

Striving for Resilient Ecosystems

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Woodlots BC

Forests in Good Hands

Supported by:



**Silviculture
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Program**

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Resilient Ecosystem Management

The face of forestry will continue to evolve, inspired by research, local knowledge, technological advances, and a more holistic approach to land management. This goes beyond sustainability of our allowable annual cut (AAC), this is sustainability of the ecosystem. To manage for a diverse and healthy ecosystem, we need to increase resiliency throughout managed forested landscapes.

At the larger landscape level, a diverse mix of connected habitats becomes more important.

***Striving for Resilient Ecosystems* provides tools and techniques to increase biodiversity and ecosystem health in your woodlot licence. This work was inspired by the *New Future for Old Forests Summary Report*.**

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Objective

To manage woodlot licences (woodlots) to be resilient so they can withstand changing environmental conditions, while supporting healthy ecosystems.

Resilient ecosystems have the ability to withstand, absorb, recover, and adapt to natural changes as well as management activities such as harvesting while maintaining essential ecological functions.

Resilient forests are dependent on old forest attributes and ecosystem health. This applies across the province - what changes are the species, scale, size, age, and climate.

About this document

Along with the supporting documentation on the woodlotsbc.ca/re website, this pamphlet will help you **identify management techniques and tools to increase resiliency across your woodlot.**

Within each management technique, the information provided breaks down the **attributes** found in old forests that make these stands imperative in a healthy ecosystem.

NOTE: Be aware that tools and techniques presented in this pamphlet may be in conflict with provincial regulations. Check your local requirements, make sure you adhere to your Woodlot Licence Plan and Worksafe requirements.

Ecological values of old forests: tree, stand, and landscape scales

🌲 Genetic

Old trees contain genetic information that makes them more resilient to disturbances like beetles, wildfires, and drought.

🌲 Biodiversity

Bark texture and canopy structure change with age, creating unique micro-habitats.

Habitat

🌲 Old trees can survive and persist for a very long time, providing a range of unique habitats as decay and damage occurs.

🌲 Unique structures and habitat features develop over long periods of time that enhance biodiversity and support uncommon species and species at risk.

🌲 Historical

Old trees provide a source of information on historical climate conditions, disturbances, and cultural uses.

🌲 Sense of place

Attachment to a place that provides a feeling of connection.

🌲 Structural variability

Structural complexity is a product of long time scales and cannot be reproduced artificially.

🌲 Hydrology

Older stands intercept more snow, buffer run off, filter water, and provide shade to regulate stream temperatures.

Carbon capture

🌲 Older trees allocate less carbon for above-ground growth, storing more carbon in stable below-ground reserves which contributes to climate stability more than young trees and wood products

🌲 Older stands store carbon in standing trees, downed and decaying wood, understory plants, forest floor, and below ground soil reservoirs.

🌲 Nutrient

Older stands have unique soil biodiversity including insects, bacteria, and fungi. Intact underground fungal networks enhance nutrient dynamics and the health of young trees.

🌲 Interconnected ecosystems

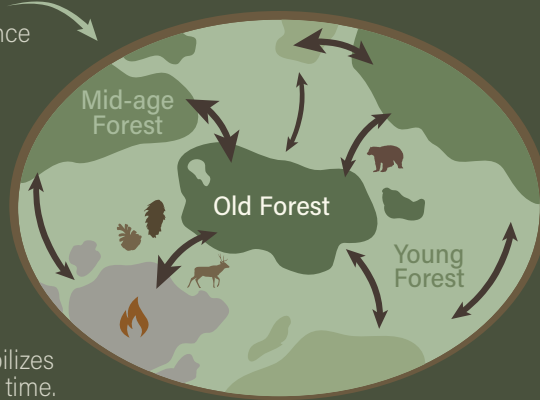
The size of old forest patches and distance between them influence how species establish, disperse, and move which promotes ecosystem integrity at different scales.

🌲 Functionality

The spatial arrangement of old forests influence how species and nutrients move around the landscape.

🌲 Resiliency

Biodiversity from old forest patches stabilizes disturbed patches via reduced recovery time.



🌲 Ecosystem variability

Spatial patterns influence landscape functionality, resiliency, and interconnections.



1 | Mixed Retention

Retention of trees and vegetation in managed stands is the backbone of a healthy and resilient ecosystem. Retention of all sizes, in clumps or scattered across managed areas, will help meet many, if not all, attributes of old forests.



Carbon storage and biodiversity are heavily linked to what's left on site. Yes, some will blow down, but don't let that stop you from leaving structure.

Soils are huge carbon sinks and provide nutrients for growth. This happens when plants sequester CO₂ from the air and break it apart into oxygen and carbon. Oxygen is released into the atmosphere, while carbon is converted into wood or sent below ground for storage and to feed soil microorganisms¹.

Maintaining a robust tree and vegetative network after managing a stand helps store carbon, is visually appealing, and provides immediate habitat opportunity.

¹ Microorganisms are bacteria, fungi, fungal mycorrhizae, protozoa, and microscopic animals.

TOOLS & TECHNIQUES

- Keep large trees dead or alive.
- Leave clumps by not skidding through advanced regen.
- Keep skidders on trails, rather than taking the direct route to the road.
- In younger stands, or when commercial thinning, leave live damaged trees that will grow and provide some cavity opportunities in the future.
- Keep vets and their close neighbours to protect roots.

NEXT LEVEL FOREST MANAGEMENT

- ▶ **Maintain mature trees at maximum 15m spacing randomly distributed.**
- ▶ Try to leave resilient species and ones that contribute to your long-term plans.
- ▶ If leaving smaller trees (poles), leave more.

These trees keep the soil microorganisms fed and therefore alive, keeping carbon stored and soils more fertile.

2 | Standing Habitat Recruitment

We've always been aware of the importance of snags. Snags provide food, shelter and nesting sites. Do you know 30–45% of bird populations are dependent on snags?

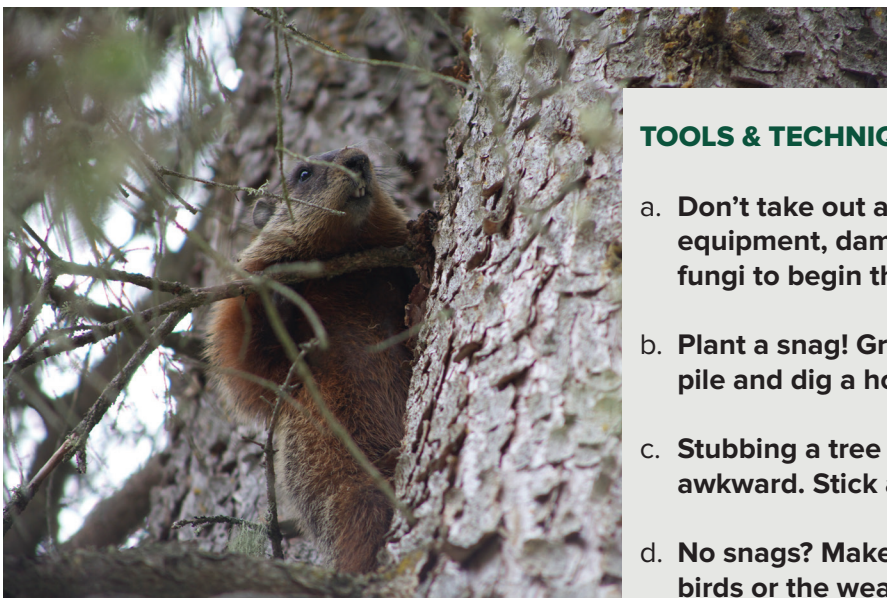
WHAT MAKES STANDING HABITAT

- Existing dead trees.
- Trees with forks or u-shaped tops.
- Trees with deformities, conks, or scars.
- Trees with large branches that will eventually break off.
- Tree species with a shorter life expectancy.

Trees with these defects have the potential to develop heart rot, creating nesting and denning opportunities. Leave trees with this type of attribute in your woodlot to recruit snags.

RECRUITMENT

Sometimes stands don't have much standing habitat potential, especially if thinning young stands or treating mature stands without a lot of defect. More commonly, they aren't in the right spot or there are too few.



TOOLS & TECHNIQUES

- Don't take out all trees damaged by equipment, damage provides a spot for fungi to begin the rotting process.**
- Plant a snag! Grab a cut tree from a debris pile and dig a hole for it to stand in.**
- Stubbing a tree does work, even if it looks awkward. Stick a pallet on top for a nesting site.**
- No snags? Make boxes for nesting birds or the weasel family.**
- Trees too healthy to decay? Drill some holes in the tree.**

3 | Downed Habitat Recruitment (CWD)

Coarse Woody Debris (CWD) is all about leaving debris behind, yet we are trained in life to keep things tidy and clean. We need to stop leaving managed areas free of debris—get a little messy, maybe a lot messy.

**CWD has a diameter more than 7.5cm, and is minimum 1m long.
Large CWD >20cm diameter and >10m long.**

The dead and dying trees or animals support 20% of the forest fauna¹. Large CWD provide ecological functions that differ from smaller pieces, as they last longer, hold more moisture, contribute more organic material, and provide habitat for a greater number of fauna. By keeping large CWD and retaining trees for future windfall, provide habitat for years to come.

¹ Wildlife Management Notes No. 4 Snags, Cavity Trees, and Downed Logs

Maintain a full range of diameter, tree species, and decay, but larger is better.

TOOLS & TECHNIQUES

- Make jumbled CWD piles with overlapping logs so some are off the ground, extending longevity.
- Keep CWD scattered across the block.
- Build low windrow piles to create corridors for smaller mammals, like fisher and martens.
- Bury debris leaving pieces sticking out of the ground for denning habitat.



NEXT LEVEL FOREST MANAGEMENT

- ▶ Large piles of CWD at roadsides are of limited ecological value. Distribute them across the block. This also reduces pile burning.
- ▶ Think temporally, consider how to add CWD over time.

HAZARD ABATEMENT

- ▶ Avoid putting fines such as branches and needles in piles you plan to leave.
- ▶ Scatter single large logs across block.

WASTE AND RESIDUE

- ▶ Benchmarks exist so CWD can be left on-site.
- ▶ Don't cut logs you want to leave until after the survey is done. If they aren't cut, they aren't waste.
- ▶ Leave them standing until after the survey.
- ▶ Discuss with local MoF staff about desired future conditions to navigate conflicting waste obligations.

4 | Complex Structure: Horizontal Diversity

Ecosystem diversity is key. It relies on spatial diversity, both in the form of vertical differences (height) and horizontal (canopy) gaps to create complex structure.

Gaps (horizontal diversity) are defined as small openings in a stand, both in riparian areas and mesic sites. These gaps might be full of berry bushes or other shrubs.

Small openings create sun spots, allowing shade intolerant vegetation to grow.

Studies carried out in artificially created gaps indicate that the diversity and species richness of birds in gaps are significantly greater than in the surrounding woodland, even in small gaps formed by the cutting down a single tree¹.

Gaps receive more sunlight on the forest floor that increases the temperature, leading to increased microbiology activity, and in the winter, warm spots. Gaps also have more rain and snow accumulation on the forest floor creating a different moisture regime.

Both cavity and ground birds utilize canopy gaps, as well as other animals.

¹ (Heltzel and Leberg, 2006, Rankin and Perlut, 2015)



Find a small gap and have a listen. In a healthy ecosystem you'll hear birds and see scat from different animals.

TOOLS & TECHNIQUES

- a. A small gap is less than 0.1 ha (about 30m by 30m).
- b. At any stage, either during harvesting, planting, or commercial thinning, gaps can be added or encouraged.
 - While planting, choose a few areas that will not be reforested. They could be around depressions, small wet areas or very dry sites.
 - While thinning, open up areas that are low points, mesic areas, or areas with a strong shrub component.
 - Make a gap around a mature tree with a defect.
- c. Update the Woodlot Licence Plan (WLP) to include silviculture alternatives that allow gaps in plantations, or a wider range of Minimum Intertree Distance (MITD) and species. There might even be areas to target reduced stocking.

5 | Complex Structure: Vertical Diversity

Vertical diversity is the second component of complex structure. Complex structure is an important feature in an old forest.

Consider what to keep in your woodlot to create vertical diversity at every stage of the rotation: during juvenile spacing, commercial thinning, stand tending, and when harvesting mature stands.



TOOLS & TECHNIQUES

a. Understory Protection

- Regardless of harvesting equipment, an understory can be retained. **Harvesting should not result in no vegetation left behind.**

b. Partial cutting

- Climate change may make it imperative to convert the stand to another species. Harvest species that will not flourish in the new climate, leaving behind those that will. The retained trees will continue growing, providing a future harvest opportunity.
- One woodlot licensee finds that a lighter removal gets better volume response over time and feels that for every 1% removal, you need 1 year of no treatment. If you remove 10% of the stand, re-enter at year 10 to take another cut.

c. Leave trees do not need to be old, they can be saplings or poles. Some deciduous trees should be maintained to provide nesting cavities as well as vertical diversity.

d. Maintain a variety of ages and consider bark maturity. An old tree has different bark then a younger one of the same species.

e. Consider early entries into younger stands that aren't well stocked or have disease or quality issues. Harvest the worst trees and underplant with a species suited to the conditions. This Assisted Nurse-Tree Shelterwood system can be used to achieve a range of timber objectives while increasing the vertical diversity, species composition and stand resilience. This method can also diversify woodlot seral stage. For example:

- Low quality immature monocultures. Maintain lots of leave trees and reforest.
- Merchantable stocked old plantations with lots of defect. Thin to increase the size of remaining trees as they will have more resources to grow. Replant large gaps.

6 | Individual Features

There are always site-specific features in woodlots: rocky knobs, specialized vegetation (such as a rocky mountain juniper), or a tree with a specific spatial orientation. Knowing your woodlot, and what is special is the value of small area-based tenures. Some features are universal, if rare, and can be created.



Perch Options

These aren't just for birds, but also for climbing animals. Try to maintain trees with brooms for perch and nesting opportunities.

- ▶ Keep trees with large branches or with a bushy form.
- ▶ Leave dead trees with a broken top for use as platforms.
- ▶ 'Plant' a mature tree. One licensee takes a log with a root wad and plants it, root wad side up, creating a perch.

Teetertotter Trees

These are any sort of structure that creates a path from the ground into the mid-point of the tree. This is useful for both birds and mammals.

- ▶ Partially break a tree as high up as you can and let it create an A shape.
- ▶ Push one tree over into another tree.

Healthy Subsurface Microorganisms

Half of your block biodiversity is beneath your feet. Microorganisms are mostly fed by excess tree sugars stored in the soil. If you remove all the trees, the microorganisms starve leading to carbon released into the atmosphere and reduced soil productivity. Therefore, there are benefits to keeping soil microorganisms robust.

- ▶ Keep live trees maximum 15m apart post-harvest, to keep microorganisms 'fed'. Additionally, the live trees:
 - Add CWD to the block over time.
 - Provide vertical diversity.
 - Provide shelter through maintaining an overstory.
 - Maintain soil fertility.

Species/Ecosystems at Risk

Identify a species or ecosystem at risk in your area. Reflect on what they need to flourish on your woodlot. Can you provide that through management? If habitat needs can't be met with existing features, there is always a solution.

- ▶ Build housing, such as marten nesting boxes or birdhouses.
- ▶ Add windrows for cover.
- ▶ Rehabilitate roads.
- ▶ Plant browse or specific groups of tree species.



7 | Ecosystem Resilience: An Intro

Woodlots must be viewed as a whole. Attributes create diverse areas with habitat features and must suit your specific landscape resources: water, sunlight, and nutrients.

Conflicting objectives add frustration. For example, leaving CWD matters, but waste and wildfire hazards must also be addressed.

Balancing contradictions is key—along with climate extremes. In this section, we provide tools to mitigate climate extremes, enhance soil fertility, and manage special features.

RESILIENCY TO WHAT

Forests and those relying on them must withstand climate extremes—drought, shorter winters, hotter summers with extended springs and falls. The range of pests and pathogens are expanding.

Species composition is shifting—more conifers, increased stocking, and fewer gaps. To quote Paul Hessburg: **“We have an epidemic of conifers.”**

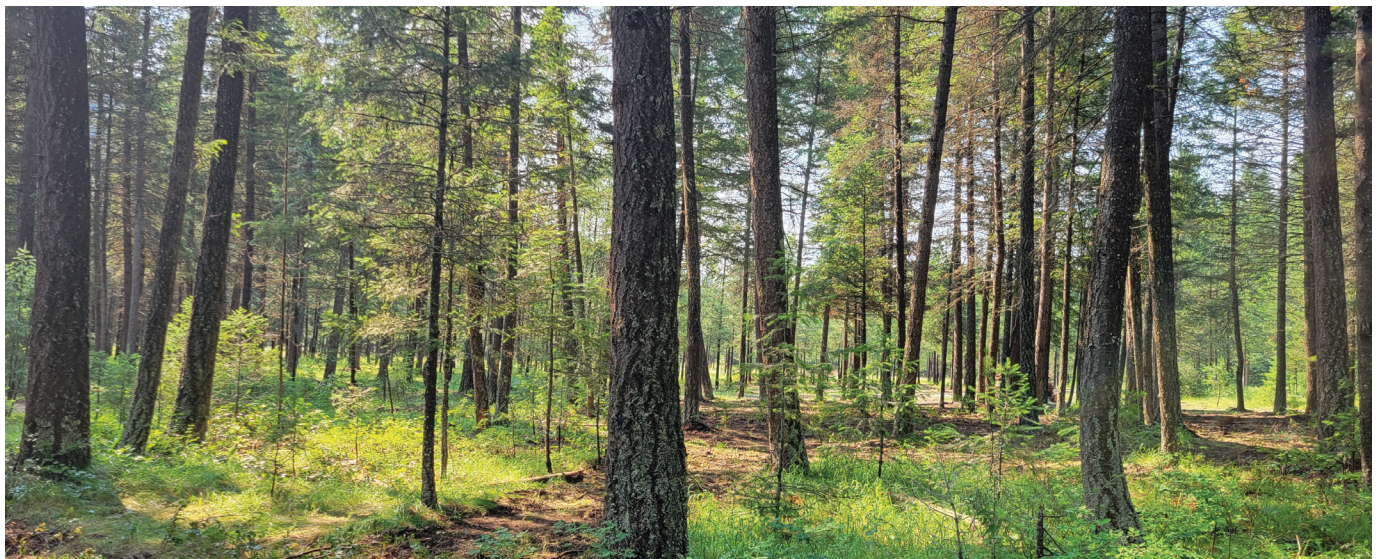
¹ <https://worldforestry.org/listen-150-years-of-forest-management-with-dr-paul-hessburg/>

TOOLS & TECHNIQUES

Government and university tools and research, including climate change modelling and research on management strategies to increase resiliency, are available.

NEXT LEVEL FOREST MANAGEMENT

- ▶ Plan at least 50 years ahead. Where are your roads, blocks, WTPs/intensive silviculture treatments going to occur?
- ▶ Network! Learn from others.
- ▶ Where are the next opportunities? Perhaps invest in a stand for spacing or pruning.



Every healthy ecosystem has a portion of “old” and that old component is almost always a critical component of the larger ecosystem. The amount of old is very ecosystem dependent. Garry Merkel, RPF

8 | How to Try New Tools

Here are some tips and considerations when trying new tools and techniques provided in this pamphlet:

- ▶ Know your BEC and your NDT (see section 9).
- ▶ Don't run with generalities.
- ▶ Try, and if you experience failure, consider site specific factors such as aspect, moisture, and shade. Did the tool fail or was it the wrong area?
- ▶ Refine and try again. We call this failing forward.
- ▶ What was true in the last century may not be true now due to shifting weather patterns and technology. Harvesting equipment has a lighter touch and seedlings are grown to different standards to name a few changes.
- ▶ Know your sites, limiting factors, and use tools to push those limits.
- ▶ Google it! Lots of research is available.

CASE EXAMPLE

On a dry site, the limiting factor is shade and moisture. Maintain some retention to add shade, plant deep to get the seedlings into the moist section of the soil profile. Process on the stump to increase mulch.

A wet site would require different tools to be employed.



You don't have to do everything, everywhere, all at once.

Do what you can do.

Influence what you can influence.

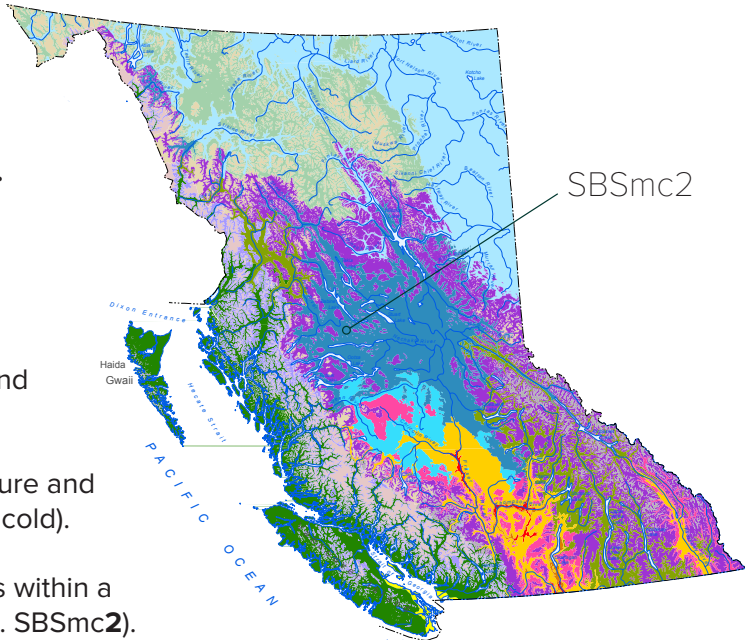
There will be things out of your control.

9 | Shifting Weather Patterns

Biogeoclimatic zones (BEC) are ecological areas classified by climate, vegetation, and soil. They help guide forest management, conservation, and ecological research based on environmental conditions.

Biogeoclimatic zones are a hierarchical classification system, divided into units:

1. **Zones** – Broad regions with distinct climate and vegetation (e.g., Sub Boreal Spruce: **SBS**).
2. **Subzones** – Further divisions based on moisture and temperature differences (e.g. SBS**mc** is moist cold).
3. **Variants** – Areas with slight climatic variations within a subzone. This is displayed with a number (e.g. SBS**mc2**).
4. **Site Series** - Specific plant communities, site moisture and nutrient conditions (e.g. SBS**mc2 01**).



KEY FEATURES OF BIOGEOCLIMATIC ZONES

- ▶ **Climate Influence** – Zones are defined by macroclimate, affecting vegetation and soil development.
- ▶ **Vegetation Types** – Each zone has dominant plant species adapted to its climate.
- ▶ **Soil Composition** – Soil properties vary based on climate and vegetation interactions.

BC has been modeling BEC zone changes projected over the next 100 years using past data. Recently a new website has been launched to show you where your BEC zone is headed.

<https://thebeczone.ca/shiny/cciss/> →



HOW TO INCLUDE THE CCISS TOOL

Rotational Survival:

- a. What species is not viable long-term? Remove those species from your woodlot through partial cutting and avoid planting.
- b. Look at your zone in the tool and identify what species range will increase. Is it plantable now in your woodlot? If so, start to introduce it into your planting program
- c. When you redo your WLP, confirm that your stocking standards are a balance of what works now and what will be viable in the future.

10 | Weather Extremes, Disease and Insects

Weather extremes such as drought, high wind, intense rainfall, warm winters, and hard frosts all impact plantations and mature timber.

Know your **Natural Disturbance Type (NDT)** and your **Biogeoclimatic Zone (BEC)**.



Adjust tools to match your **NDT and BEC Zones**.

DROUGHT TOOLS & TECHNIQUES



- ▶ **Try adjusting planting methods**
 - **Choose short seedlings with large root collars.** Large root collars mean more roots to absorb nutrients and fewer needles to sustain.
 - **Plant older seedlings such as 2+0's.**
 - **Adjust planting timing** to early spring or fall for better soil moisture.
 - **Plant deep to** access deeper soil moisture.
 - **Maintain overstory** to provide shade.
- ▶ **Leave branches** scattered on-site as mulch.
- ▶ **Improve soil water retention** by keeping moss, leaf litter, and decomposed plant material in place to help soils absorb and hold moisture, benefiting tree growth.
- ▶ **Manage forest density**
 - **Thin overcrowded stands** to reduce tree density and competition for water and nutrients.
 - **Maintain understory vegetation** to shade soil, reducing evaporation and helping maintain moisture levels.
- ▶ **Maintain riparian features**
 - Protect riparian areas, as streams and wetlands store water, provide habitat, and support biodiversity.
 - Add a non-deleterious brush area as a 5m buffer in your WLP silviculture alternative.
 - Create small gaps around wet areas.

WIND DAMAGE TOOLS & TECHNIQUES

- ▶ **Know your prevailing winds** and plan blocks accordingly.
- ▶ **Feather the edges**, especially along wet and shallow rooted areas.
- ▶ **Use wedge shapes** and small blocks to guide wind.
- ▶ **Diversify stand structure**
 - **Plant mixed-species**, combining deep-rooted and wind-resistant trees, such as fir, will enhance forest stability against storms.
 - **Vary tree spacing** to disrupt wind tunnel effects.
- ▶ **Strengthen root systems**
 - **Encourage deep rooting** to better anchor trees by opening the canopy.
 - **Minimize equipment use** around retained trees as compacted soils weaken tree stability.
- ▶ **Manage thinning practices carefully by gradually thinning stands** as sudden tree removal can expose remaining trees to stronger winds, increasing the chance of wind damage.
- ▶ **Use windbreaks & buffer zones**
 - **Plant windbreaks.** Rows of trees or shrubs reduce wind speed and protect vulnerable forest areas.
 - **Maintain understory vegetation** to stabilize soil.
 - **Keep buffer zones along forest edges** to create wind barriers to stabilize nearby trees.
- ▶ **Adapt forest management to local conditions**
 - **Plan your block.** Design forest management around wind patterns, soil type, and tree species to optimize resilience.
 - **Monitor forest health** with regular assessments to help identify weak trees before they become hazards in extreme weather.

11 | Weather Extremes, Disease and Insects

FIRE RESILIENCY TOOLS & TECHNIQUES

- ▶ **Thin dense forests** to reduce fuel loads, slowing fire spread and increasing control effectiveness.
- ▶ **Salvage high-mortality stands** and remove excess dry material to decrease ignition sources.
- ▶ **Perform prescribed burns.** Controlled low-intensity fires mimic natural cycles, clearing undergrowth and making forests more resilient.
- ▶ **Adjust stocking standards.** Some regions favour fire-resilient stocking standards, often with lower densities and more deciduous trees for better fire resistance.
- ▶ **Prescribe site prep** to break up slash blankets by leaving small unburned piles, disc trenching, or broadcast burning.



DISEASE AND INSECT TOOLS AND TECHNIQUES

- ▶ **Ecosystem diversity is key.** Maintaining a variety of tree species within a woodlot helps trees withstand disease and insect infestations. Varied microhabitats will create a more resilient stand by:
 - Reducing host species and hiding the host among the trees.
 - Increasing insect predator habitat or reducing co-host habitat.

Proactive forest management strives towards a resilient ecosystem.



12 | Sequester Carbon

Carbon is absolutely crucial in forest soils—it's the backbone of soil fertility, ecosystem stability, and climate regulation. The benefits:

1. **Soil Structure & Health** – Organic carbon improves structure, water retention, and reduces erosion.
2. **Nutrient Cycling** – Decomposed matter releases nutrients like nitrogen and phosphorus, fueling plant growth.
3. **Microbial Life** – Supports microorganisms that break down organic material.
4. **Climate Regulation** – Forest soils store carbon, preventing excess CO₂ emissions.
5. **Resilience** – Higher soil carbon aids recovery from drought, deforestation, and environmental stress.

STRATEGIES TO MAINTAIN SOIL CARBON

Add Organic Matter

- ▶ Keep forest litter intact – Fallen leaves, branches, and decomposing vegetation boost soil carbon.
- ▶ Maintain deep-rooted plants and consider targeted brushing – Nitrogen fixing species enrich soil and improve nutrient cycling.
- ▶ Keep large CWD for long-term contributions.

Enhance Microbial Activity

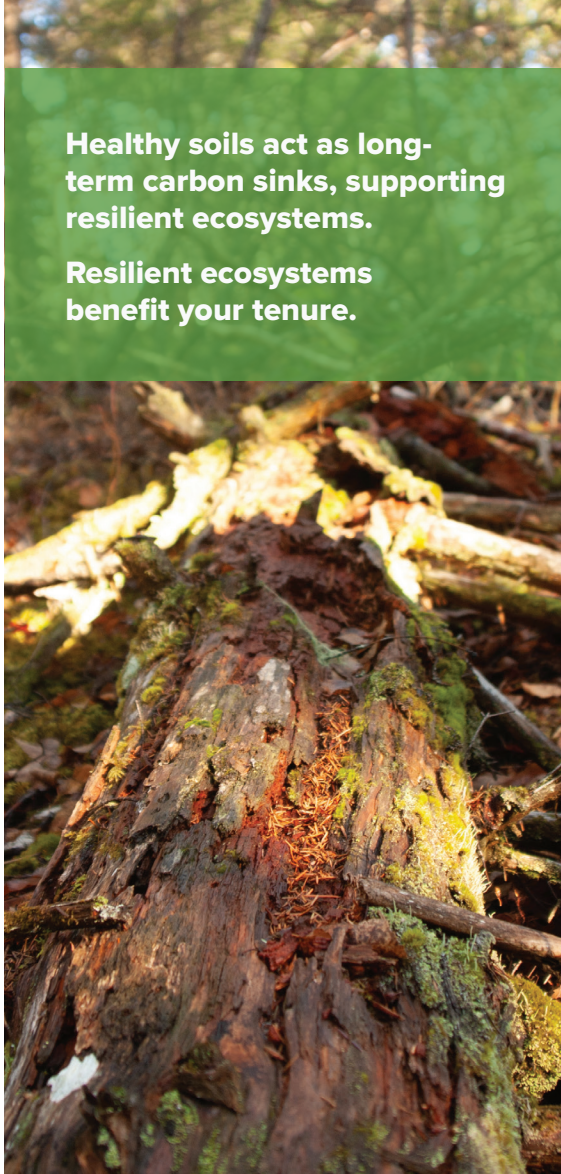
- ▶ Design clearcuts with retention – Add in block retention, or tree minimum every 15m to maintain soil fertility.
- ▶ Foster microorganism diversity – Fungi and other microorganisms stabilize carbon in soil.
- ▶ Concentrate equipment to trails to protect porosity and microorganism communities.

Encourage Regeneration & Reforestation

- ▶ Plant diverse forests – Mixed species store more carbon than monocultures. Deciduous leaves also increase soil fertility.
- ▶ Use CWD and slash – Debris adds carbon and protects seedlings through mulch and shade.

Manage Fire & Decomposition

- ▶ Prevent intense burns – Wildfires release carbon while controlled low intensity burns recycle nutrients.
- ▶ Slow decomposition – Mosses, fungi, and ground cover plants help soil retain carbon longer.



Healthy soils act as long-term carbon sinks, supporting resilient ecosystems.

Resilient ecosystems benefit your tenure.



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For more information, and references...

woodlotsbc.ca/re

