Carbon and Forest Management Work Group

2024 Legislative Progress Report

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WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES

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Acronyms

DNR	Washington Department of Natural Resources
FIA	Forest Inventory and Analysis
FVS	Forest Vegetation Simulator (model)
GEM	General ecological management
GCM	Global circulation model
HCP	*State Trust Lands Habitat Conservation Plan*
IMPLAN	Impact Analysis for Planning (model)
LURA	Land Use and Resource Allocation (model)
PCT	Pre-commercial thinning
RCP	Representative concentration pathway
RFRS	*Riparian Forest Restoration Strategy*
WWA	Western Washington (model)

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Executive Summary

In the last few years, the world has experienced powerful storms, droughts, record heat waves, and massive wildfires. Although these are natural events, climate change is thought to make these events more intense and destructive.

Concerns about these and other effects have led to global efforts to mitigate climate change by reducing the concentration of carbon dioxide in the atmosphere. One way to achieve this goal is to enhance the ability of forests and other natural systems to absorb (sequester) and store carbon.

Mitigating climate change is important to the Washington State Department of Natural Resources' (DNR) mission, which is to manage, sustain, and protect the health and productivity of Washington's lands and waters to meet the needs of present and future generations. The challenge for DNR is to meet this goal while also meeting its major fiduciary, ecological, and Tribal responsibilities across the 2.1 million acres of forested state trust lands in its care:

- **Fiduciary**: As a trust lands manager, DNR has a fiduciary responsibility to generate revenue to support trust beneficiaries like counties and schools. Non-tax revenue from timber harvest and other uses pays for schools, roads, and other vital infrastructure and services.
- **Ecological**: DNR's ecological goals are described in the *Policy for Sustainable Forests* and the *State Trust Lands Habitat Conservation Plan (HCP)*, a contractual agreement between DNR and the Federal Services (NOAA and U.S. Fish and Wildlife Service). In a series of conservation strategies, the HCP describes how DNR will provide habitat for threatened and endangered species within a working forest. The *Policy for Sustainable Forests* includes policies for protecting old-growth forest, wildlife habitat, forest health, and other ecosystem services (Photo ES-1).
- **Tribal**: DNR has special obligations and responsibilities toward Tribes because the lands that DNR manages are the ancestral homelands and territories of native peoples. DNR has deep respect for and gratitude towards these original and active stewards of the region. In respect of the sovereignty of Tribal Nations and their rights, titles, and treaties, one responsibility is to engage in government-to-government relationships to ensure access, protection of cultural resources, and sustainable use of shared natural resources. DNR operates under a set of guiding principles as described in the Commissioner's Order on Tribal Relations and DNR's Tribal consultation policies.

Photo ES-1. An older forest on state trust lands being managed to meet ecological goals like wildlife habitat.

Seeking Solutions

In the 2023 legislative session, the Washington State Legislature passed a $2.5 million Capital Budget proviso to help DNR meet this challenge. The proviso requires DNR to perform the following:

- Assemble a work group comprised of a balanced representation of trust beneficiaries and stakeholders.
- Contract with a professional meeting facilitator, who will guide the work group through a collaborative process to identify possible changes to the management of state trust lands. Changes will be identified within the context specified in the proviso, which includes conserving and managing older, carbon-dense, structurally complex forest (Text Box 1); increasing carbon sequestration in forests and harvested wood products; providing predictable revenue to trust beneficiaries; and supporting the timber industry and rural economies.
- Contract with universities or other researchers or consultants to conduct advanced computer modeling of proposed management changes. These models will help the work group understand how the proposed changes will affect carbon sequestration and storage, the timber market, and rural economies.
- Working with the meeting facilitator, guide the work group through a collaborative process to develop the final recommendations for potential changes to state trust land management. Summarize the recommendations in a final legislative report.

DNR is focusing this effort on the approximately 1.5 million acres of forested state trust lands located west of the Cascade Crest. Given western Washington's mild climate and abundant rainfall, these forests are much more productive than forests in eastern Washington and have

significant potential to sequester and store carbon. In addition, most of the older, carbon-dense, structurally complex forests on state trust lands are in this portion of the state.

Text Box ES-1. Difference between old-growth and structurally complex forest.

According to DNR's *Policy for Sustainable Forests*, a structurally complex forest is defined as a forest in the "botanically diverse," "niche diversification," or "fully functional" stage of stand development. Forests in these phases have varying sizes of trees, understory vegetation and lichen, downed wood and snags, etcetera. This definition of structurally complex forest was approved by the Board of Natural Resources.

Old-growth forests are defined in the *Policy for Sustainable Forests* as forest stands at least five acres in size, in the most complex stand development stage, that regenerated naturally prior to 1850. All old-growth forests on forested state trust lands are deferred from stand replacement harvest.

Significant Progress

DNR began this project in the late summer of 2023. In December 2023, DNR submitted a preliminary progress report to the legislature that covered establishing the work group and hiring the meeting facilitator (BluePoint Planning), plus the project timeline and the format of work group meetings.

In the following report, DNR will cover the significant progress that has been made on this project in 2024:

- **Modeling contractors**. DNR hired two highly qualified contractors through a competitive process. For the carbon sequestration and storage modeling, DNR hired ESSA, a firm with over 30 years of experience in forest carbon modeling and simulation. For the economic modeling, DNR hired Evergreen Economics, which specializes in statistical modeling, benefit-cost analysis, economic impact analysis, and survey research.
- **Management scenarios**. In a series of monthly meetings that took place between January and May of 2024, the work group developed eight forest management approaches called "scenarios."

  The basis for every scenario was DNR's current management practices. Work group members created scenarios by adjusting at least one aspect of DNR's current practices. Each aspect was referred to as a "dial":

  - Length of harvest rotation (time between planting and harvest),
  - Amount of thinning performed,
  - Deferral of additional forest from stand replacement harvest, and
  - Increased emphasis on silviculture activities to boost forest growth.

As an example, work group members created two "single dial" scenarios by adjusting the current length of DNR's harvest rotations: one scenario shortened the harvest rotation, and another lengthened it.

In general, dials were turned the same amount across the different scenarios. For example, the harvest rotation was shortened the same amount in Scenario 3 as it was in Scenario 8, as compared to current operations.

However, in some cases, dials were adjusted for specific scenarios at the request of work group members. For example, the rotation length for Site Class 4 (the poorest sites for growing trees) was lengthened 50 years for Scenario 2 but only 10 years for scenarios 5 and 6.

Following is a list of the scenarios developed by the work group.

- **Scenario 1**: DNR current operations
- **Scenario 2**: Lengthen harvest rotation by 25 to 50 years, depending on site class
- **Scenario 3**: Shorten harvest rotation by 10 to 20 years, depending on site class
- **Scenario 4**: Significantly increase the amount of thinning
- **Scenario 5**: Lengthen harvest rotation + significantly increase thinning
- **Scenario 6**: Lengthen harvest rotation + significantly increase thinning + defer forests that regenerated prior to 1945 from stand replacement harvest
- **Scenario 7**: Increase emphasis on silviculture + significantly increase thinning
- **Scenario 8**: Increase emphasis on silviculture + significantly increase thinning + shorten harvest rotation

For most scenarios, stand replacement harvest occurs when a forest reaches a certain timber volume. The rotation lengths listed here are based on the expected growth rates of Douglas-fir. In practice, exact rotation lengths may vary from one site to another based on the mix of tree species, location, elevation, density, and numerous other, inter-related factors.

The only exception would be Scenarios 5 and 6, in which the rotation length is based on stand age for less productive sites.

- **Carbon and economic models**. Both contractors are fully engaged in developing their respective models.

ESSA is using one model plus a climate extension to estimate carbon sequestration and storage. At the request of the work group, ESSA is modeling the eight scenarios two ways: under current climate conditions, and under future conditions projected under climate change. For climate change, they are using representative concentration pathway (RCP) 4.5. With RCP 4.5, global carbon emissions peak in roughly 2040 and then begin to decline. ESSA's analysis is specific to DNR-managed lands in western Washington. The analysis period is 100 years.

ESSA will present their preliminary model results to the work group for the eight scenarios, with and without climate change, in early December. Because these results have not been presented yet, DNR did not include them in this legislative report. However, a summary of these results will be posted on DNR's Carbon and Forest Management Work Group web page under the December 11 work group meeting heading.

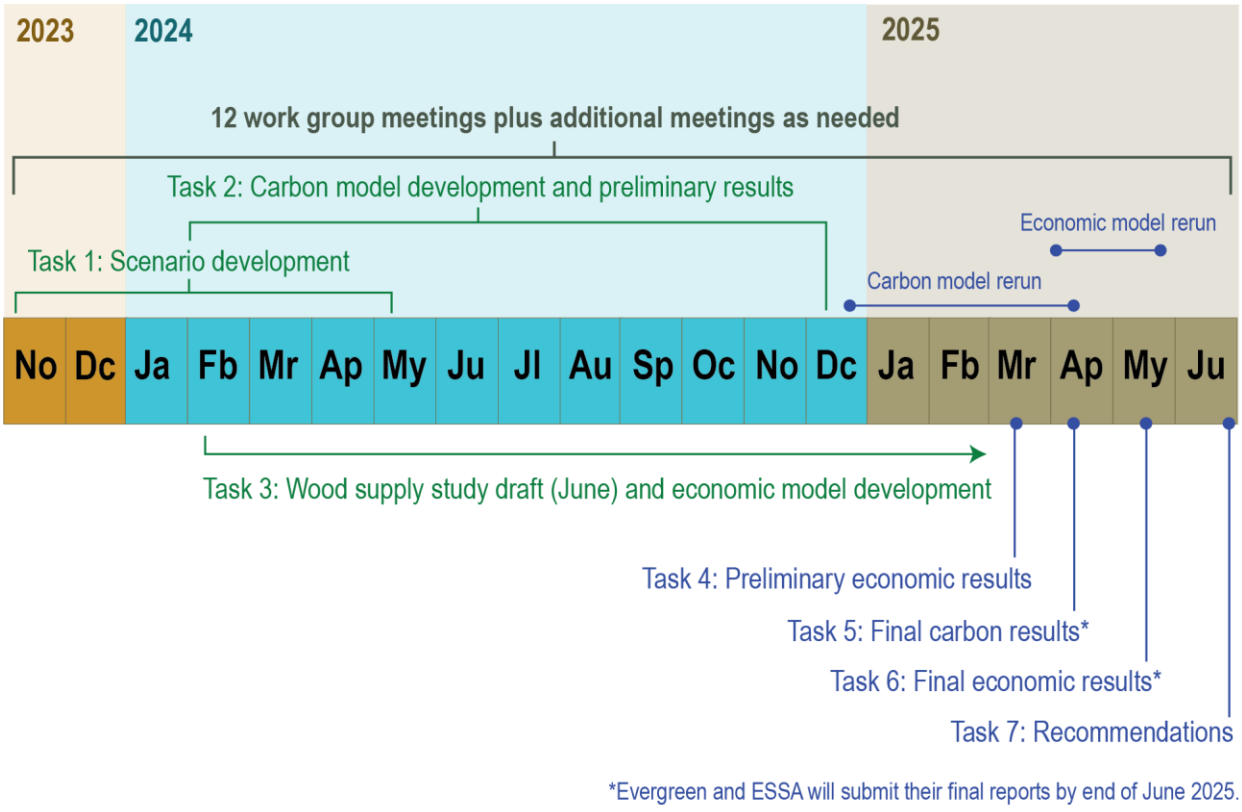
Evergreen is using three models to examine the potential economic impacts of the scenarios at a variety of spatial scales. One model covers all ownerships in western Washington plus additional areas in Oregon and Idaho; one covers all ownerships in western Washington; and one covers all ownerships across the contiguous U.S. Analysis periods differ for each model. Evergreen's models do not incorporate climate change projections.

Evergreen has produced a preliminary report on their work, which provided some insight into harvest volumes and economic indicators for DNR-managed lands under current conditions. This report is called the Wood Supply Study and is posted on DNR's Carbon and Forest Management Work Group web page. Evergreen is now working on completing their models and generating preliminary results.

Note that both the carbon and economic models are fundamentally different from the "forest estate model" that DNR is developing to calculate the decadal sustainable harvest level for western Washington. Outputs from the carbon and economic models will be used only to understand the scenarios for the purposes of this work group.

Figure ES-1 provides a timeline for the latter half of the project, showing the steps that will be covered in this legislative report (Tasks 1 through 3) and those that will be summarized in the final report, which is due in December 2025 (Tasks 4 through 7).

Figure ES-1. High-level project timeline. Tasks 4 through 7 will be covered in the final legislative report.



Looking Ahead

In the first six months of 2025, ESSA and Evergreen will complete their modeling and present their final results to the work group. In the meantime, DNR and the meeting facilitator, BluePoint Planning, will collaborate with the work group to develop recommendations based on the scenarios. Recommendations will be finalized by June 30, 2025, the close of the biennium.

In the final legislative report, DNR will describe each of these recommendations, along with key model results, final vote tallies, and any major concerns of work group members about the recommendations. Work group members who vote against a recommendation that is ultimately selected by the work group will be invited to write a minority report, which will be included in the final legislative report. DNR will submit the final legislative report in December 2025.

This Work Matters

The challenges facing state trust lands are serious, but so is DNR's determination to meet them. Over the past several years, DNR has demonstrated its commitment through several efforts, two

of which are development of the *Plan for Climate Resilience*, which highlights actions DNR can take to ensure it is both prepared for and adapting to climate-related changes; and the *Carbon Playbook*, which describes opportunities to implement or support carbon projects in Washington that will provide real and verifiable climate benefits.

With this work group, DNR is taking another major step forward. Made possible by this one-time budget appropriation, the work of this group should yield creative, workable solutions that put DNR on a sustainable path forward into an uncertain future.

Introduction

In its 2023 session, the Washington State Legislature awarded the Washington Department of Natural Resources (DNR) $2.5 million to address a pressing question: how to increase carbon sequestration and storage in a working forest managed for multiple objectives. Forests store massive amounts of carbon, and increasing their capacity to sequester and store carbon could help mitigate the high concentrations of carbon in the atmosphere that could lead to severe climate change impacts.

DNR manages over 2.1 million acres of forested state trust lands in Washington for fiduciary and ecological goals as well as social and cultural benefits, such as the protection of cultural resources. Timber harvest and other activities on state trust lands provide much-needed, non-tax revenue for essential services and infrastructure for counties, schools, and other trust beneficiaries. These forests also provide wildlife habitat, clean air and water, natural beauty, biodiversity, and other ecosystem services. It is essential to preserve the ability of these forests to provide these services, while also securing the future by increasing carbon sequestration and storage (Photo 1).

Photo 1. Riparian area on state trust lands. Protected areas such as streams and wetlands are interspersed with actively managed areas, creating a landscape mosaic that provides wood for harvest, clean air and water, wildlife habitat, and other services.

The 2023 budget proviso directs DNR to assemble a work group consisting of a "balanced representation of trust beneficiaries and stakeholders" to develop potential forest management approaches in the context of the following:

- Conserving and managing older, carbon-dense, structurally complex forest stands[1] located on DNR-managed lands;
- Increasing carbon sequestration and storage in forests and harvested wood products from DNR-managed forestlands;
- Generating predictable beneficiary revenue;
- Maintaining timber supplies that support local industry; and
- Addressing economic needs in rural communities.

The proviso also requires DNR to contract with a professional meeting facilitator, and with carbon and economic modeling specialists to determine how changes in forest management will impact carbon sequestration, local economies, and the timber industry. A full copy of the proviso text can be found in Appendix A.

DNR submitted its first legislative progress report in December 2023, which detailed establishing the work group, hiring the meeting facilitator, and other early project stages. In the following report, DNR provides a brief overview of the project and describes the major steps that have been taken since the last report was submitted.

[1] Per the *Policy for Sustainable Forests,* a forest in the "botanically diverse," "'niche diversification," or "fully functional" stage of stand development. Forests in these phases have varying sizes of trees, understory vegetation and lichen, downed wood and snags, etcetera. This definition of structurally complex forest was approved by the Board of Natural Resources.

Part 1: Project Overview and Timeline

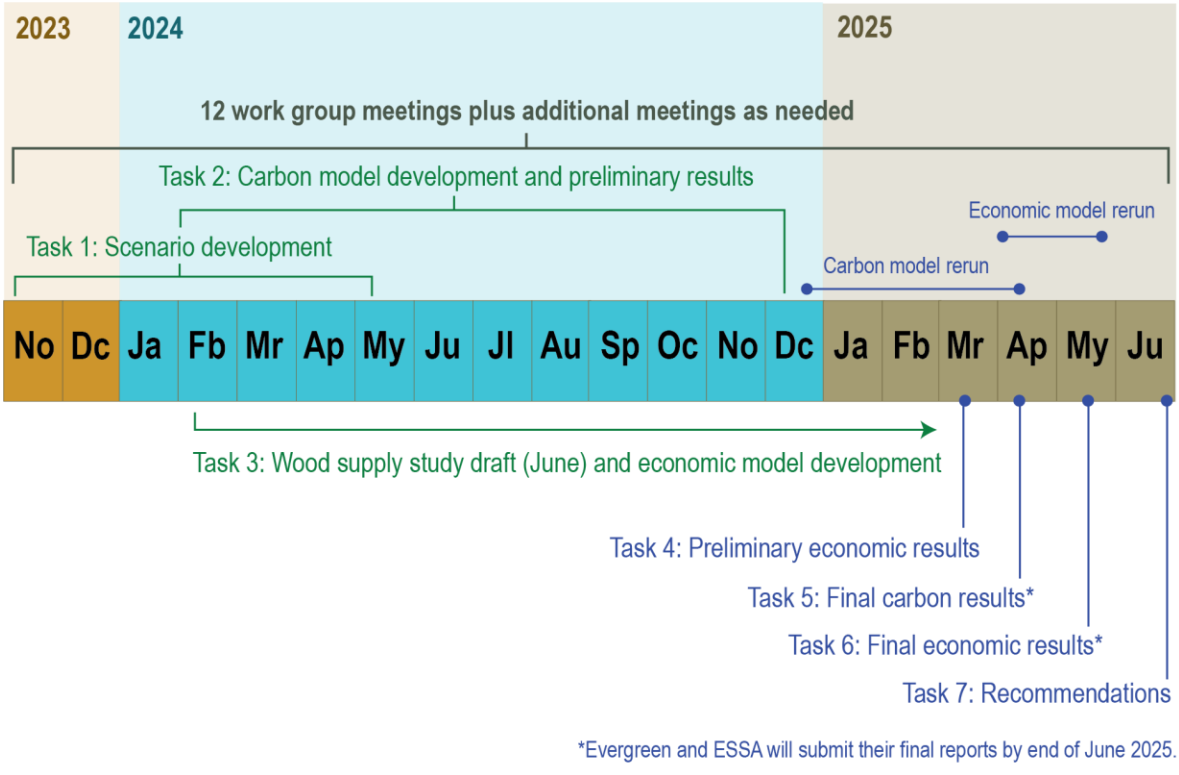
DNR began working on this project soon after the budget proviso was passed in the 2023 legislative session. Early steps described in the previous legislative progress report included hiring the meeting facilitator and establishing the work group. The meeting facilitator is BluePoint Planning, a California-based firm with over 25 years of experience in facilitation and consensus building. A list of work group members can be found under "Acknowledgments and Primary Contacts" at the end of this report.

DNR will focus this effort on the most productive forestlands that DNR manages, the approximately 1.5 million acres of forested state trust lands located west of the Cascade Crest. Due to schedule and budget constraints, it is unlikely that DNR and the work group will be able to address forest management in eastern Washington as part of this project.

Tasks Summarized in this Progress Report

This project is on an aggressive timeline to meet the June 30, 2025 deadline for completing the final management recommendations (refer to Figure 1). Following, DNR will highlight the work that has been accomplished since the 2023 report was written.

Figure 1. High-level project timeline. Tasks 4 through 7 will be covered in the final legislative report.



Task 1: Management Scenario Development

Each proposed management approach is called a scenario. The work group developed eight management scenarios in five work group meetings that took place between January and May 2024. Refer to **Part 2** of this report for a full description of the scenarios and how they were developed.

All management scenarios change one or more of DNR's current management practices, such as harvest rotation length or the amount of thinning DNR performs.

Task 2: Carbon Modeling Development and Preliminary Results

DNR contracted with two modeling consultants through a competitive process. Contracts were signed in January 2024 for the economic modeling contract (Evergreen Economics) and in February 2024 for the carbon modeling contract (ESSA).

A Canadian firm with headquarters in Vancouver, British Columbia, ESSA brings to the team over 30 years of experience in forest carbon modeling and simulation. Their task is to develop and run a carbon quantification model.

The model will enable work group members to understand, for each management scenario, how changing forest management on state trust lands will affect the total amount of carbon stored in the forest and in harvested wood products made from logs harvested from state trust lands at the end of a 100-year analysis period. ESSA is modeling each scenario twice: once under current climate conditions, and once under projected future climate conditions. To date, ESSA has run their model and provided initial results. Refer to **Part 3** of this report for more information.

Task 3 and 3a: Wood Supply Study and Economic Model Development

With offices in Portland, Oregon and Berkeley, California, Evergreen Economics specializes in statistical modeling, benefit-cost analysis, economic impact analysis, and survey research. Evergreen's task is to perform economic modeling.

Evergreen is using three different economic models for this project. Collectively, these models will enable them to understand how the scenarios will affect the timber industry, including mills, and rural economies, and will also provide insights into how the scenarios could affect trust beneficiaries. While ESSA's results are specific to state trust lands, two of Evergreen's models encompass all working forests in western Washington, including federal, Tribal, and private lands. One of these models also includes additional lands in Oregon and Idaho, and a third model encompasses all forests in the contiguous U.S. These different spatial scales are necessary

to understand how management changes on state trust lands interact with state and national timber markets. Analysis periods are different for each model.

Results will be presented in a report called the Wood Supply Study. Evergreen submitted a preliminary draft of the study in the June 2024 work group meeting and is currently developing initial model results for all scenarios. Refer to **Part 3** of this report for more information.

Pending Tasks to be Addressed in Final Legislative Report

The final legislative report (due in December 2025) will describe the following, pending tasks of this project:

- **Tasks 4 and 5, model results**: Once both contractors have gathered feedback from the work group, they will make necessary adjustments to their models and re-run them to produce final results. This phase may include minor adjustments to the scenarios themselves, although the scope of changes will be limited due to the aggressive timeline for this project. Both contractors will also prepare their final reports.
- **Task 6, recommendations:** The work group will evaluate the model results to understand the carbon and economic implications of management changes. Based on this understanding, they will make their recommendations for potential changes to DNR's management of state trust lands. These recommendations will be based on the scenarios and will be clearly presented in the final legislative report, along with feedback on the recommendations from work group members.

Part 2: Management Scenarios

In this section of the report, DNR will describe the collaborative process used to develop the scenarios and the scenarios themselves.

Scenario Development Process

In November and December 2023, BluePoint and DNR held the first two work group meetings. Since the work group represents a diversity of interests and perspectives, initial meetings included presentations and discussions of background information. Topics included DNR's management of state trust lands, the provisions of the *State Trust Lands Habitat Conservation Plan* (HCP)[2] and the *Policy for Sustainable Forests*, and an introduction to forest stand development stages. BluePoint also led the group through a discussion on the goals of the proviso to promote a common understanding across the work group.

From January to May 2024, the work group focused on developing the forest management scenarios that would advance to modeling. All work group meetings were held via Zoom, generally on the 2nd Wednesday of each month. To keep the work group and public informed, work group materials, including meeting agendas, summaries, presentations, and recordings, were posted on the Carbon and Forest Management Work Group webpage on DNR's website. The web page also includes the work group charter.

The scenario development process involved both informal polls to explore and narrow down ideas for scenarios, and formal votes to select the final forest management scenarios for modeling and analysis. For both polls and votes, the facilitator requested each member to vote thumbs up, sideways, or down:

- **Thumbs up** means full endorsement,
- **Thumbs sideways** means consent with reservations, and
- **Thumbs down** means formal disagreement.

In a formal vote, a supermajority of the work group must vote "thumbs-up" or "thumbs-sideways" for a scenario to move forward. A supermajority is defined as 75 percent of the work group members who are present in the meeting.

[2] A contractual agreement between DNR and the Federal Services (NOAA and U.S. Fish and Wildlife Service). The HCP describes how DNR will provide habitat for threatened and endangered species within the working forest.

From Dials to Scenarios

Scenario development was an iterative process in which ideas were proposed, discussed, combined, separated, altered, and finally adopted or dismissed. Along the way, the modeling contractors gave presentations on their respective models to provide additional context for the discussions.

The basis for every scenario was DNR's current management practices. To get started, DNR proposed "dials" that can be turned to create scenarios. Each dial represents an adjustment to DNR's current operations. The four dials are as follows:

- Length of harvest rotation (time between planting and harvest),
- Amount of thinning performed,
- Deferral of additional forest from stand replacement harvest, and
- Increased emphasis on silviculture activities to boost forest growth, such as removal of competing vegetation.

The group began by defining "single dial" scenarios that changed only one aspect of DNR's management. These simple scenarios are useful in a modeling exercise as it enables work group members to understand the effect of a single management change on carbon sequestration and storage and economics.

After adopting the single-dial scenarios, members were interested in developing more complex scenarios that turned two or more dials at once. Two of the proposed multi-dial scenarios were developed by work group members with help from DNR. Other multi-dial scenarios were developed by DNR based on ideas from work group members.

During discussions, work group members could propose "friendly amendments" to a scenario. DNR also held an informational meeting toward the end of the process to give work group members more time to understand the multi-dial scenarios and ask questions. The final scenarios were adopted at the May 2024 meeting.

This was a very collaborative process, with efforts made to hear work group member's concerns and address them. However, the level of support varied for each adopted scenario. For the final legislative report in December 2025, work group members who vote "thumbs down" on a recommendation in the final vote will be invited to share their thoughts and concerns in a minority report, which will be included in the final legislative report.

Some of the scenarios that were discussed and ultimately selected for modeling could require additional funding if they were to be implemented. For example, DNR funds silvicultural

activities like site preparation and pre-commercial thinning (PCT)[3] with a portion of the timber sale proceeds, but often seeks additional funding to help cover these needs.

Some scenarios may be adjusted based on preliminary modeling results. Funding and other considerations will be part of future work group discussions as the group moves toward final recommendations in June 2025.

Scenario Descriptions

Following is a high-level description of the eight scenarios selected for modeling. Each discussion includes the final vote tally and changes made to the scenario based on work group discussion. As a reminder, **both thumbs up and thumbs sideways meant a scenario could advance to modeling**. The total number of votes differed between the scenarios because the votes were taken at different meetings.

The eight scenarios are as follows:

- **Scenario 1**: DNR current operations
- **Scenario 2**: Lengthen harvest rotation
- **Scenario 3**: Shorten harvest rotation
- **Scenario 4**: Significantly increase thinning
- **Scenario 5**: Lengthen harvest rotation + significantly increase thinning
- **Scenario 6**: Lengthen harvest rotation + significantly increase thinning + defer forests that regenerated prior to 1945 from stand replacement harvest
- **Scenario 7**: Increased emphasis on silviculture + significantly increase thinning
- **Scenario 8**: Increased emphasis on silviculture + significantly increase thinning + shorten harvest rotation

The following descriptions are high level and brief. For a full description of the scenarios, refer to Appendix B.

Scenario 1, DNR Current Management

As stated previously, Scenario 1 represents DNR's current management and is the basis for all the scenarios. Scenarios 2 through 8 were created by adjusting specific aspects of this scenario.

DNR manages state trust lands to generate revenue for trust beneficiaries, for social and cultural values like protection of cultural resources, and for habitat, clean air and water, and other ecosystem services. On forested state trust lands, DNR generates revenue primarily through

[3] A thinning in which the trees are young and still too small to be sold.

timber harvest. Timber harvest is governed by state and federal laws, DNR's *Policy for Sustainable Forests*, and the HCP. Timber harvest is also governed by a decadal sustainable harvest level to help ensure sufficient timber is available for both current and future generations of trust beneficiaries. Forested state trust lands are managed within three land classifications:

- **General ecological management (GEM)** lands are the lands on which DNR can perform the full range of forest management activities. GEM lands make up roughly 45 percent of forested state trust lands in Washington.
- **Riparian** lands are designated through the riparian and wetland habitat conservation strategy in the HCP and managed for ecological values under the *Riparian Forest Restoration Strategy* (RFRS). These lands include fish-bearing streams and wetlands plus protective buffers. Riparian forests can be thinned only once for ecological objectives, and stand replacement harvest is not allowed except in very limited circumstances. Riparian lands comprise roughly 24 percent of forested state trust lands in Washington.
- **Uplands** have specific ecological objectives per the HCP, *Policy for Sustainable Forests*, and all relevant laws. Stand replacement harvest in uplands is either restricted entirely, or allowed only when certain conditions are met. These areas comprise roughly 31 percent of forested state trust lands in Washington. Thinning rules vary depending on the type of habitat being managed.

Lands within any of these classifications, including GEM lands, can be deferred from stand replacement harvest for ecological reasons, such as protection of northern spotted owl and marbled murrelet nesting areas, old-growth forest,[4] and other areas. When deferrals and riparian areas are combined, 48 percent of forested state trust lands are unavailable for stand replacement harvest and managed for ecological objectives. Stand replacement harvest also is restricted in uplands, as noted above.

Types of Management

In western Washington, DNR does two major types of commercial harvest: stand replacement harvest and thinning.

- For **stand replacement**, DNR performs variable retention, which leaves a minimum of 8 "leave trees" per acre. Due to protected areas such as riparian buffers, harvests tend to be irregular in shape. All stands are different due to tree species, elevation, climate, and site class, but in general, DNR harvests forests when they reach a timber volume of about

[4] Defined in the *Policy for Sustainable Forests* as forest stands at least five acres in size, in the most complex stand development stage, that regenerated naturally prior to 1850.

30,000 to 35,000 board feet per acre, which translates to a rotation length of roughly 50 to 80 years.[5]

- DNR's **commercial thinning** type depends on where the harvest is occurring. In GEM areas, thinning is done to improve tree growth, and trees are removed in a fairly uniform pattern. Over the past 10 years, DNR has performed commercial thinning on less than approximately 8 percent of the GEM lands on which it operates each year. The amount is small because commercial thinning is costly to implement and generates less revenue than stand replacement harvest.

  In riparian and upland areas, some portions of the stand are thinned more heavily than others. This type of thinning is called variable density and is done to improve habitat conditions.

  In all stands, commercial thinning is not done until the stand reaches about 18,000 to 20,000 board feet per acre.

DNR also conducts a range of silvicultural activities to keep stands healthy and growing well. As these treatments do not generate revenue, they are highly dependent on the availability of funding. These treatments include PCT (currently done on roughly 50 percent of GEM lands), site preparation to remove competing vegetation before planting (75 percent of GEM lands), and release treatments to remove competing vegetation as the young stand is growing (75 percent of GEM lands).

Final vote: 9 thumbs up, 2 thumbs sideways, no thumbs down

Scenario 2: Lengthen harvest rotation (single dial scenario)

Scenario 2 is the same as Scenario 1 in all respects except two: rotation length and planting density.

- DNR will conduct stand replacement when forest stands in GEM areas have reached 50,000 to 55,000 board feet per acre, instead of 30,000 to 35,000 board feet per acre under current practices.

[5] Site class indicates the ability of an area to grow repeated crops of trees, and timber volume is an estimate of the amount of wood in a forest stand, often measured by board foot. A board foot is equivalent to 144 cubic inches, commonly expressed as a piece of wood 12 by 12 inches and one inch thick. Rotation lengths are based on DNR's yield curves for Douglas-fir on Site Class 1 through 4. Actual rotation lengths will vary depending on tree species, location, elevation, density, whether a commercial thinning was performed, and numerous other, inter-related factors.

- Increasing the minimum board feet for stand replacement harvest will lengthen the rotation to 75 to 130 years, depending on site class, from the current length of 50 to 80 years, because trees will take longer to reach this timber volume.
- Planting density after stand replacement harvest will be roughly 15 percent lower as compared to current practices.

Final vote: 6 thumbs up, 3 thumbs sideways, 2 thumbs down

Scenario 3: Shorten harvest rotation (single dial scenario)

Scenario 3 is the same as Scenario 1 in all respects except one: rotation length.

- DNR will conduct stand replacement when forest stands in GEM areas have reached 20,000 to 25,000 board feet per acre, instead of 30,000 to 35,000 board feet under current practices.
- Decreasing the minimum board feet for stand replacement harvest will shorten the rotation to 40 to 60 years, depending on site class, from the current length of 50 to 80 years, because trees will take less time to reach this timber volume.

Final vote: 8 thumbs up, 1 thumb sideways, 2 thumbs down

Scenario 4: Significantly increase thinning

Scenario 4 is the same as Scenario 1 in all respects except two: thinning and planting density.

- In GEM areas, DNR will require one commercial thinning entry in each harvest rotation. PCT will be increased from 50 to 75 percent of forest stands. DNR recommended 75 percent instead of 100 to capture the inherent uncertainty of PCT; whether to do a PCT is a decision made by the forester based on stand conditions. The increase in PCT was added to this scenario as a friendly amendment during work group discussion.
- In riparian areas, DNR will increase the amount of riparian thinning it performs under current management by 10 percent, which translates to a total of 91.3 acres of riparian thinning per year. This goal is modest for two reasons. One, riparian thinning must occur at the same time as an upland harvest and can be expensive and difficult to implement; and two, the RFRS allows riparian forests to be thinned only once for ecological objectives.
- Upland forests that are available for thinning will be thinned only once.

- To accommodate increased thinning levels, DNR will increase planting density following stand replacement harvest by 30 percent, as compared to current practices.

Final vote: 7 thumbs up, 4 thumbs sideways, 0 thumbs down

Scenario 5: Lengthen harvest rotation + significantly increase thinning

Scenario 4 is the same as Scenario 1, current management practices, except that it lengthens the harvest rotation (as described under Scenario 2), significantly increases thinning (as described under Scenario 4), and increases planting density by 30 percent after stand replacement harvest.

A change was made to the rotation length component of this scenario based on work group feedback. For sites that are less productive for growing trees, forests will become available for stand replacement harvest when they reach 80 years old (Site Class 3) or 90 years old (Site Class 4), instead of when they reach 50,000 to 55,000 board feet per acre.

Final vote: 7 thumbs up, 2 thumbs sideways, 3 thumbs down

Scenario 6: Lengthen harvest rotation + significantly increase thinning + increase deferrals

This scenario is the same as Scenario 5 but also defers additional forests from stand replacement harvest.

Under this scenario, all forests in GEM areas that are 80 years old or older at the time of model development (regenerated prior to 1945) will be deferred from stand replacement harvest. These deferred forests will include older, carbon-dense, structurally complex forest as DNR defines them in the *Policy for Sustainable Forests*. This total excludes forests that are already deferred for other objectives. This is a one-time deferral; under this scenario, DNR will not defer additional forest in GEM areas in the future as those forests reach 80 years old.

DNR will not conduct stand replacement harvest in deferred areas. However, these stands can be thinned if needed for forest health or other ecological objectives.

Final vote: 6 thumbs up, 5 thumbs sideways, 1 thumb down

Scenario 7: Significantly increase thinning + increased emphasis on silviculture

This scenario combines Scenario 4 with additional silvicultural activities to promote forest growth, namely:

- Greater use of improved seed stock to boost growth,
- Increase site preparation and release treatments from 75 to 100 percent of planted stands in GEM area, and
- Varying planting density by species and elevation. Planting density will be 30 percent higher than current practices.

Final vote: 9 thumbs up, 2 thumbs sideways, 1 thumb down

Scenario 8: Shorten harvest rotation+ significantly increase thinning +increased emphasis on silviculture

This scenario combines Scenario 3 and 7 but with a minor modification suggested by a work group member. For the "significantly increase thinning" portion of this scenario, stands will undergo commercial thinning when they reach 10,000 to 12,000 board feet per acre instead of 18,000 to 20,000 board feet.

Final vote: 8 thumbs up, 2 thumbs sideways, 2 thumbs down

Part 3: Modeling

Section 3.b of the budget proviso requires DNR to "Contract with universities or other researchers or consultants for additional analysis that is beneficial to the execution of this section…." These two contractors will model the scenarios for carbon (ESSA) and economic effects (Evergreen). Following is a high-level description of these modeling efforts.

ESSA | Carbon Quantification Modeling

Key Points

- **Models used:** FVS, Climate-FVS
- **Analysis period:** 100 years starting in 2024
- **Results reported at:** End of analysis period (2124)
- **Geographic area:** Western Washington
- **Ownerships:** DNR-managed lands only
- **Climate change incorporated into model:** Yes
- **Outputs:** Carbon in live and dead pools, carbon in harvested wood products, other outputs as requested

One of the most fundamental questions facing the work group is how proposed changes in forest management will affect the amount of carbon that is sequestered and stored in forests and harvested wood products, as required by section 3.b.II of the budget proviso.

To answer this question, ESSA is developing a carbon quantification model. The carbon model includes only DNR-managed lands located west of the Cascade Crest and is based on a 100-year analysis period that begins in 2024.

Model Type and Input Data

For this work, ESSA is using the **Forest Vegetation Simulator (FVS)**. Developed by the U.S. Forest Service, FVS is a model that simulates the growth of trees and forests over time. The model has geographic "variants" that represent growing conditions in different areas across the U.S. ESSA is using the Pacific Northwest variant (FVS-PN), which matches the project area. FVS was developed in 1973 from decades of forest research and experience and has been widely used for peer-reviewed scientific publications and other work.

ESSA provides the model with forest inventory data that describes current forest conditions, such as the diameter, height, and species of the trees growing in the forest now, along with topographic information like elevation and slope. Provided by DNR, the forest inventory data is a combination of remotely sensed and ground-collected data. The model is also provided with information on the terrain, forest productivity, land classifications, harvest restrictions, tree volume equations, and tree mortality rates.

In addition, ESSA provides the model with instructions that tell the model which forest management activities to implement where and when under the scenarios. For example, in GEM areas the instructions may tell the model to harvest a stand when it reaches a certain timber volume, and replant it with a specified mix and density of tree species.

How the Model Works

As the model runs, it simulates forest growth and management over a 100-year analysis period, implementing the specific sequences of activities that are unique to each scenario.

Each scenario is modeled two ways: under current climate conditions, and under climate change projections. For the latter, ESSA models future conditions based on representative concentration pathway (RCP) 4.5. An RCP is a prediction of how concentrations of greenhouse gases in the atmosphere will change over time due to human activities.

RCP 4.5 is a moderate scenario in which global greenhouse gas emissions peak around 2040 and then begin to decline, and global average temperatures rise between 2 and 3 degrees Celsius by 2100. This RCP was chosen because it aligns well with DNR's work on other major planning projects, such as the sustainable harvest calculation. The work group also felt that the other choice they were offered, RCP 8.5, was too extreme. Under RCP 8.5, global temperatures rise about 4.3 degrees Celsius by 2100.

To simulate changes under RCP 4.5, ESSA is using the **Climate-FVS** extension. Climate-FVS forecasts how the species composition of forests will change over time in response to shifts in mean annual temperatures, precipitation, annual and seasonal dryness, and other variables. As the climate continues to change, some species may be unable to live in their present range, some may be unaffected, and some may experience improved growth. These types of changes will affect the variables of interest to this work group, such as timber volume for different species of trees.

Climate-FVS uses future climate simulations based on the averaged outputs of 17 global circulation models (GCMs) created as part of the 2013 Intergovernmental Panel of Climate Change (IPCC) Fifth Assessment Report (AR5). GCMs are mathematical models that represent global climate change assumptions.

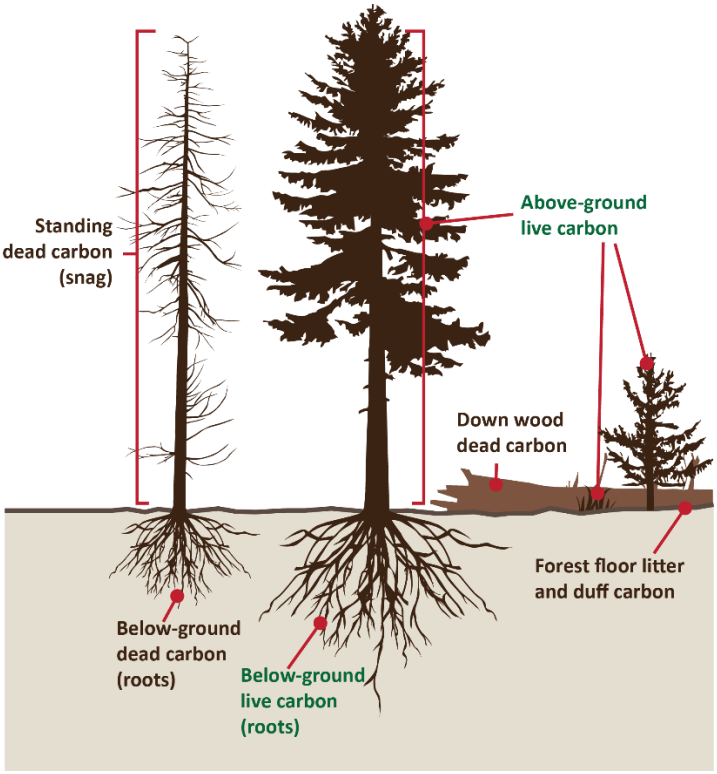
ESSA's use of FVS (and Climate-FVS) is consistent with the highest methodological complexity (Tier 3) recommended by the IPCC guidelines for national greenhouse gas inventories, as required by Section 3.b.II of the budget proviso.

Model Outputs

Once the model is run, ESSA exports data that describes forest conditions at the end of the modeling period (2124) to a database. Through post-processing of the data, ESSA quantifies the amount of carbon stored in the following carbon pools (in tons per acre):

- Live and dead pools (refer to Figure 3)
- Harvested wood product pools

Figure 3. Carbon Pools



Harvested wood products are items made from wood harvested from state trust lands, such as furniture, lumber, and paper. ESSA will calculate carbon in wood products that are currently in use and those stored in landfills at the end of the analysis period.

In addition, ESSA can calculate other variables of interest to the work group, such as standing volume and volume removed.

ESSA will deliver initial model results to the work group at the December 11, 2024 work group meeting. As the results have not yet been presented, they are not included in this legislative report. After the work group meeting, they will be posted on DNR's website under the December 11, 2024 meeting heading. Based on initial results, the work group may ask ESSA to make minor adjustments to the model or scenarios and rerun the model, which will happen in early 2025.

Evergreen | Economic Modeling

It is vital to understand how proposed management changes could affect trust beneficiaries; rural, timber-dependent communities; and the timber industry itself. Economic modeling work fulfills Section 3.b.I of the budget proviso.

Evergreen is using three models to accomplish this work:

- The **Western Washington Timber Supply (WWA) model** to understand how the scenarios may impact the Washington timber industry directly. This model is for the **long-term** (the next 50 years).
- The **Land Use and Resource Allocation (LURA) model** to understand how economic results for Washington may be affected by potential shifts in the national timber market. This model is for the **short term** (the next 20 years).
- The **Impact Analysis for Planning (IMPLAN) model** to understand the how each scenario might affect local economies in Western Washington. This model is for the **near term** (0 to 10 years).

In the following section, DNR will explain each of these models. Together, these three models will provide a range of data outputs, including the following:

- Merchantable timber volume
- Projected harvest levels
- Wood products manufacturing
- Exports
- Direct and indirect impacts on employment, payroll, and economic output by industry
- Carbon in live and dead pools
- Carbon in harvested wood products
- Carbon emissions

The WWA Model

- **Purpose**: Understand direct impacts to the timber industry in Washington
- **Analysis period:** 100 years starting in 2024
- **Results reported:** Every five years for first five decades
- **Geographic area:** Western Washington plus additional land in Oregon and Idaho
- **Ownerships:** All
- **Climate change incorporated:** No

The WWA model has several features in common with the carbon quantification model:

- Both models rely on FVS to project forest growth over time.
- Both models incorporate DNR's forest inventory to represent forested state trust lands.
- Both models are using the instructions that ESSA produced for the carbon model to promote consistency across model platforms.
- Both models include information on terrain, site index, land classifications, harvest restrictions, mortality rates, and other characteristics.

Unlike the carbon model, the WWA model is a constrained *optimization* model. This type of model determines the "optimal" approach for achieving a given objective, subject to restrictions and limitations such as state and federal laws, legal agreements, and policies.

Other key differences between the WWA and carbon quantification model include the following:

- Scenarios are modeled within the WWA model itself, not within FVS.
- The WWA model includes private, federal, and Tribal land, not just forested state trust lands. To represent non-DNR ownerships in the model, Evergreen is using forest inventory data from the U.S. Forest Service's national Forest Inventory and Analysis (FIA) sampling system. The forest service maintains a network of permanent plots in forested areas across the U.S. and re-measures them every 5 to 10 years. In the model, management on non-DNR managed lands will be based on average harvest over the past ten years.
- While both models cover western Washington, the WWA model also includes wood processing centers (mills) in Oregon and Idaho within 200 miles of the study boundaries. It also includes forests in Oregon and Idaho within 100 miles of the study boundaries that may supply wood to Washington mills.

- Although both models are using a 100-year analysis period, Evergreen will only provide results for the first five decades because economic projections become more uncertain the further one moves into the future.
- Climate change will not be incorporated into the WWA model because it would compound the uncertainty inherent in economic modeling. Based on the forest products industry and local economies as they exist today, the WWA model results will be most accurate in the first two decades and become increasingly uncertain beyond this. Climate change impacts are expected to take time to develop, and the worst impacts will be felt in later decades, when the economic results would be more uncertain (with or without climate change). The other two economic models used for this project also will not incorporate climate change.

How the Model Works

Evergreen uses FVS to simulate the growth of each forest stand under myriad combinations of forest management activities. These projections are incorporated into the WWA model as input data. Evergreen uses DNR and FIA inventory data for this step.

Evergreen also provides the model with location and product information for mills and ports. Ports are included because logs from private and tribal lands can be exported *out of* the U.S., and forest products can be imported *into* the U.S. In addition, the WWA model includes a comprehensive network of roads along which (a) timber is transported from forest to mills or ports and (b) lumber, chips, and other intermediate forest products are transported from mill to mill, mill to port, or port to mill.

Evergreen runs the WWA model for each scenario over the 100-year analysis period.

- As the model runs, it determines the optimal combination of forest management activities for each scenario that would need to be implemented in each forest stand to maximize net present value[6] for those who purchase logs and logging residues, and those who sell them (forestland owners and managers). The model's "solution" is called a harvest schedule. Put another way, the model solves for market equilibrium, which is the price at which the quantity of logs provided equals demand. Market equilibrium is permitted to adjust throughout the 100-year analysis period.
- As it runs, the model chooses which FVS growth projections to apply to each forest stand, based on the selected combination of management activities for that stand.

For each scenario, the model provides data describing forest conditions at five-year intervals. With these data, Evergreen will summarize merchantable harvest volume by county and species,

[6] The sum of current and future cash flow; for example, the cash inflow (revenue from timber sales) minus cash outflow (costs of forest management).

mill output, log exports, carbon flux[7] and pools, and direct impacts on jobs within the timber industry, such as jobs in hauling and processing logs.

Evergreen will provide these results for the first five decades. Collectively, these outputs will enable Evergreen to address the key questions raised by the budget proviso, including the amount of wood needed to maintain mills and the jobs they provide.

Evergreen will estimate timber volume and revenue at the county level, which will provide insights into possible impacts on trust beneficiaries. It is not possible to conduct a full analysis of changes to beneficiary revenue until and unless the Board of Natural Resources directs DNR to analyze one or more of the scenarios as part of the sustainable harvest calculation. The sustainable harvest calculation uses a different model and is separate from the work being done under this proviso; refer to "Model Disclaimer" at the end of this section for more information.

The LURA Model

- **Purpose:** Understand how impacts to the Washington timber industry may be affected by potential shifts in the national timber market
- **Analysis period:** 20 years starting in 2024
- **Results reported at:** End of each year
- **Geographic area:** Entire U.S.
- **Ownerships:** All
- **Climate change incorporated:** No

The Washington timber market is affected by the greater U.S. market, particularly the productive areas of the southern states. To understand these effects, Evergreen is using the LURA model.

The LURA model covers approximately 676 million acres of forests across all ownerships in the lower 48 states. These lands are represented by 164,000 FIA data plots, including FIA plots on forested state trust lands.[8] The model also includes thousands of ports and mills and the roads that connect them to the forest.

Like the WWA model, the LURA model solves for market equilibrium. Yet it does so at the national rather than the western Washington scale, taking into consideration large-scale economic changes that affect the national timber market, such as increases or decreases in housing starts. Due to the massive spatial scale, the LURA model will be run for only 20 years. Results will be reported for the end of each year in this 20-year period.

[7] The flow of carbon between different carbon pools.
[8] Due to the large geographic scale of this analysis, Evergreen is not using DNR inventory data to represent state trust lands in the LURA model.

The LURA model outputs can be used to estimate marketable harvest volume and similar metrics. By comparing the results of the LURA and WWA models in the near term, Evergreen can gain insight into how changes in the national timber market may affect the timber market in Washington.

The IMPLAN Model

- **Purpose:** Understand how the scenarios may affect local economies
- **Analysis period:** 0 to 10 years starting in 2024
- **Results reported at:** End of each year
- **Geographic area:** Western Washington
- **Ownerships:** All
- **Climate change incorporated:** No

The WWA and LURA models provide results that can be used to estimate changes to employment within the timber industry. However, these models cannot estimate how changes in forest management will affect local economies. For that, Evergreen is using the IMPLAN model.

IMPLAN is an input-output model, meaning that it represents the interdependencies between different sectors of an economy. The IMPLAN model is commonly used to measure how an economic "shock," such as a change in harvest volume, will affect economic activity in a geographic area. Evergreen is building an IMPLAN model for the entire western Washington analysis area, as well as each individual county within that area.

The IMPLAN model estimates the potential direct, indirect, and induced changes that could result from implementing the scenarios:

- **Direct effects** change the expenditures of businesses or other entities that rely directly on the industry being examined. For example, mills may lay off workers or purchase new equipment to increase capacity, depending on whether harvest volume goes down or up.
- **Indirect effects** are changes in business-to-business purchases that result from shifts within an industry. For example, a plywood manufacturer may increase the amount of electricity, equipment, and supplies they purchase in response to an increase in plywood production.
- **Induced effects** are the increases or decreases in household spending of labor income (after removal of taxes, savings, and commuting expenses) by employees who work for a given industry. Examples include the purchase of groceries and other goods.

Evergreen sums the direct, indirect, and induced effects to provide insights into jobs, employee compensation, economic output, and state and local taxes under each scenario.

IMPLAN is being used to understand economic contributions within the first ten years of the analysis period *only*. The model is based on current economic assumptions.

Evergreen's Carbon Analysis

Evergreen will provide carbon outputs to complement ESSA's results. For all ownerships except DNR-managed lands, they will report the amount of carbon stored in the following carbon pools (refer to Figure 1) under each scenario (without climate change applied):

- Below-ground live carbon
- Above-ground live, merchantable carbon
- Above-ground live, non-merchantable carbon
- Dead carbon (above and below ground)
- Carbon in harvested wood products

Evergreen will report these amounts by decade so that the work group can understand carbon flux. Evergreen also will report the following:

- Carbon emissions from harvesting and transporting logs from all ownerships, including DNR-managed lands.
- Carbon emissions from the manufacture of harvested wood products using logs from all ownerships, including DNR-managed lands, and from the decay of these products over time.

Carbon storage will be calculated from WWA model outputs.

Status of Economic Modeling Effort

Evergreen will provide their initial results at the April 2025 work group meeting. Following that meeting, Evergreen will make any necessary adjustments and rerun the models. Final results will be presented at the June 2025 meeting. Evergreen will summarize their results in the Wood Supply Study. They produced an initial draft of this study in June 2024, which is posted on DNR's Carbon and Forest Management webpage.

Model Disclaimer

No matter how sophisticated, all models have limitations and tradeoffs and should be viewed as providing insights into projected trends over time rather than definitive answers. In addition, even two models that use the same input data are unlikely to provide identical answers to the

same questions, especially if the models are fundamentally different in how they operate. The contractors are working together to achieve as much continuity as possible between the carbon and economic models but some differences in outputs from the models are unavoidable.

All of these models are different than the "forest estate model" DNR is developing to calculate the decadal sustainable harvest level, which is the timber volume scheduled for harvest from state trust lands during a planning decade (RCW 79.10.300(5)). Harvest volume, carbon, or other results from either the carbon or economic model should not be directly compared to forest estate model outputs.

The effort to develop the 2025-2034 western Washington sustainable harvest level is separate from the efforts of the Carbon and Forest Management Work Group. Recommendations developed by this work group could influence the action alternatives considered in the environmental impact statement for the sustainable harvest level, but none of the harvest volume information produced by either the carbon or economic model will, of itself, constitute a sustainable harvest level.

Conclusion: Looking Ahead

In the months ahead, the modeling contractors will complete their work and provide the information the work group needs to make informed choices.

In the meantime, DNR and the meeting facilitator, BluePoint Planning, will begin developing the recommendations with the work group. The work group will finalize these recommendations by June 30, 2025, the close of the biennium.

In the final legislative report, DNR will describe each of these recommendations, along with key model results, final vote tallies, and concerns of work group members about individual scenarios. Because DNR cannot write this report until after the work group has completed this process, DNR will not submit this report until December 2025.

Managing forested state trust lands is a major responsibility, and part of that responsibility is to keep these forests healthy and functional in perpetuity. That effort includes climate mitigation. DNR looks forward to bringing the legislature workable solutions that will secure the future of these forests for the trust beneficiaries and the people of Washington.

Acknowledgments and Primary Contacts

DNR Steering Committee

- Duane Emmons, Assistant Deputy Supervisor for State Uplands, Executive Management and Support
- Csenka Favorini-Csorba, Policy Director, Executive Management and Support

DNR Technical Team

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- Florian Deisenhofer, Natural Resource Scientist, Silviculture
- Daniel Donato, Natural Resource Scientist, HCP and Scientific Consultation
- Joshua Halofsky, Natural Resource Scientist, HCP and Scientific Consultation
- Kristoffer Larson, Lead Economist, Office of Finance, Budget, and Economics
- Sharon Lumbantobing, Assistant Division Manager, Strategic Planning Office
- Kate McBurney, Assistant Division Manager, Forest Informatics
- Denise Roush-Livingston, Environmental Planner, Strategic Planning Office

Carbon and Forest Management Work Group

- Matthew Comisky, American Forest Resource Council
- Heidi Eisenhour, Jefferson County
- Randy Johnson, Clallam County
- Hannah Jones, Firelands Workers United
- Ryan Miller, The Tulalip Tribes
- Ed Murphy, Sierra Pacific Industries
- Bryan Pelach, Washington Conservation Action
- Russ Pfeiffer-Hoyt, Washington State School Directors Association
- Jason Spadaro, Washington Forest Protection Association
- Paula Swedeen, Conservation Northwest
- John Talberth, Center for Sustainable Economy
- Pat Tonasket, Elected Official, Confederated Tribes of the Colville Reservation

Alternates

Work group members can designate alternates to attend in their place when unable to make a meeting. The following have served as alternates in one or more work group meetings.

- Mike French, Clallam County, alternate for Randy Johnson
- Brel Froebe, Center for Responsible Forestry, alternate for John Talberth
- Steve Hinton, The Tulalip Tribes, alternate for Ryan Miller
- Olivia Jacobs, Xyla Land and Resource Advisors, alternate for Jason Spadaro
- Miguel Perez-Gibson, Washington Conservation Action, alternate for Paula Swedeen

Contractors

BluePoint Planning Team

- Mindy Craig, Principal-in-Charge
- Lauren Schmitt, Project Manager
- Nora Bayley, Project Associate
- Chris Mendoza, Sole Proprietor, Mendoza Environmental LLC (subconsultant)

ESSA Team

- Clint Alexander, Principal-in-Charge
- Dr. Cedar Morton, Project Manager
- Frank Poulsen, Lead Carbon Modeler (subconsultant)
- Donald Robinson, Senior Carbon Modeling Specialist (subconsultant)
- Dr. Ira Sutherland, Forest Carbon Modeler
- Alexandra Tekatch, Forest Carbon Modeler
- Dr. Graham Mushet, Forest Carbon Modeler
- Jessica Castellanos-Labarcena, Forest Carbon Modeler

Evergreen Team

- Dr. Ted Helvoigt, Project Manager
- David Ford, Lead Analyst of Forest Carbon Markets and Forest Carbon Sequestration
- Dr. Gregory Latta, Lead Analyst and Modeler (subconsultant)

Primary DNR Contacts

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Appendix A: Budget Proviso

Fiscal Year 2023-25 Capital Budget Proviso, Carbon Sequestration Forests
Carbon and Forest Management Work Group | Chapter 474, Laws of 2023, Section 3130 (3a), pages 149-150

(3) $2,500,000 of the appropriation is provided solely for the department to:

a. Contract with an independent facilitator to convene a stakeholder group comprised of a balanced representation of relevant stakeholders and tribal interests to:

   I. Collaborate on approaches related to the conservation and management of older, carbon dense, structurally complex forest stands located on lands managed by the department; increasing carbon sequestration and storage in forests and harvested wood products from department managed forestlands; generating predictable beneficiary revenue; maintaining timber supplies that support local industry; and addressing economic needs in rural counties

   II. Develop an understanding of current timber supply by region and the effect of potential changes to forest management practices on regional wood supply for the timber market, including an analysis of what is currently known about the needs of existing forest industry infrastructure and what information gaps exist

   III. Explore concepts and strategies relevant to the sequestration and storage of carbon in forests and wood products from forested state trust lands managed by the department, including the effect of potential changes to forest management practices, that satisfy the department's trust management responsibilities

b. Contract with universities or other researchers or consultants for additional analysis or existing research that is beneficial in the execution of this section, which must include an analysis of:

   I. The existing and future demand for wood supply by region, including levels required to maintain existing industry related infrastructure, and modeled impacts on wood supply increases or decreases based on potential changes to forest management practices.

   II. Carbon accounting and quantification methodologies outlined by the intergovernmental panel on climate change as well as emerging scientific research.

The methodologies considered must be used to verify and assess the potential increases or decreases in carbon sequestration and storage, in both forests and harvested wood products based on potential changes to management practices on forested state trust lands that also account for increases or decreases in the availability of wood products harvested from forests managed by the department.

c. A report of the stakeholder group's findings, including any information received in work performed in (b) of this subsection (3), must be submitted to the appropriate committees of the legislature by December 1, 2023.

Appendix B: Detailed Scenario Descriptions

This appendix describes in detail the eight forest management scenarios that the Carbon and Forest Management Work Group selected for carbon and economic modeling.

For the carbon analysis only, each scenario will be modeled two ways: with no climate change assumptions, and with moderate climate change assumptions. These assumptions are based on representative concentration pathway (RCP) 4.5, under which carbon emissions peak around 2040 and then decline.

Following is a description of each scenario, including any adjustments that were made to the scenarios based on work group feedback. Background information on site class can be found Appendix C.

The diagrams and yield curves that accompany the text are simplified representations of the scenarios, meant to help readers understand the management changes being considered. They are not meant to capture all of the complexities of forest management. For example, yield curves do not reflect the potential impact that a commercial thinning may have on rotation length.

Scenario 1: DNR Current Management

Scenario 1 provides the foundation on which all other scenarios are built. Following are key details about this scenario. The description is broken out by three major land classes:

- **General ecological management (GEM)**: Lands available for harvest subject to the requirements of the *State Trust Lands Habitat Conservation Plan* (HCP), *Policy for Sustainable Forests*, and all relevant laws. GEM areas are the primary revenue-generating lands in the state trust lands portfolio.
- **Riparian**: Lands designated through the riparian and wetland habitat conservation strategy in the HCP. These lands include fish-bearing streams and wetlands plus protective buffers. Buffer widths depend on stream and wetland type. Management in these areas is guided by both the HCP and DNR's *Riparian Forest Restoration Strategy* (RFRS), as well as all relevant laws.
- **Uplands**: Lands that have specific ecological objectives that limit (but do not preclude) harvest per the HCP, *Policy for Sustainable Forests*, and all relevant laws. Examples include areas being managed for northern spotted owl conservation or for hydrologic maturity, and special habitat areas managed for marbled murrelets.

GEM Areas

- **Stand replacement harvest**: To be eligible for stand replacement harvest, forest stands typically have roughly 30,000 to 35,000 board feet per acre, although this range can vary from site to site. For Douglas-fir, this range translates to a harvest rotation of approximately 50-80 years depending on site class. Stand replacement harvest removes an average of 90 percent of the timber volume within each timber sale unit, although actual removals may vary widely depending on stand objectives and conditions.
- **Site preparation:** Over the past 10 years, DNR has done site preparation on approximately 75 percent of areas being replanted.
- **Stand regeneration:** About 60 percent of the seedlings that DNR plants on state trust lands are grown from improved seed stock. Improved seeds are gathered from orchard trees that have performed well in field testing across a wide range of environments.

  In general, DNR plants approximately 360 seedlings per acre across all GEM lands.

  On most sites, DNR plants at least two species. For example, in 2022, 72 percent of harvested sites were replanted with two or more species.

Seventy-eight percent of seedlings planted on state trust lands in 2022 were Douglas-fir, 11 percent were western hemlock, and 5 percent were western redcedar. The remaining 1 to 2 percent of planted seedlings included Sitka spruce, red alder, white pine, and noble fir.

- **Release treatments:** Over the past 10 years, DNR has done release treatments (herbicide spraying or slashing) on roughly 75 percent of planted stands. Release treatments are typically done about two years after planting.
- **Pre-commercial thinning (PCT):** Based on its most recent estimates, DNR has done PCT on approximately 50 percent of its forests in GEM areas over the past 10 years, on average. Note that the amount of PCT (and release treatments) that DNR can perform from one year to the next is highly dependent on funding, so acres can vary widely from one year to the next. Recent PCT work has been funded through an appropriation from the Climate Commitment Act.

  PCT is done when stands are anywhere from 8 to 12 years of age, on average (earlier on more productive sites, later on less productive sites). Post-PCT tree densities range from 250 to 330 stems per acre if no commercial thinning is anticipated.
- **Commercial thinning:** Over the past 10 years, DNR has performed commercial thinning on less than approximately 8 percent of the GEM lands on which it operates each year. Depending on objectives, the technique can be an intermediate-type thinning, in which trees are removed in a regular pattern and remaining trees have similar growing space; or a variable density thinning, but without gaps. In either case, the volume removed in a thinning is roughly 30 percent of timber volume within the thinning boundary.

Riparian Areas

- **Stand replacement harvest**: Not allowed except under very limited circumstances (such as hardwood conversions).
- **Commercial thinning**: Between 2019 and 2067, DNR anticipates thinning a total of 4,000 acres of riparian forest. That equates to 83 acres of riparian forest thinning per year.
- **PCT:** Currently, DNR does virtually no PCT in riparian areas.

Other upland areas:

- **Stand replacement harvest, PCT, commercial thinning**: Stand replacement harvest is only allowed in select areas. When performed, it has the same requirements as stand replacement harvest in GEM lands. Thinning (PCT and commercial) is allowed in some

upland areas per the requirements of the HCP and other policies and laws. Thinning rules vary depending on habitat type and objectives. Commercial thinning in habitat areas is usually variable density with gaps ranging from a quarter to half acre each. PCTs in uplands have the same parameters as GEM lands.

- **Stand regeneration:** Only applicable in areas that have undergone stand replacement harvest. Parameters are the same as GEM lands.

Figure B-1 shows current management practices. Currently, the top track (regenerate, harvest, regenerate) is far more common than the middle track (regenerate, thin, harvest, replant) or the lower track (thin only). Note that this simplified graphic does not show the silvicultural practices that DNR does now, such as release treatments or PCT.

Figure B-1. Simplified schematic of DNR current management.

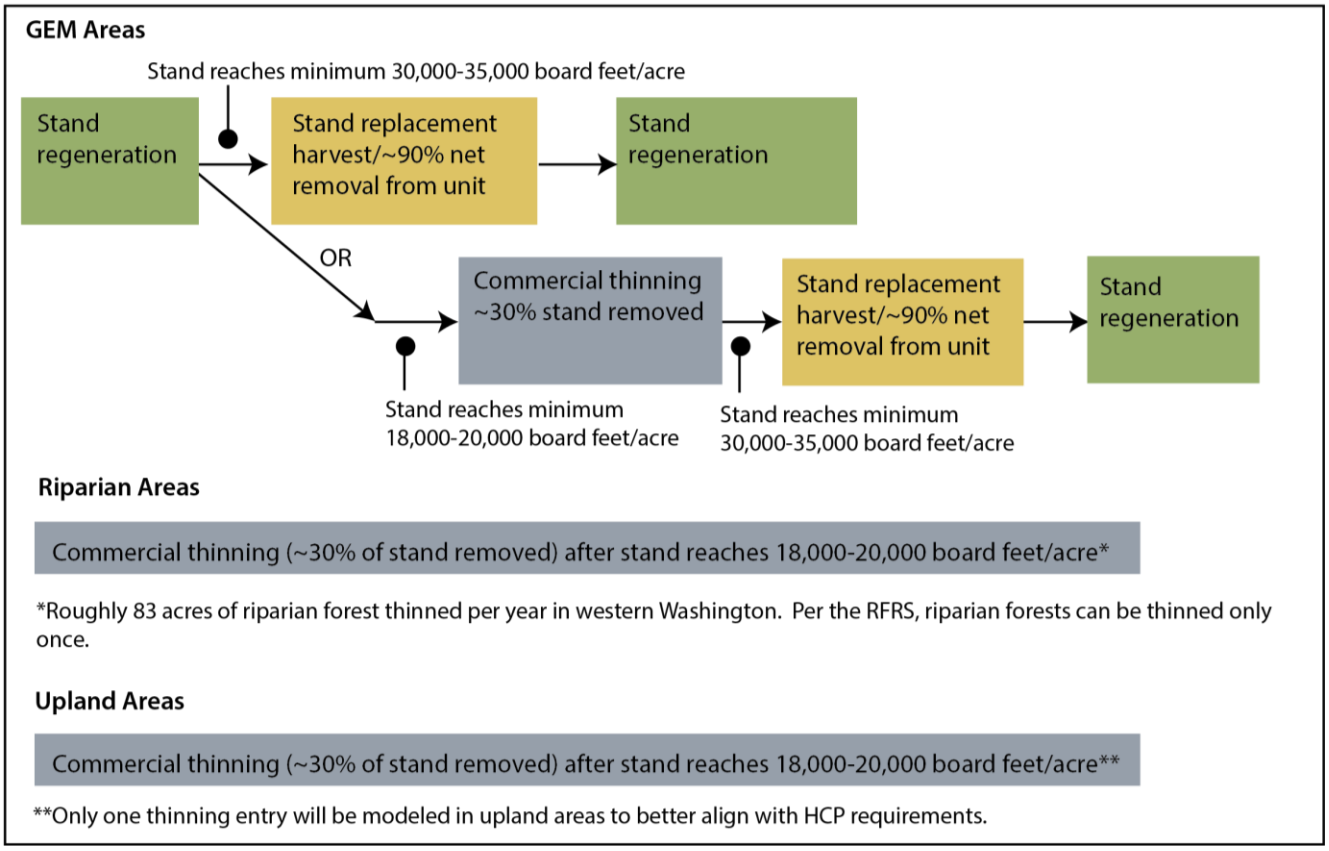
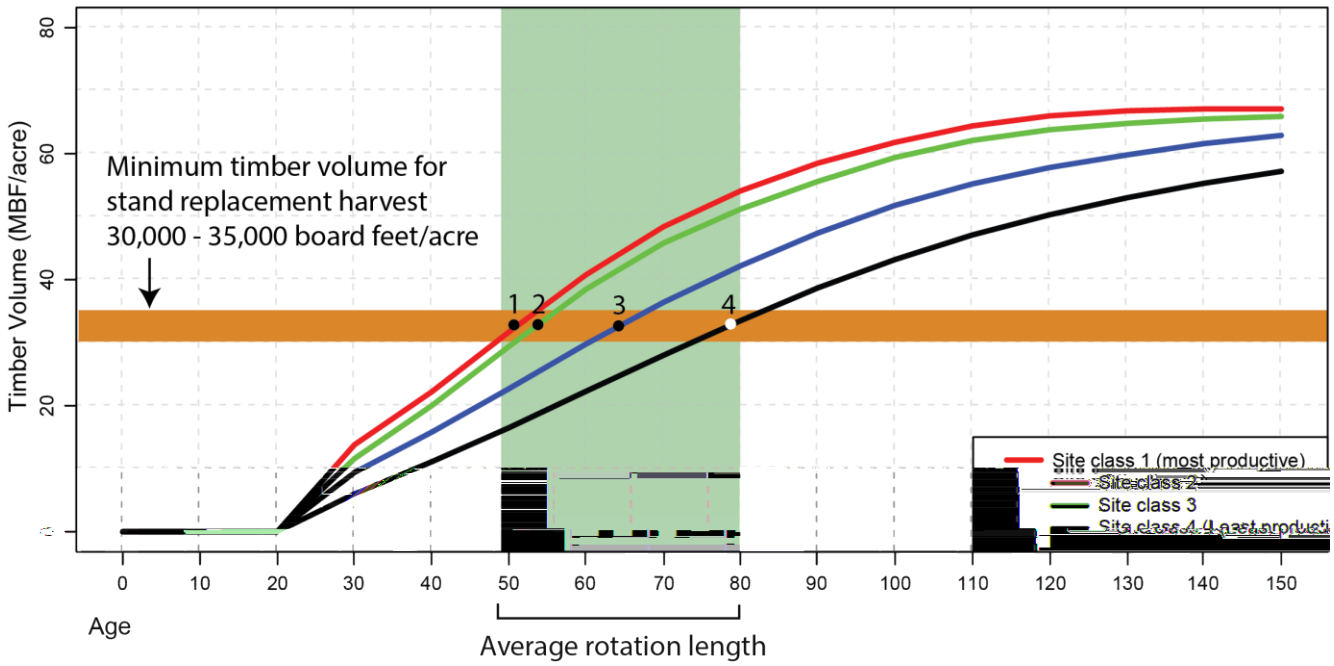


Figure B-2 is sample yield curve for Douglas-fir in western Washington showing rotation age, based on a minimum harvest volume of 30,000 to 35,000 board feet per acre.

Figure B-2. Sample Douglas-fir yield curve for western Washington showing the relationship between minimum timber volume and stand age for Scenario 1.

Yield curve generated from DNR inventory plots and stratified using information from DNR's inventory. Yield curve does not reflect the potential impact that commercial thinning may have on rotation length.



Scenario 2: Lengthen Harvest Rotation (Single Dial Scenario)

Under this scenario, forest stands in GEM areas must have a minimum of 50,000 to 55,000 board feet per acre to be considered available for stand replacement harvest. For Douglas-fir, this range translates to a harvest rotation age of roughly 75 to 130 years, depending on site class. Stand replacement harvest removes an average of 90 percent of the timber volume within the boundaries of each timber sale unit, although actual removals may vary widely depending on objectives and stand conditions.

This minimum board feet per acre requirement is much higher than DNR's current minimum of 30,000 to 35,000 board feet per acre. Increasing the minimum board feet per acre requirement will lengthen the harvest rotation, because it will take the forest stand longer to reach this timber volume.

Planting density after stand replacement harvest will be roughly 15 percent lower as compared to current practices.

Refer to Figure B-3 for a simplified schematic of this scenario and Figure B-4 for a sample yield curve.

Figure B-3. Simplified schematic of Scenario 2.

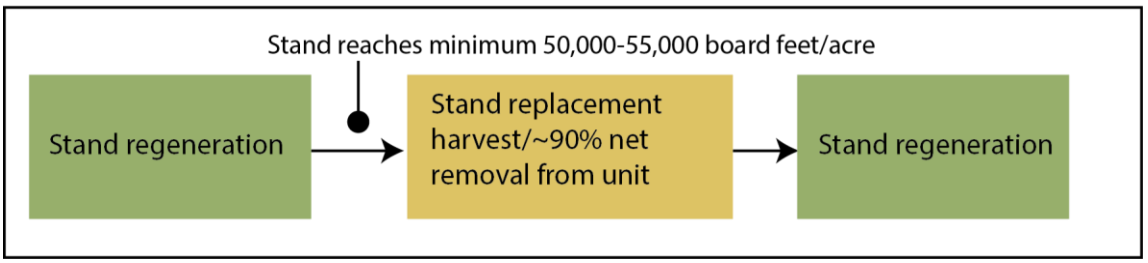
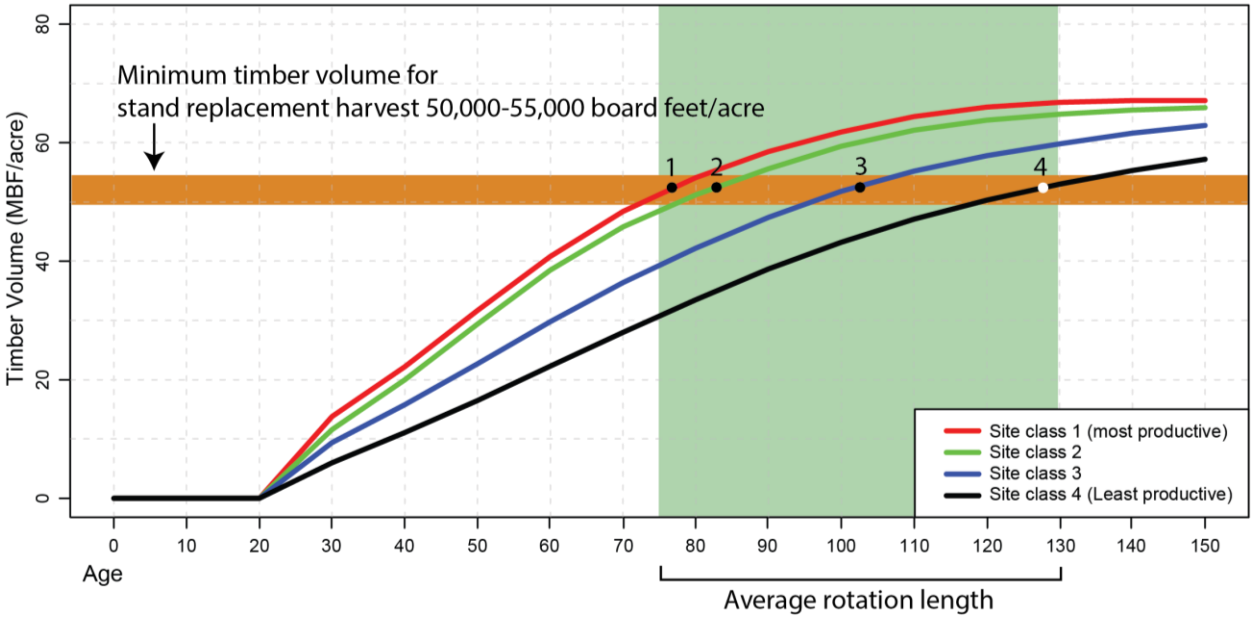


Figure B-4. Sample Douglas-fir yield curve for western Washington showing the relationship between minimum timber volume and stand age for Scenario 2.

Yield curve generated from DNR inventory plots and stratified using information from DNR's inventory. Yield curve does not reflect the potential impact that commercial thinning may have on rotation length.



Scenario 3: Shorten Harvest Rotation (Single Dial Scenario)

Under this scenario, a forest stand in GEM areas must have a minimum of 20,000 to 25,000 board feet per acre to be considered available for stand replacement harvest. For Douglas-fir, this range translates to a harvest rotation of roughly 40 to 60 years, depending on site class. Stand replacement harvest removes an average of 90 percent of the timber volume within each timber sale unit, although actual removals may vary widely depending on objectives and stand conditions.

This minimum board foot per acre requirement is lower than DNR's current minimum of 30,000-35,000 board feet per acre. Reducing the minimum board feet per acre will shorten the harvest rotation, because the forest stand will reach this volume sooner than it would if the board feet requirement were higher. Refer to Figure B-5 for a simplified schematic of this scenario and Figure B-6 for a sample yield curve.

Figure B-5. Simplified schematic of Scenario 3.

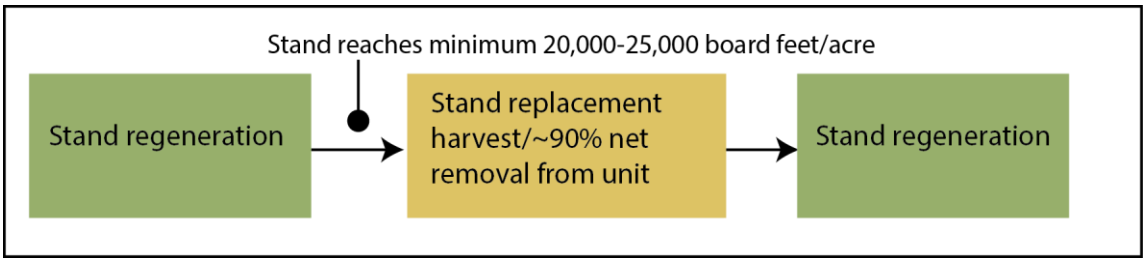
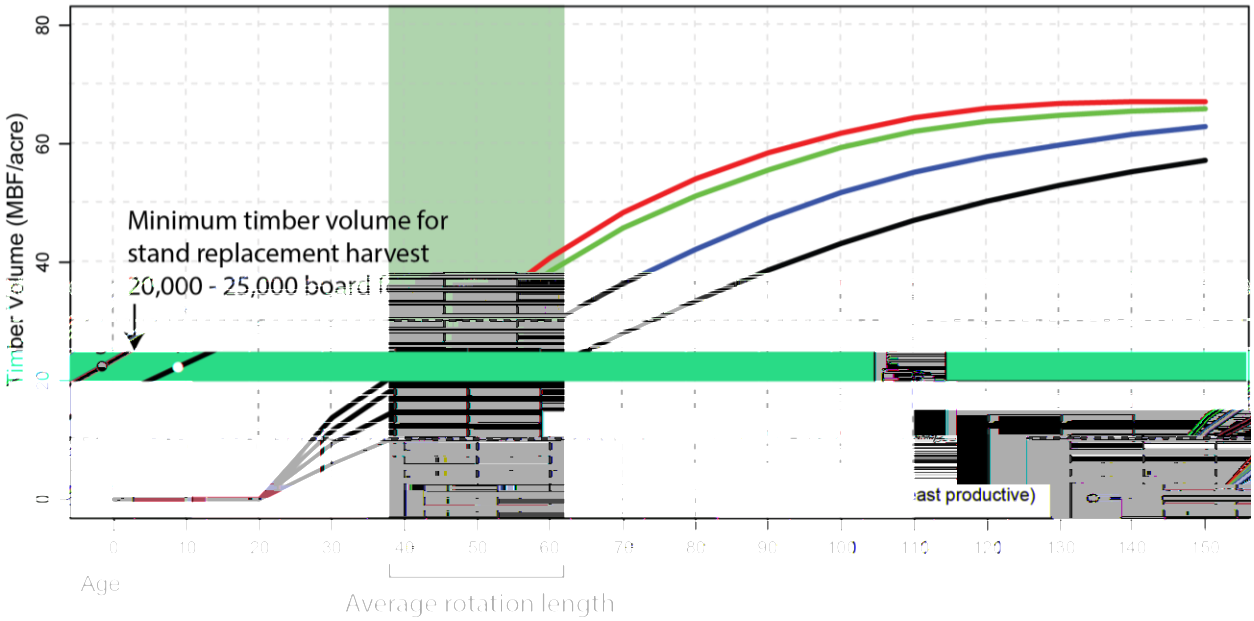


Figure B-6. Sample Douglas-fir yield curve for western Washington showing the relationship between minimum timber volume and stand age for Scenario 3.

Yield curve generated from DNR inventory plots and stratified using information from DNR's inventory. Yield curve does not reflect the potential impact that commercial thinning may have on rotation length.



Scenario 4: Significantly Increase Thinning (Single Dial Scenario)

This scenario increases both commercial and pre-commercial thinning.

In GEM areas, DNR will require one commercial thinning entry in each harvest rotation. The minimum timber volume for a thinning will be roughly 18,000 to 20,000 board feet per acre. In practice, the technique can be an intermediate-type thinning, in which trees are removed in a regular pattern and remaining trees have similar growing space, or a variable density thinning but without gaps. The volume removed in a thinning is roughly 30 percent of timber volume within the thinning boundary.

Riparian areas are managed under the HCP and the RFRS. The RFRS allows riparian forests to be thinned only once for ecological objectives. In riparian areas, only one thinning entry will be modeled over the 100-year analysis period. The amount of thinning will be a total of 91.3 acres per year, which is roughly a 10 percent increase in riparian thinning from Scenario 1 (DNR current management). Riparian stands to be thinned must have a minimum timber volume of 18,000 to 20,000 board feet per acre to be thinned, and roughly 30 percent of the timber volume will be removed.

Upland areas are managed for ecological objectives according to the conservation strategies in the HCP, and each strategy has its own harvest rules. Upland thinnings are almost always variable density. In practice, thinning intensity in habitat areas is variable and depends largely on stand objectives. Upland areas can be thinned only once after the stand reaches 18,000 to 20,000 acres, and 30 percent of the volume is removed.

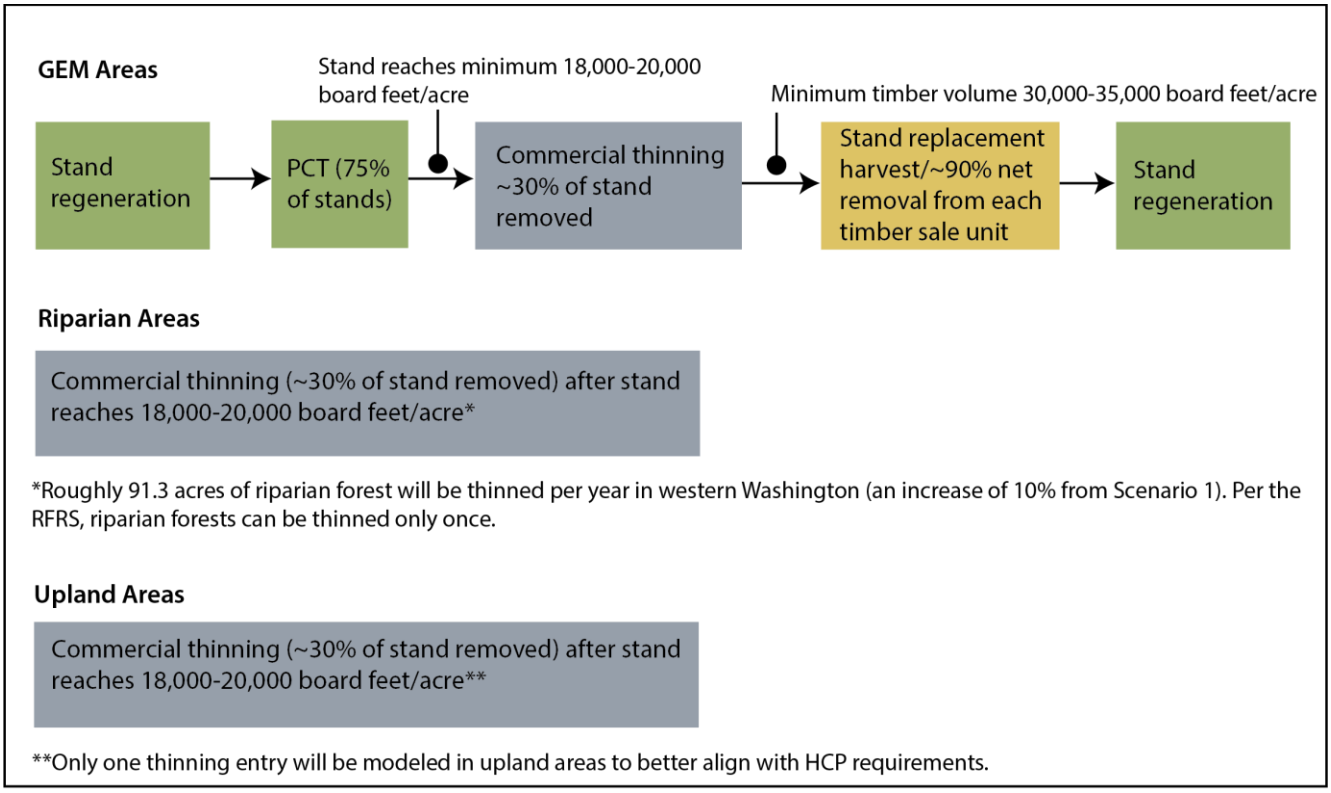
In addition, DNR will conduct PCT on 75 percent of forest stands. Stands should be roughly 8 to 12 years old, and the PCT should leave 350 to 465 trees per acre to ensure there are enough stems to support a later commercial thinning, which would occur after the stand reaches a minimum of 30,000 to 35,000 board feet per acre.

To accommodate increased thinning levels, DNR will increase planting density following stand replacement harvest by 30 percent, as compared to current practices.

Why not 100 Percent for PCT?

Whether to conduct a PCT is a stand-level decision. Some stands may benefit from a PCT, and others may not. DNR will capture this uncertainty in the model by applying PCT to only 75 percent of stands. Refer to Figure B-7 for a simplified schematic of this scenario.

Figure B-7. Simplified schematic of Scenario 4.



Scenario 5: Lengthen Harvest Rotation and Significantly Increase Thinning (Multi-Dial Scenario)

This scenario includes the following components:

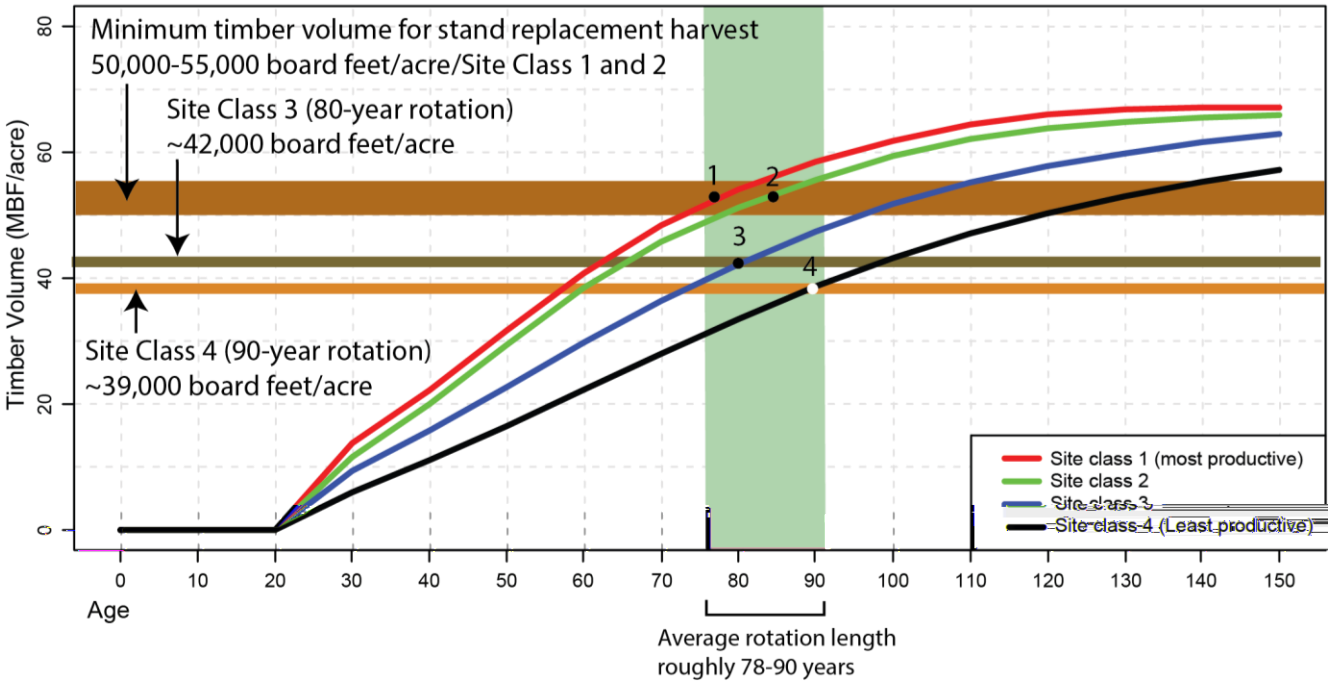
Lengthen Harvest Rotation

This scenario includes a version of Scenario 2 that was partially modified based on work group input. Site Classes 1 and 2 are unchanged from Scenario 2; for those site classes, a stand becomes available for stand replacement harvest when it reaches 50,000 to 55,000 board feet per acre. However, stands on Site Classes 3 and 4 can be harvested when they reach a specific age: 80 years for Site Class 3 and 90 years for Site Class 4. For Douglas-fir, these ages correspond to an estimated timber volume of 42,000 board feet per acre for Site Class 3 and 39,000 board feet per acre for Site Class 4 (Figure B-8).

To accommodate increased thinning levels, DNR will increase planting density following stand replacement harvest by 30 percent, as compared to current practices.

Figure B-8. Sample Douglas-fir yield curve for western Washington showing the relationship between minimum timber volume and stand age for Scenario 5.

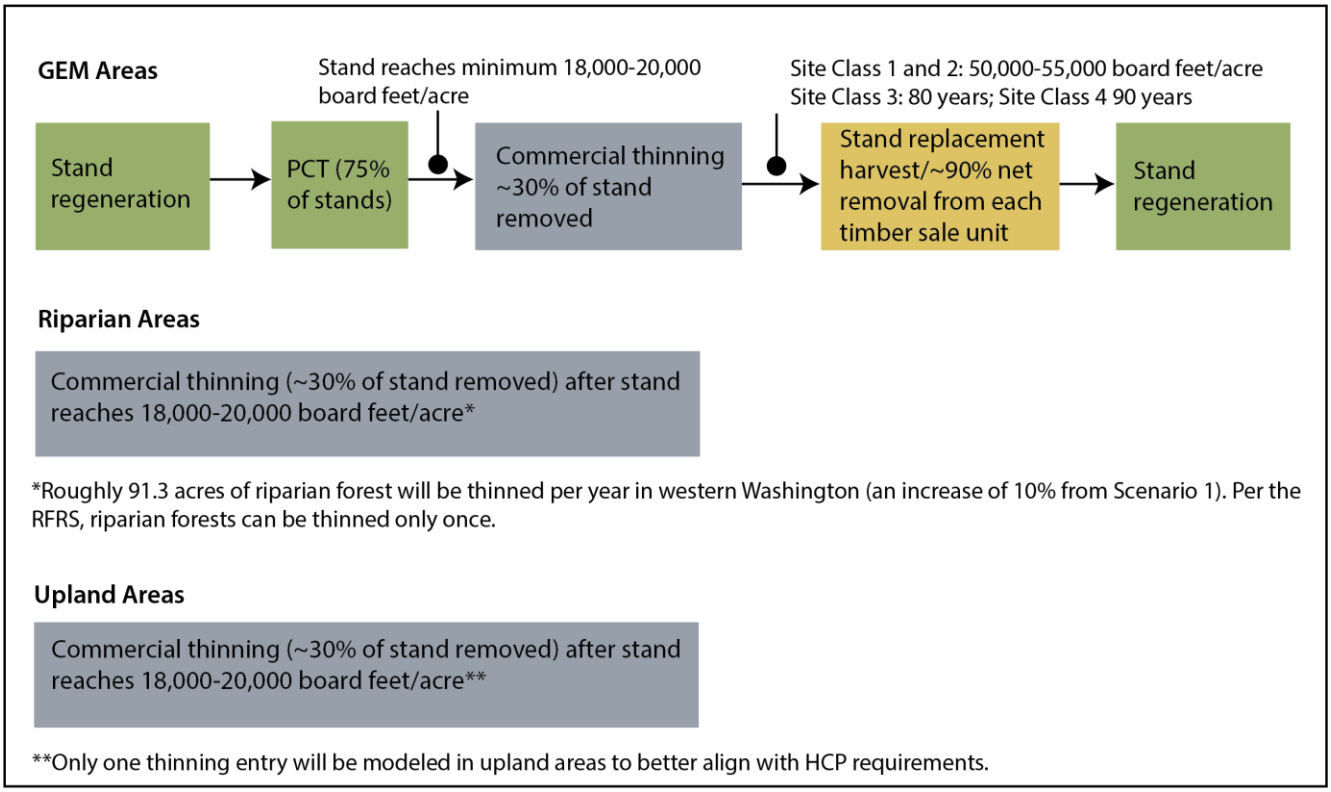
Yield curve generated from DNR inventory plots and stratified using information from DNR's inventory. Yield curve does not reflect the potential impact that commercial thinning may have on rotation length.



Significantly Increase Thinning

Refer to the description under Scenario 2. Figure B-9 shows how the two components of this scenario interact.

Figure B-9. Simplified schematic of Scenario 5.



Scenario 6: Lengthen Harvest Rotation, Significantly Increase Thinning, and Increase Deferrals (Multi-Dial Scenario)

This scenario includes the following components:

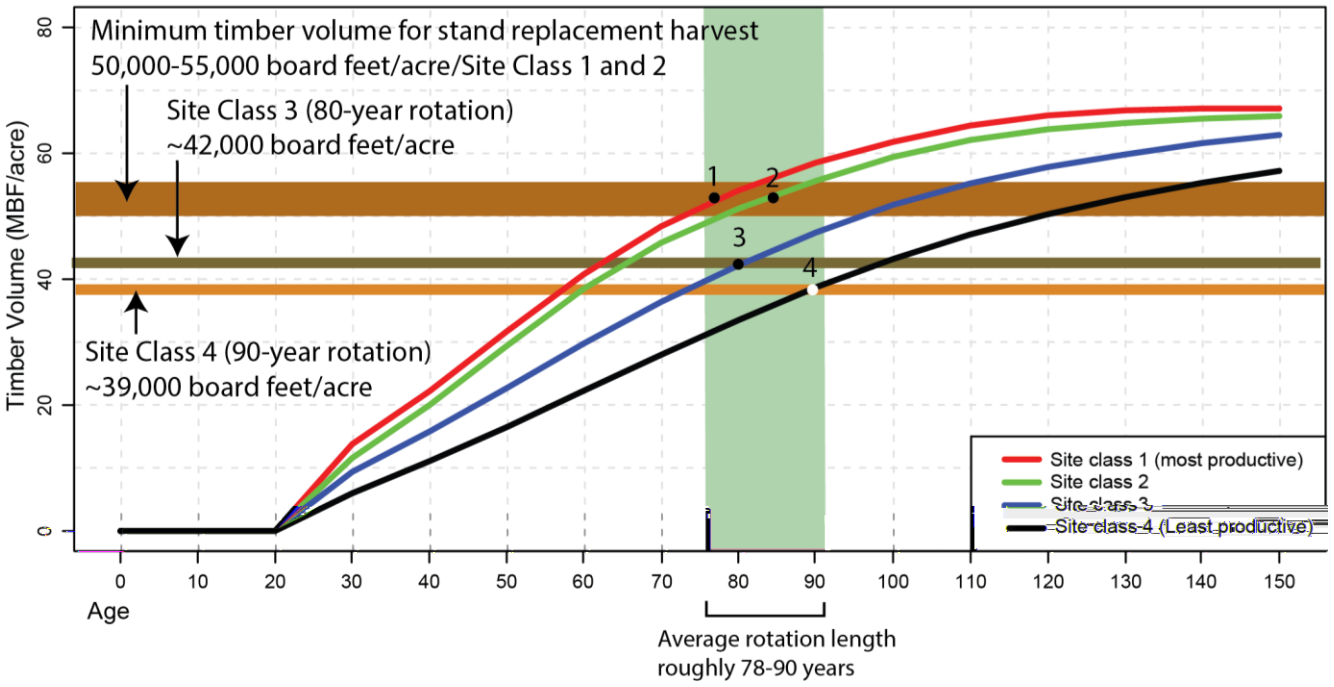
Lengthen Harvest Rotation

This scenario includes a version of Scenario 2 that was modified based on work group input, as described under Scenario 5. Refer to Figure B-10.

To accommodate increased thinning levels, DNR will increase planting density following stand replacement harvest by 30 percent, as compared to current practices.

Figure B-10. Sample Douglas-fir yield curve for western Washington showing the relationship between minimum timber volume and stand age for Scenario 6.

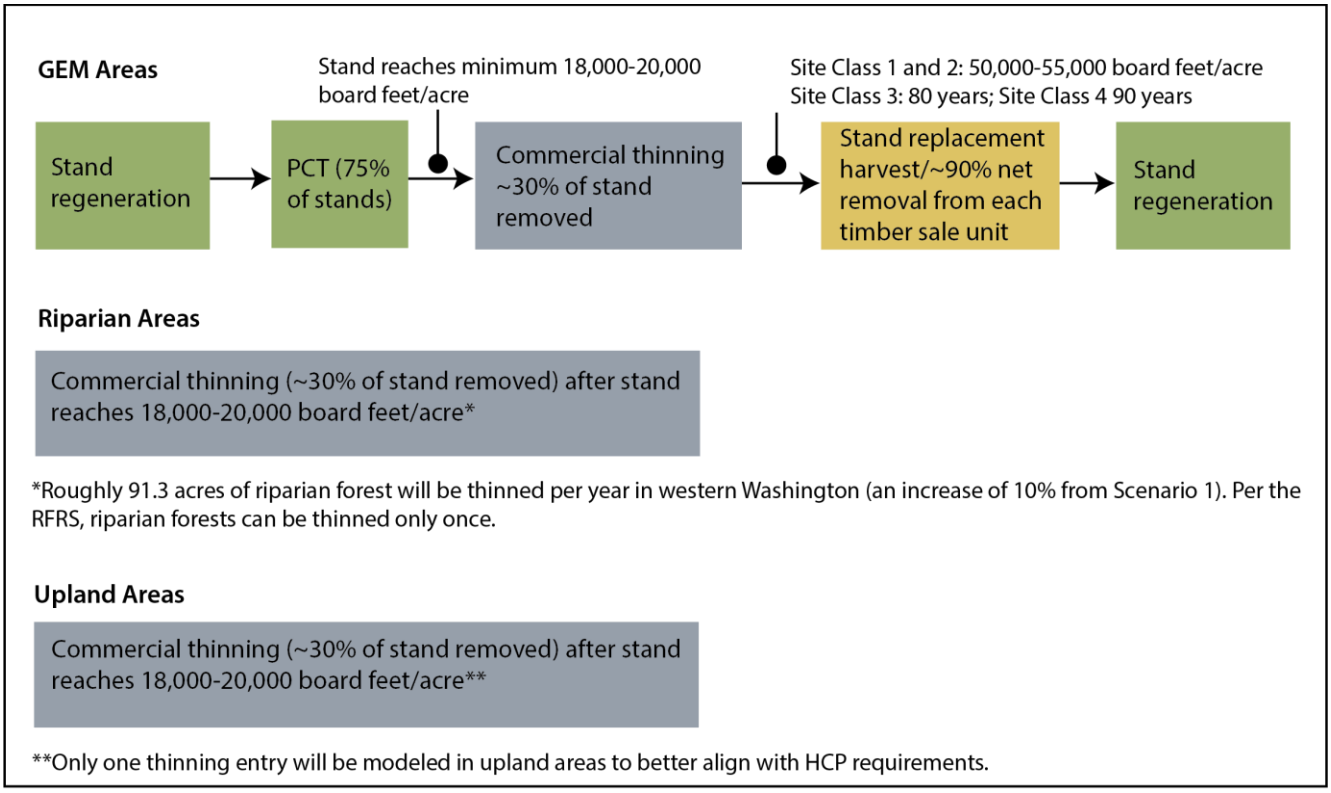
Yield curve generated from DNR inventory plots and stratified using information from DNR's inventory. Yield curve does not reflect the potential impact that commercial thinning may have on rotation length.



Significantly Increase Thinning

Refer to the description under Scenario 2. Figure B-11 is a simplified schematic of this scenario.

Figure B-11. Simplified schematic of Scenario 6.



Increase Deferrals

Under this scenario, all forests in GEM areas that are 80 years old or older at the time of model development will be deferred from stand replacement harvest. Deferred areas will include all older, carbon-dense, structurally complex forest as DNR defines them in the *Policy for Sustainable Forests*[9]. DNR will not conduct stand replacement harvest in deferred areas. However, these stands can be thinned if needed for forest health or other ecological objectives.

This scenario uses age as a surrogate for structure. This approach mirrors the methodology used in the HCP. As noted in Franklin et. al. 2002[10], "The maturation stage typically begins at 80-100 years and may persist for 100-150 years in naturally regenerated Douglas-fir stands."

[9] A forest in the 'botanically diverse' 'niche diversification' or 'fully functional' stage of stand development. Forests in these phases have varying sizes of trees, understory vegetation and lichen, downed wood and snags, etc. This definition from the *Policy for Sustainable Forests* is the only definition DNR recognizes for structurally complex forest.

[10] Franklin, J. F., T. A. Spies, R. Van Pelt, A. B. Carey, D. A. Thornburgh, D. R. Berg, D. B. Lindenmayer, M. E. Harmon, W. S. Keeton, D. C. Shaw, K. Bible, and J. Chen. 2002. Disturbances and Structural Development of Natural Forest Ecosystems with Silvicultural Implications, Using Douglas-fir Forests as an Example. Forest Ecology and Management 155:399–423. Oliver, C. D. and B. C. Larson. 1996. Forest Stand Dynamics, update edition. John Wiley & Sons, New York, New York. 520 p.

DNR estimates the total number of acres deferred under this scenario to be approximately 66,725. This total excludes forests that are already deferred for other objectives, including the 2,000 acres of forest being deferred under Section 1.b of this budget proviso (c 474 §3130).

This scenario also includes a 30 percent increase in planting density following stand replacement harvest, as compared to current practices.

Scenario 7: Significantly Increase Thinning and Increased Emphasis on Silviculture (Multi-Dial Scenario)

This scenario includes the following components:

Significantly Increase Thinning

Refer to the description under Scenario 2.

Increased Emphasis on Silviculture

This component is designed to increase the growth of forests through more intensive silvicultural practices.

- **Seed and seedling improvement:** Across state trust lands, about 60 percent of the seedlings that DNR plants are grown from improved seed stock. Improved seeds are gathered from orchard trees that have performed well in field testing across a wide range of environments. This scenario would increase the percentage of improved seedlings to 80 percent.

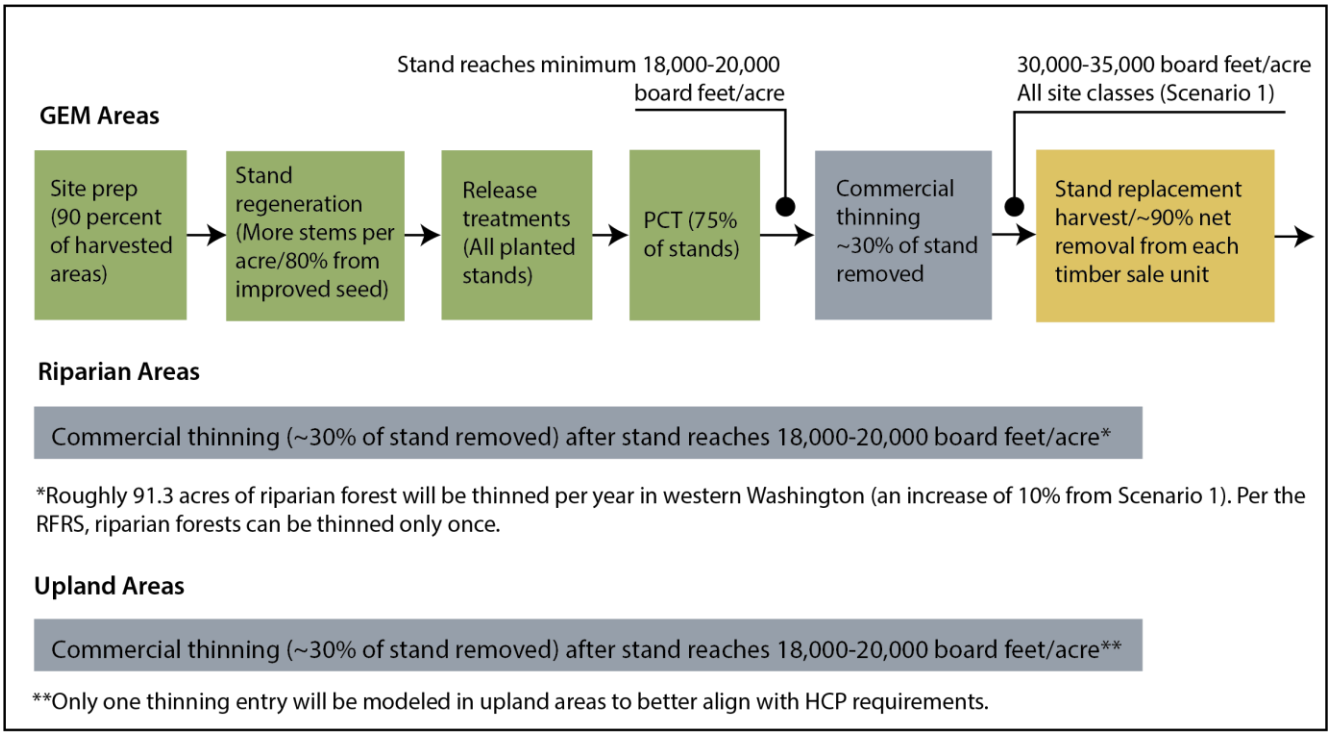
- **Planting density:** Vary planting density by species and site. Trees per acre are as follows:
  - Coastal, low-elevation sites: 520 western hemlock
  - Low-elevation sites near coast: 260 Douglas-fir, 260 western hemlock
  - Mixed species stands and low-elevation sites away from coast: 383 Douglas-fir, 33 western hemlock, 20 western redcedar
  - High-elevation sites: 572 noble fir

  These planting densities are roughly 30 percent higher than current practices. Note that all sites will experience infill from natural regeneration.

- **Site preparation**: Increase site preparation from 75 to 90 percent of planted acres in GEM areas. Site preparation enhances seedling survival and growth through removal of competing vegetation. It also makes the site easier to plant.
- **Release treatment:** Increase release treatments from 75 to 100 percent of planted stands in GEM areas. Release treatments involve the removal of competing vegetation through mechanical or chemical means.
- **PCT**: Conduct PCT on 75 percent of stands in GEM areas. Each thinning would leave roughly 350 to 465 stems per acre, if a commercial thinning is desired.

Refer to Figure B-12 for a simplified schematic of this scenario.

Figure B-12. Simplified schematic of Scenario 7.



Scenario 8: Shorten Harvest Rotation, Significantly Increase Thinning, and Increased Emphasis on Silviculture (Multi-Dial Scenario)

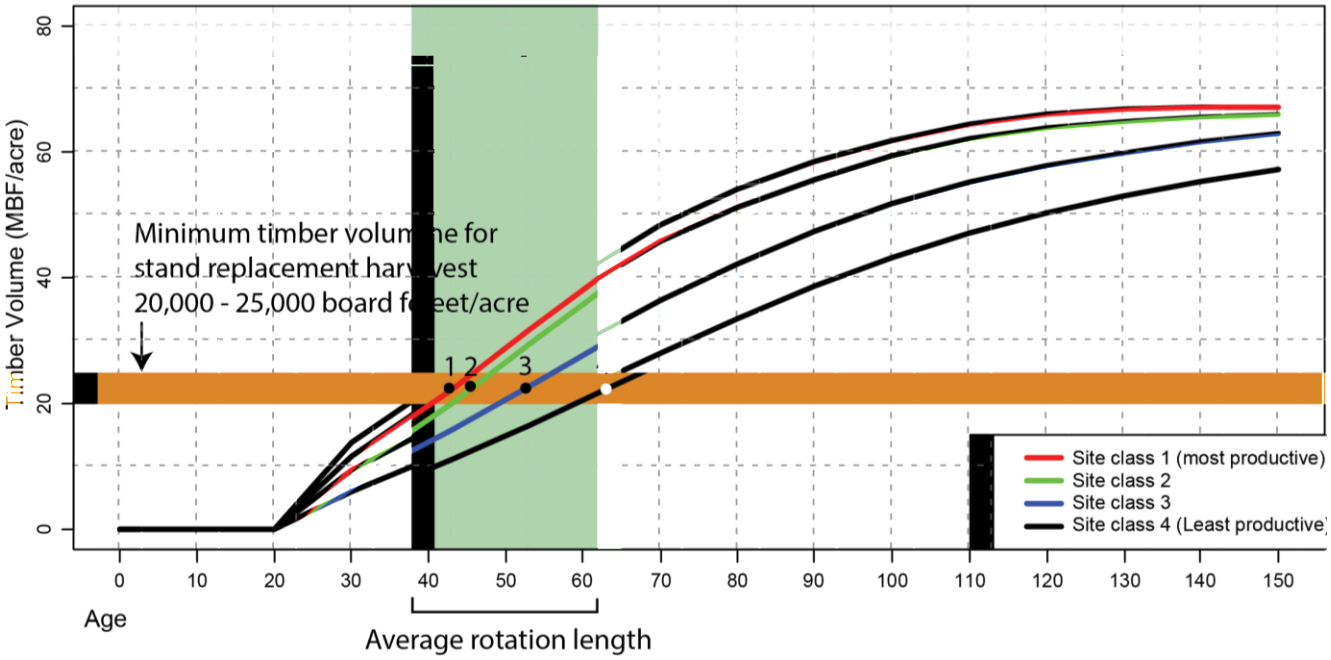
This scenario includes the following components:

Shorten Harvest Rotation

Refer to description under Scenario 3. Refer to Figure B-13 for a sample yield curve.

Figure B-13. Sample Douglas-fir yield curve for western Washington showing the relationship between minimum timber volume and stand age for Scenario 8.

Yield curve generated from DNR inventory plots and stratified using information from DNR's inventory. Yield curve does not reflect the potential impact that commercial thinning may have on rotation length.



Increased Emphasis on Silviculture

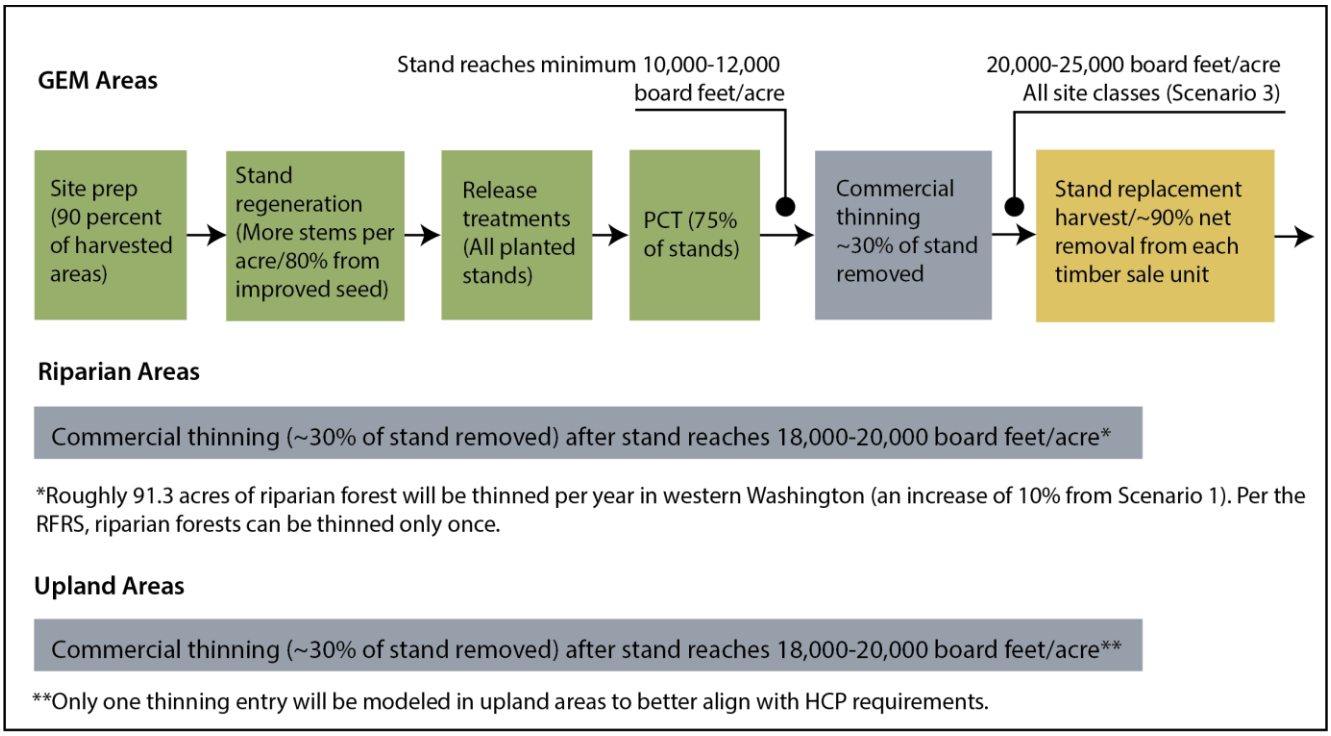
Refer to description under Scenario 7.

Significantly Increase Thinning

Refer to the description under Scenario 2. Note that for this scenario only, the minimum harvest volume for a thinning in GEM areas has been reduced from 18,000 to 20,000 board feet per acre

to 10,000 to 12,000 board feet per acre based on work group feedback. Refer to Figure B-14 for a simplified schematic of this scenario.

Figure B-14. Simplified schematic of Scenario 8.



Appendix C: Site Class

In general ecological management (GEM) areas, most state trust lands in western Washington (79%) are Site Class 2 or 3:

- Site Class 1: 5%
- Site Class 2: 41%
- Site Class 3: 38%
- Site Class 4: 12%
- *Site Class 5 and 6: 4%*

In the scenarios, DNR did not specify rotation lengths for Site Class 5 or 6 because there are few acres on the landscape and the growing conditions are poor. These sites tend to have glacial till, glacial drift over bedrock, or gravel alluvium, and are rarely productive enough to actively manage for timber harvest.