOGEOCLIMATIC ECOSYSTEM CLASSIFICATION (BEC) V11	DataBC	BEC_BIOGEOCLIMATIC_POLY.gdb\WHSE_FOREST_VEGETATION_BEC_BIOGEOCLIMATIC_POLY	2021
ELEVATION	Forsite derived from Provincial DEM	Elevation	2021
GENERALIZED FOREST COVER OWNERSHIP	DataBC	F_Ownership_2020.gdb\F_OWN	2020
GLOBAL FOREST CHANGE (LOSS)	Hansen/UMD/Google/USGS/NASA	Hansen_GFC-2020-v1.8_lossyear_50N_120W.tif	2020
GLOBAL FOREST CHANGE (LOSS)	Hansen/UMD/Google/USGS/NASA	Hansen_GFC-2020-v1.8_lossyear_50N_130W.tif	2020
GLOBAL FOREST CHANGE (LOSS)	Hansen/UMD/Google/USGS/NASA	Hansen_GFC-2020-v1.8_lossyear_60N_120W.tif	2020
GLOBAL FOREST CHANGE (LOSS)	Hansen/UMD/Google/USGS/NASA	Hansen_GFC-2020-v1.8_lossyear_60N_130W.tif	2020
GLOBAL FOREST CHANGE (LOSS)	Hansen/UMD/Google/USGS/NASA	Hansen_GFC-2020-v1.8_lossyear_60N_140W.tif	2020
HARVESTED AREAS OF BC (CONSOLIDATED CUTBLOCKS)	DataBC	Consolidated_Cutblocks.gdb\Cut_Block_all_BC	2020
HISTORICAL BURN SEVERITY	DataBC	VEG_BURN_SEVERITY_SP.gdb\WHSE_FOREST_VEGETATION_VEG_BURN_SEVERITY_SP	2020
LANDSCAPE UNIT	DataBC	RMP_LANDSCAPE_UNIT_SVW.gdb\WHSE_LAND_USE_PLANNING_RMP_LANDSCAPE_UNIT_SVW	2021
NATURAL RESOURCE DISTRICTS	DataBC	WHSE_ADMIN_BOUNDARIES_ADM_NR_DISTRICTS_SP	2020
OLD GROWTH MANAGEMENT AREAS - LEGAL	DataBC	RMP_OGMA_LEGAL_CURRENT_SVW.gdb\WHSE_LAND_USE_PLANNING_RMP_OGMA_LEGAL_CURRENT_SVW	2021
OLD GROWTH MANAGEMENT AREAS - NON-LEGAL	DataBC	RMP_OGMA_NON_LEGAL_CURRENT_SVW.gdb\WHSE_LAND_USE_PLANNING_RMP_OGMA_NON_LEGAL_CURRENT_SVW	2021
PROVINCIAL SITE PRODUCTIVITY LAYER (PSPL)	DataBC	Site Productivity - Site Index by Tree Species	2020
SLOPE	Derived from Provincial DEM	Slope Classes	2021
TFL THLB CLASSIFICATIONS	Various	Layer provided by Licensee (most) or Forsite derived an approximation using published data package documents (few).	2021
TSA THLB	FAIB Adrian Walton	tsa_thlb	2020
TSA/TFL BOUNDARIES	Forsite	TSA_TFL	2020
UNGULATE WINTER RANGE AREAS	DataBC	WCP_UNGULATE_WINTER_RANGE_SP.gdb\WHSE_WILDLIFE_MANAGEMENT_WCP_UNGULATE_WINTER_RANGE_SP	2020
VEGETATION RESOURCES INVENTORY (VRI)	DataBC	VEG_R1_2020_Truncated	2020
VISUAL LANDSCAPE INVENTORY	DataBC	FOREST_VEGETATION_REC_VISUAL_LANDSCAPE_INVENTORY	2021
WILDLIFE HABITAT AREAS	DataBC	WCP_WILDLIFE_HABITAT_AREA_POLY.gdb\WHSE_WILDLIFE_MANAGEMENT_WCP_WILDLIFE_HABITAT_AREA_POLY	2020

DataBC = https://catalogue.data.gov.bc.ca

Detailed Forest Inventory Data Updates

- The 2021 release of the VRI Forest Vegetation Composite Rank 1 (current to Jan 1, 2020) was used as the foundation for the inventory. For ease of processing, this was split into 71 management units (34 Tree Farm Licences [TFLs], and 37 Timber Supply Areas [TSAs]).
- Individual TFL data was acquired from TFL licensees where not available in the provincial dataset.
- Baseline Thematic Mapping was used to fill any remaining data gaps (e.g. Kitlope Park) and updated for depletions over the past 20 year with Global Forest Change loss dataset.
- Next, the Harvested Areas of BC (Consolidated Cutblocks; downloaded from DataBC on May 11, 2021) were also split by the same 71 management units. The Consolidated Cutblocks layer was filtered to "OPENING_IDs" not already in the VRI and that that had a harvest year attribute >= 2001. This set of cutblock areas were then unioned with the individual VRI units.
- An "AGE_2021" field was added and first populated with "PROJ_AGE_1" + 1 from the VRI (if it had data) and then the harvest year attribute from the Consolidated Cutblock data was used to update the "AGE_2021" field.
- MPB mortality in mature stands: If the "STAND_PERCENTAGE_DEAD" attribute was >= 50% and the mortality occurred in the last 20 years ("EARLIEST_NONLOGGING_DIST_DATE" was >= 2000) and the stand age was >= 20, then the "AGE_2021" field was updated using the year of mortality.
- The historical burn severity layer downloaded May 25, 2021 was intersected with each management unit VRI feature class and a field called "AGE_2021_FIRE" was added and first populated with "AGE_2021" data. If the "BURN_SEVERITY_RATING" was "High" or "Medium", the "AGE_2021_FIRE" field was updated with 2021-"FIRE_YEAR". This served to update fires since 2015. Older fires were not addressed unless they were captured in the creation of the inventory data.
- A "SERAL_STAGE" and "SERAL_STAGE_FIRE" was added to the working inventory and the "AGE_2021" and "AGE_2021_FIRE" data was used to assign Seral stages for "SERAL_STAGE" and "SERAL_STAGE_FIRE" respectively, according to the logic presented in Appendix B.
- The following features were added to the working inventory using a majority rule to add the attributes into the working inventory:
    - Forest Ownership
    - Districts and Regions
    - Timber Harvesting Land Base (THLB) factors for Timber Supply Areas (TSAs)
    - Landscape Units (LU) and Biodiversity Emphasis Options (BEO)
    - OGMA legal and non-legal
    - Wildlife Habitat Areas (WHA) - No Harvest
    - Ungulate Winter Range (UWR) – No Harvest
    - Preservation and Retention Visual Quality Objective (VQO) Polygons
- Slope and Elevation were determined for each polygon using the provincial 20m DEM (TRIM data).
- Species Codes were simplified to match the coding used in the Provincial Site Productivity Layer (PSPL).
- Area weighted Provincial Site Productivity Layer (PSPL) site index values were calculated for each species in PSPL. If a PSPL value was available for the leading species it was used, otherwise the second species position was used, and on to the 6th species position. If no species matched, the predominant species for that particular BEC variant was used.
- The Great Bear Rainforest protected areas include BMTA's plus areas selected to meet the old seral representation targets in the BGR Land Use order (targets by LU-Site Series Groups targets).
- A Protected designation flag was added. Treed forest was considered protected if it overlapped with a legal or non-Legal Old Growth Management Area (OGMA), a No-Harvest Ungulate Winter Range, a No-Harvest Wildlife Habitat Area, a Preservation or Retention Visual Quality Objective, a old growth Designated Area, a Great Bear Rainforest old representation stand, or if the stand was categorized in one of the following Forest Ownership Codes: 50, 51, 52, 53, 54, 60, 63, 65, 66, 67, 68, 69, 80, 81 (including federal, provincial, regional parks and reserves).

Appendix B - Old Age Definitions and Expected Old

NATURAL DISTURBANCE TYPE	BEC SUBZONE AND VARIANTS (BEC V11)	NATURAL DISTURBANCE INTERVAL (YEARS)*	OLD SERAL AGE (YEARS) DEFINITION	EXPECTED % AREA AS OLD FOREST
1	CWHvh1, CWHvh2, CWHvh3, CWHvm1, CWHvm2, CWHwh1, CWHwh2, CWHwm	250 to >3000	>250	37-90%
	ESSFvc_, ESSFwc_, ESSFwh1, ESSFwk_, ESSFwm_, ESSFwv	350		49%
	ICHvc, ICHvk_, ICHwk_	250		37%
	MHmm_, MHun, MHwh_	350 to > 3000		49-90%
2	CDFmm	200	>250	29%
	CWHdm, CWHds_, CWHmm_, CWHms_, CWHws_, CWHxm_	200 to > 1000		29-80%
	ESSFdc_, ESSFmc, ESSFmh, ESSFmk, ESSFmm_ ESSFmv_, ESSFmw_, ESSFwh_, ESSFwm_, ESSFxv_	200		29%
	ICHmc_, ICHmk3, ICHmm, ICHmw_, ICHwc			
	SBSvk, SBSwk_			
	SWBmk_, SWBun, SWBvk_			
3	BWBSdk, BWBSmk, BWBSmw, BWBSvk, BWBSwk_	Dec: 100	>100	37%
		Con: 125	>140	33%
	ICHdk, ICHdm, ICHdw_, ICHmk_	150		39%
	ESSFdc_, ESSFdk_, ESSFdv_, ESSFun, ESSFxc_	150		39%
	MSdc_, MSdk, MSdm_, MSdv, MSdw, MSmw_, MSxk_, MSxv	150		39%
	SBPSdc, SBPSmc, SBPSmk, SBPSxc	100		25%
	SBSdh_, SBSdk, SBSdw_, SBSmc_, SBSmh, SBSmk_, SBSmm, SBSmw, SBSun, SBSwk_	125		33%
4	ICHxw_	250	>250	37%
	IDFdc, IDFdk_, IDFdm_, IDFdw, IDFmw_, IDFw_, IDFxc, IDFxh_, IDFxk, IDFxm, IDFxw, IDFxx2			
	PPxh_			

* Values are from the Biodiversity Guidebook. NDT1 values for coastal areas also include estimates of disturbance intervals from the EBM Coast Information Team (https://www.for.gov.bc.ca/tasb/slrp/citbc/c-ebm-scibas-fin-04May04.pdf). Expected old % calculated as Exp(-Old Age/Disturbance Interval). Example: Exp(-250/250)=37%

Refined values for Northeast BC are also available based on work by Craig Delong (2011) but are not shown here as they require a higher level of spatial resolution. See https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/cumulative-effects/protocols/cef_forest_biodiversity_protocol_sept2020_final.pdf pg51. The use of these values is recommended for any regionally specific work.