Carbon and Forest Management Work Group

Adopted Scenarios

Part 1: Introduction

This document describes the eight forest management scenarios that the Carbon and Forest Management Work Group has selected for carbon and economic impact modeling.

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

All scenarios modify specific elements of DNR's current management. For example, some scenarios increase thinning, some lengthen or shorten harvest rotations, some defer additional areas from harvest, and some increase the amount of silvicultural treatments, such as site preparation and release treatments, that DNR performs on state trust lands.

The first four scenarios were selected at the March 10 work group meeting:

- **Scenario 1** represents DNR's current management.
- **Scenarios 2 through 4** are "single dial" scenarios that change one aspect of DNR's current management. Single dial scenarios help the work group isolate the influence of a single change in management.

Scenarios 5 through 8 were selected at the May 8 work group meeting. All four of these scenarios are "multi-dial" scenarios because they change multiple elements of DNR's management. These scenarios have been renumbered for ease of reporting in the next step of the project.

Table 1 shows all 8 scenarios, their components, and the number they had at the time of voting.

Table 1. Scenarios.

Scenario number	Component (s)			Original number
1	DNR current operations			1
Single-dial scenarios				
2	Lengthen harvest rotation			2
3	Shorten harvest rotation			3
4	Significantly increase thinning			4
Multi-dial scenarios				
5	Lengthen harvest rotation	Significantly increase thinning		8
6	Lengthen harvest rotation	Significantly increase thinning	Increase deferrals	10
7	Increased emphasis on Silviculture	Significantly increase thinning		11
8	Increased emphasis on silviculture	Significantly increase thinning	Shorten harvest rotation	16

Part 2: Scenario Descriptions

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 and structurally complex forest can be found in the appendices.

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, on average, over the past 10 years. 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 large 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 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.

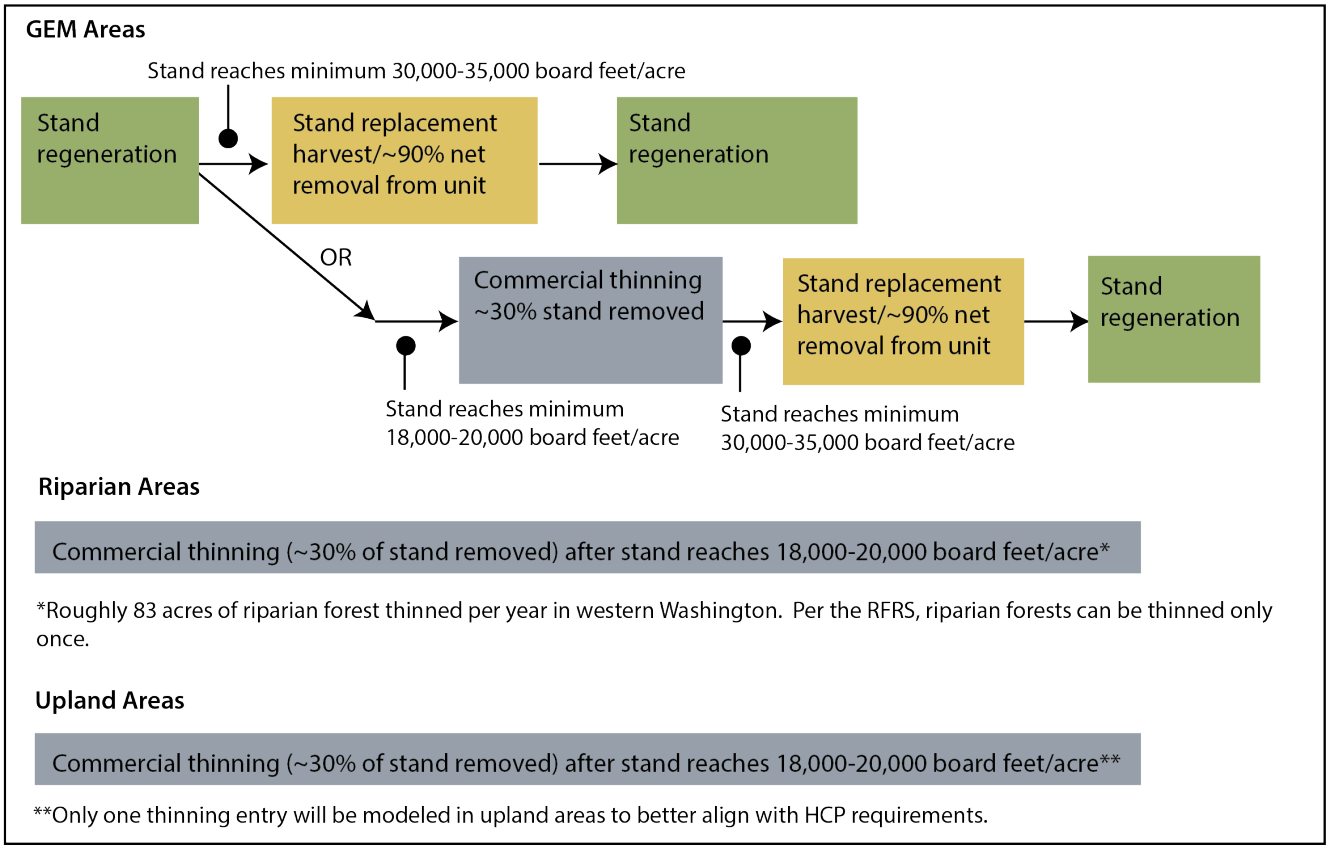
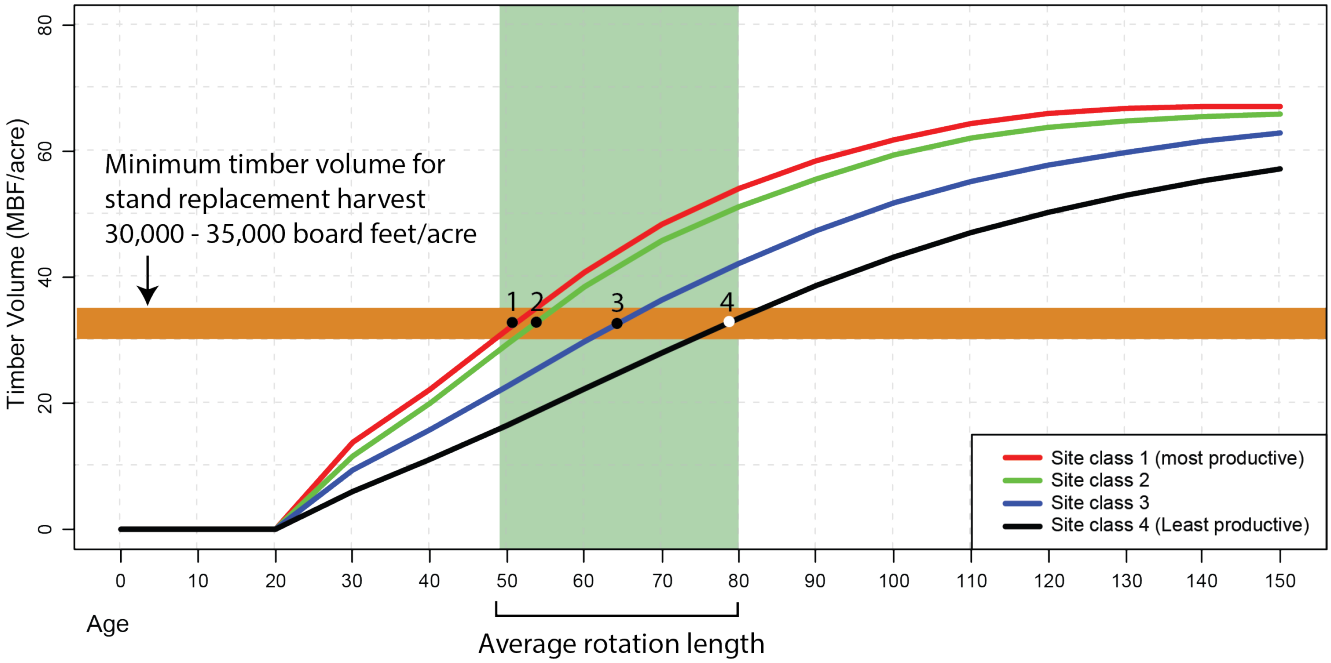


Figure B-1. Simplified schematic of DNR current management.

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 RSFRIS 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.

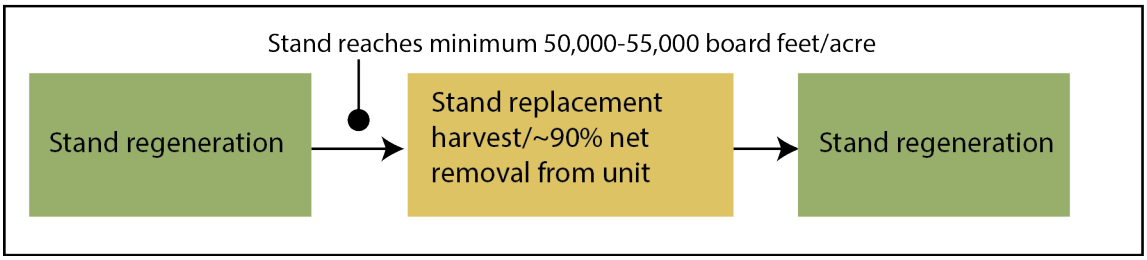
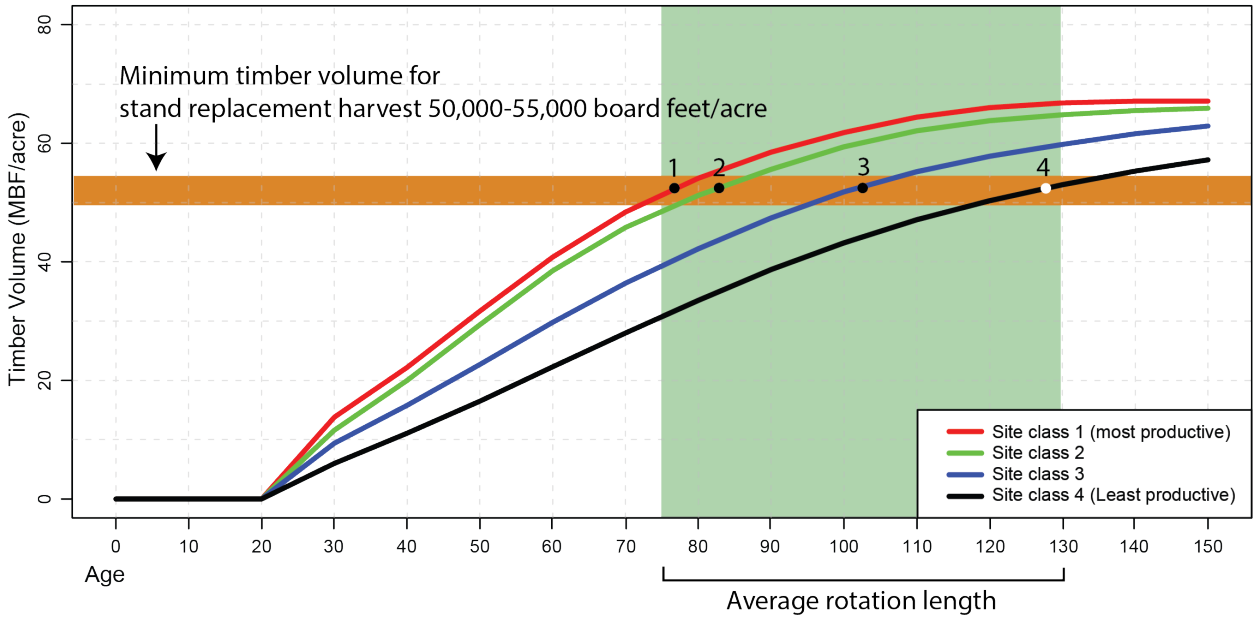


Figure B-3. Simplified schematic of Scenario 2.

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 RSFRIS 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.

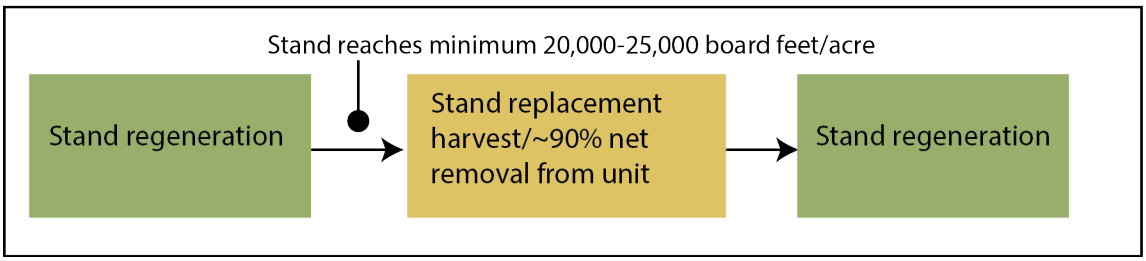
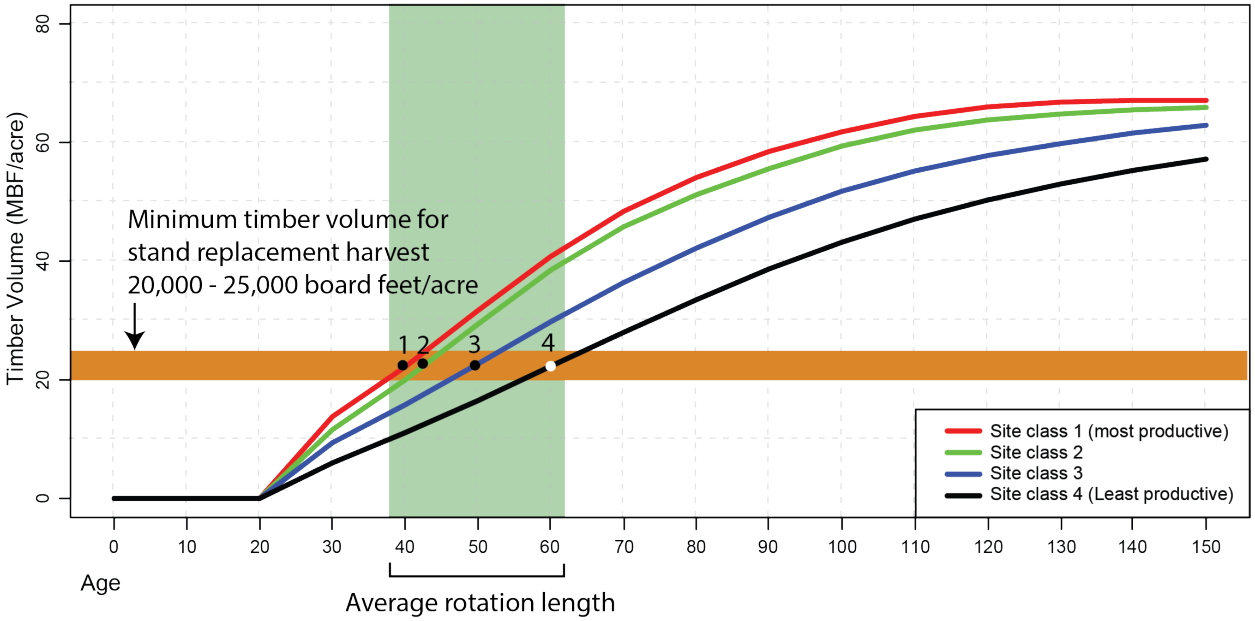


Figure B-5. Simplified schematic of Scenario 3.

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 RSFRIS 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 large 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 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.

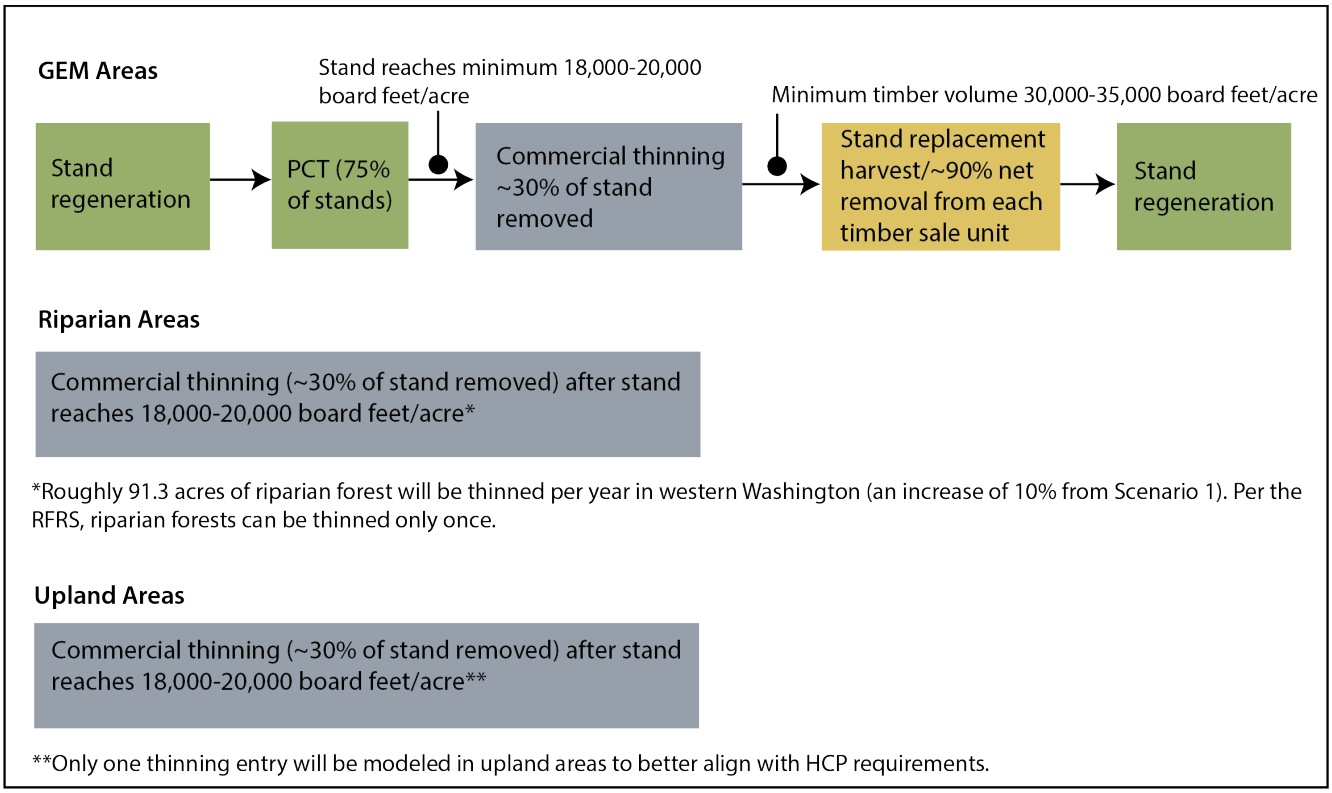


Figure B-7. Simplified schematic of Scenario 4.

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

This scenario includes the following components:

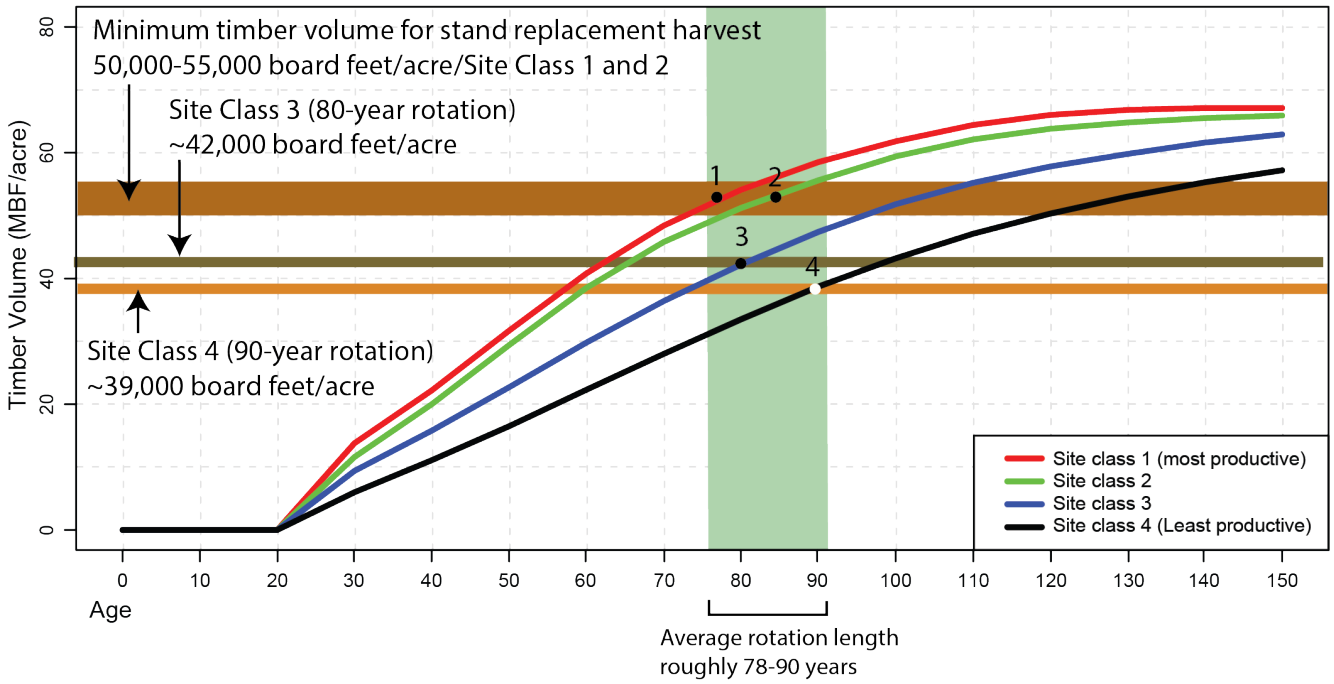
Lengthen Harvest Rotation

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, 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 RSFRIS 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.

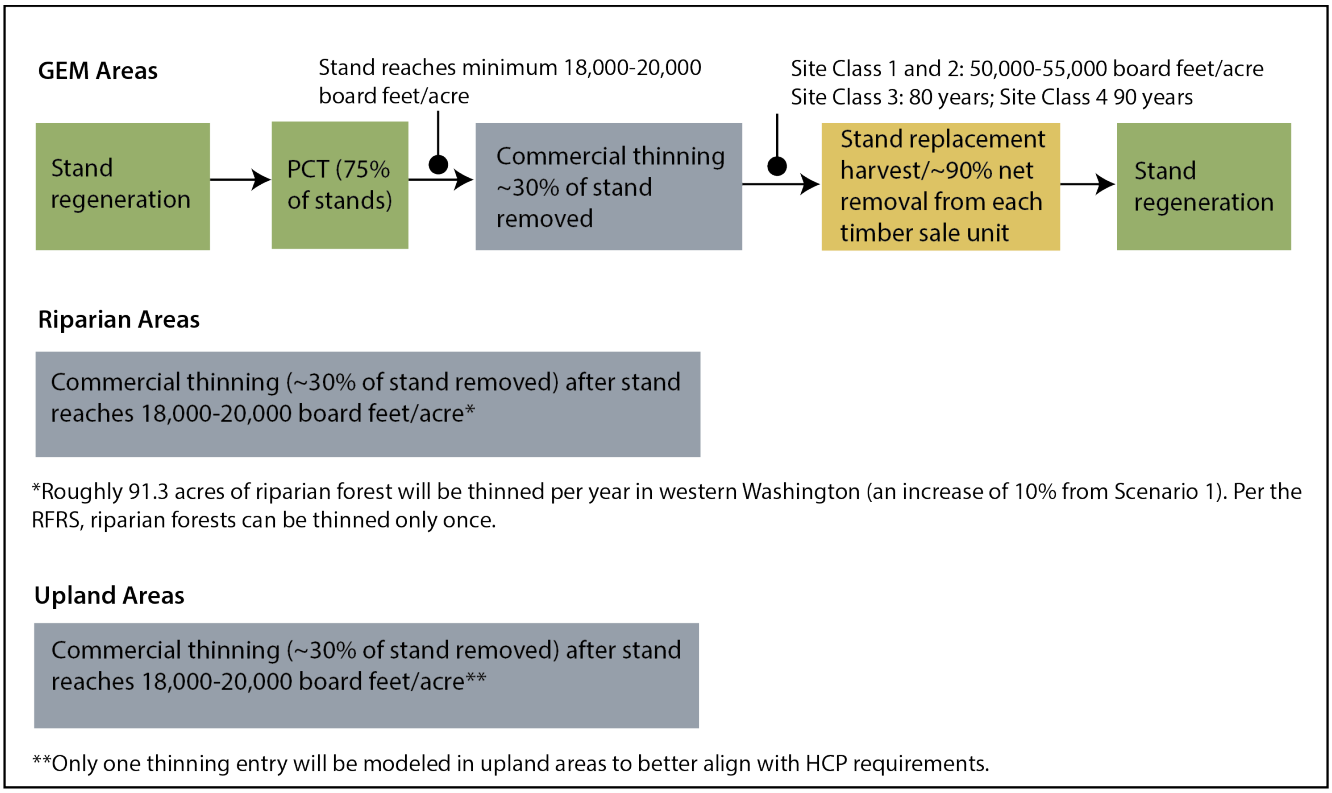


Figure B-9. Simplified schematic of Scenario 5.

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

This scenario includes the following components:

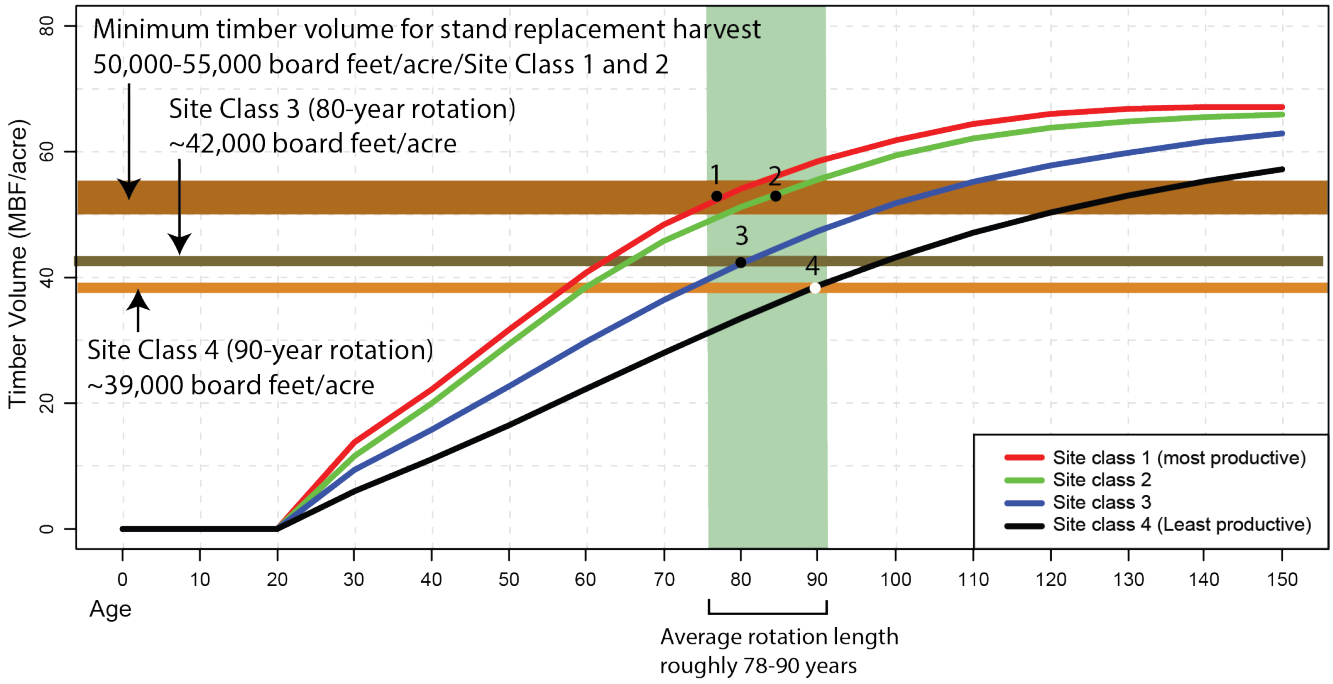
Lengthen Harvest Rotation

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 RSFRIS 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.

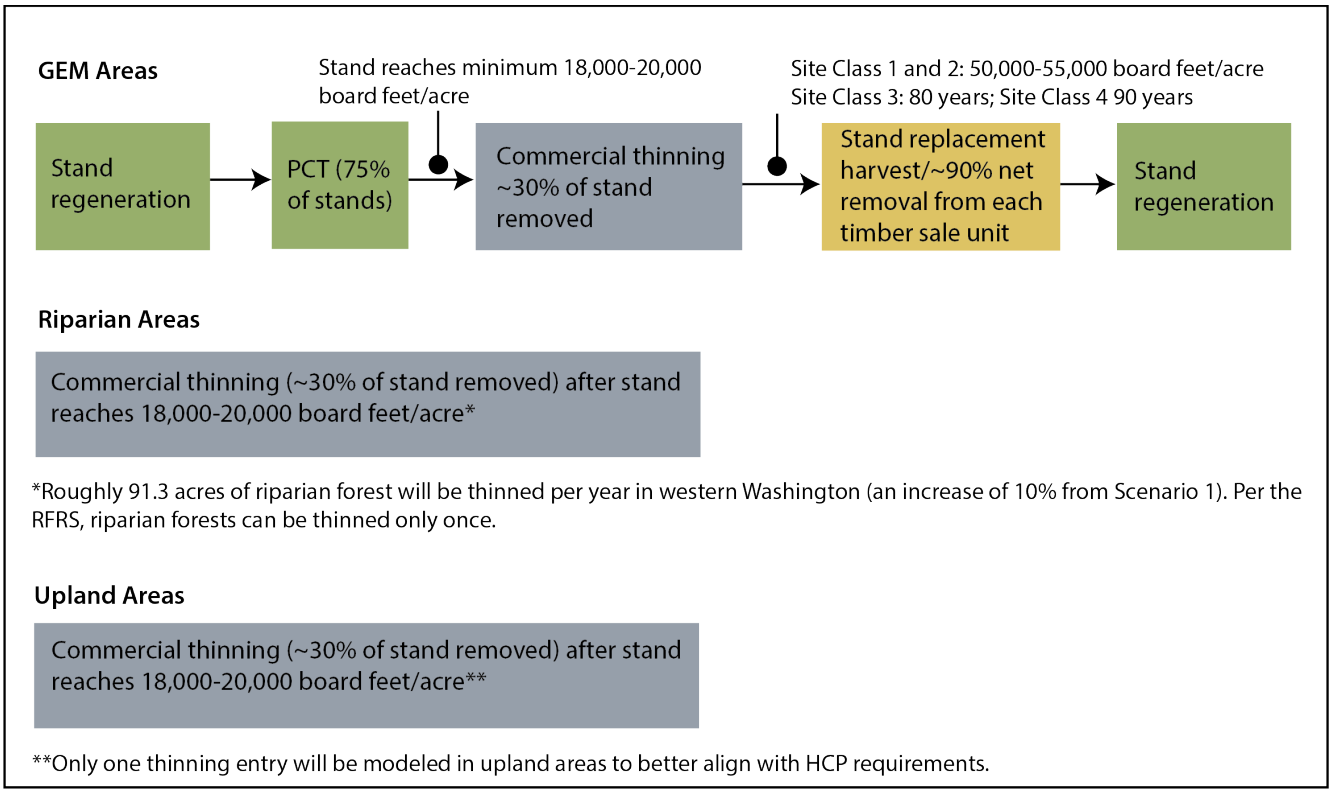


Figure B-11. Simplified schematic of Scenario 6.

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*[1]. 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[2], "The maturation stage typically begins at 80-100 years and may persist for 100-150 years in naturally regenerated Douglas-fir stands."

[1] 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.

[2] 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.

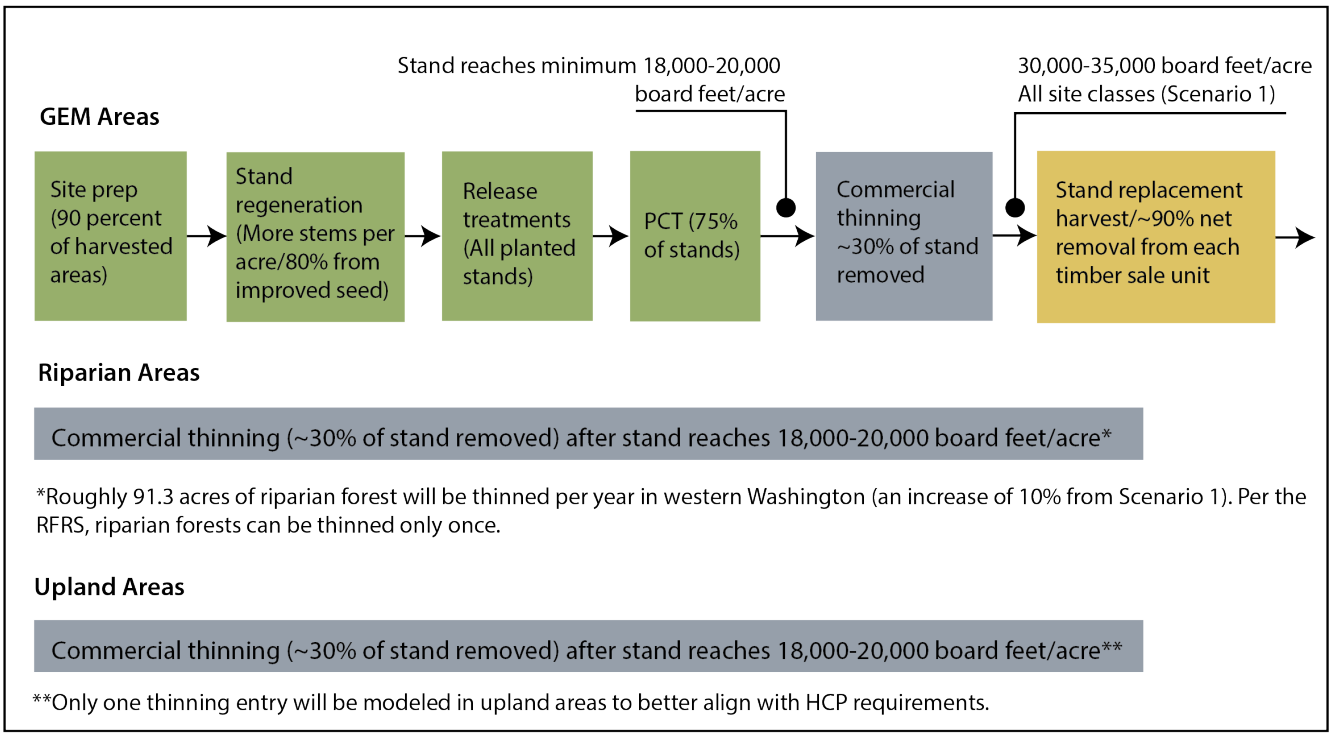


Figure B-12. Simplified schematic of Scenario 7.

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

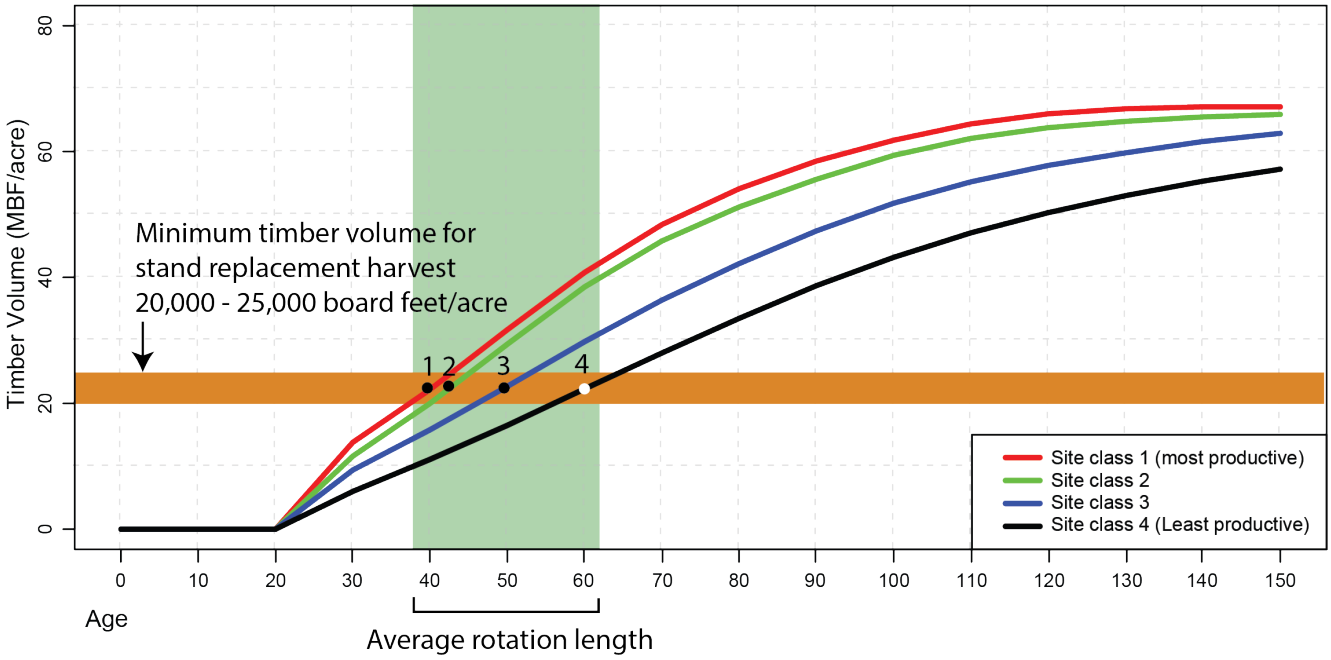
This scenario includes the following components:

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 RSFRIS 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.

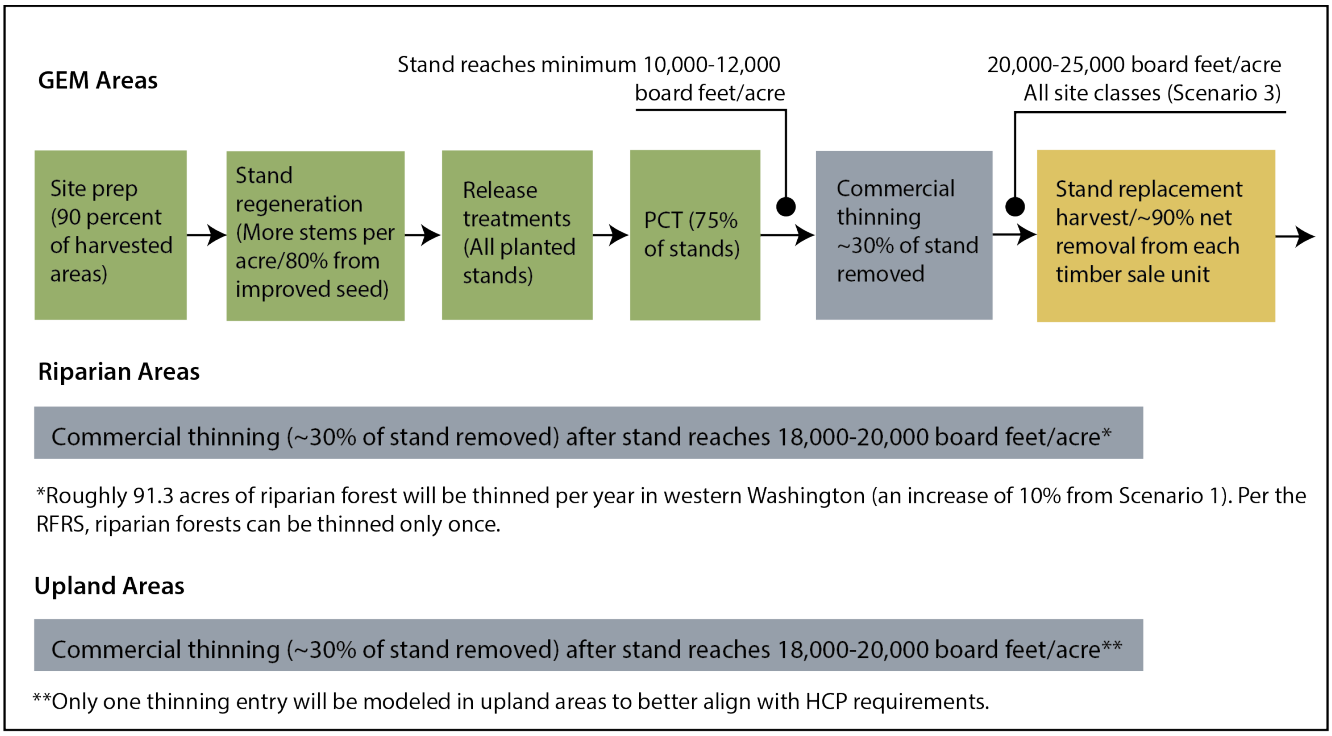


Figure B-14. Simplified schematic of Scenario 8.

Appendix A: Structurally Complex Forest

For the purposes of scenario development for the Carbon and Forest Management Work Group, DNR will use the definition of structurally complex stand in its 2006 *Policy for Sustainable Forest (Appendix C)*:

> 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.[3]

The Policy for Sustainable Forests uses stand development terms from the booklet *Identifying Mature and Old Forests in Western Washington* by Robert Van Pelt. These terms are different than the terms DNR used in the December 2023 work group meeting, which are based on a different stand classification system. Refer to the table below for a crosswalk between these terms and the general characteristics of each stage.

Term used in December 2023 work group meeting (based on Franklin et al. 2002.)[4]	**Term used in Van Pelt guide and the *Policy for Sustainable Forests* (based on Carey and Curtis 1996.)[5]**	**Characteristics**
Maturation II	Botanically diverse	Small gaps begin to form from natural disturbances such as wind, resulting in a understory developing with different tree species growing into the lower and middle tree (mid-story) canopy. Large pieces of down woody material (fallen trees) and large snags (standing dead trees) are few or absent in the stand.
Vertical diversification	Niche diversification	The lower and mid-story tree canopies have diversified, with more tree species and a greater range in tree diameters. The amount of large down woody material and number of snags has increased.
Horizontal diversification	Fully functional	The original trees from stand initiation are dying out more rapidly, resulting in abundant snags, large pieces of down woody material, and larger gaps in the

[3] This is the only definition of structurally complex forest recognized by DNR.

[4] Franklin, J.F., Spies, T.A., Van Pelt, R., Carey, A.B., Thornburgh, D.A., Berg, D.R., Lindenmayer, D.B., Harmon, M.E., Keeton, W.S., Shaw, D.C. and Bible, K., 2002. Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. *Forest ecology and management*, *155*(1-3), pp.399-423.

[5] Carey, A.B. and Curtis, R.O., 1996. Conservation of biodiversity: a useful paradigm for forest ecosystem management. *Wildlife Society Bulletin*, *24*(4), pp.610-620.

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Term used in December 2023 work group meeting (based on Franklin et al. 2002.)[4]	Term used in Van Pelt guide and the *Policy for Sustainable Forests* (based on Carey and Curtis 1996.)[5]	Characteristics
		upper tree canopy. Shade-tolerant trees have reached the upper tree canopy.

On the following page is a table that shows the stand development stages definitions to be used in modeling (botanically diverse, niche diversification, and fully functional).

Table A1. Stand development stage defintions to be used in modeling

Stages			Stand-level Variable and Associated Threshold Value									
							Management Activity					
Summarized	Detailed		QMD	Canopy Layer	RD	Stand Age	BioThin Age	Years Since BioThin	Thin Age	Years Since Thin	Snag Ratio1	CWD
Ecosystem Initiation	Ecosystem Initiation		<2									
Competitive Exclusion	Sapling Exclusion		>=2									
	Pole Exclusion		>5									
		or							>0	>=0		
	Large Tree Exclusion		>11									
		or	>11						>0	>=0		
	Understory Development		>=2	>1								
		or	>=2		>=MaxRD							
		or	>=2			>MaxRD Age						
		or	>=2				>0	>=0				
Structually Complex	Botanically Diverse		>=2	>1								
		or	>=2	>1		>=MaxRD Age+60						
		or	>=2	>1			>0	>=0				
		or	>=2	>1	>=MaxRD							
		or	>=2		>=MaxRD	>=MaxRD Age+60						
		or	>=2		>=MaxRD		>0	>=0				
		or	>=2			>=MaxRD Age+60	>0	>=0				
		or	>=2				>0	>5				
		or	>=2	>1		>MaxRD Age						
		or	>=2			>=MaxRD Age+60						
		or	>=2			>MaxRD Age	>0	>5				
	Niche Diveris-ification		>=2	>1		>=MaxRD Age+80					>0.07	>2400
		or	>=2	>1		>=MaxRD Age+80	>0	>0				
		or	>=2	>1			>0	>5				
		or	>=2		>=MaxRD	>=MaxRD Age+80					>0.07	>2400
		or	>=2		>=MaxRD	>=MaxRD Age+80	>0	>0				
		or	>=2		>=MaxRD		>0	>5				
		or	>=2			>=MaxRD Age+80					>0.07	>2400
		or	>=2			>=MaxRD Age+80	>0	>0				
		or	>=2			>MaxRD Age	>0	>5				
		or	>=2			>=MaxRD Age+80	>0	>=0			>0.07	>2400
		or	>=2			>=MaxRD Age+80	>0	>0				
		or	>=2				>0	>5			>0.07	>2400
	Fully Functional		>=2	>1		>=MaxRD Age+160					>0.07	>2400
		or	>=2	>1		>=MaxRD Age+160	>0	>0				
		or	>=2	>1			>0	>40				
		or	>=2		>=MaxRD	>=MaxRD Age+160					>0.07	>2400
		or	>=2		>=MaxRD	>=MaxRD Age+160	>0	>0				
		or	>=2		>=MaxRD		>0	>40				
		or	>=2			>=MaxRD Age+160					>0.07	>2400
		or	>=2			>=MaxRD Age+160	>0	>0				
		or	>=2			>MaxRD Age	>0	>40				
		or	>=2			>=MaxRD Age+160	>0	>=0			>0.07	>2400
		or	>=2			>=MaxRD Age+160	>0	>0				
		or	>=2				>0	>40			>0.07	>2400

Appendix B. 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 "low" sites tend to have glacial till, glacial drift over bedrock, or gravel alluvium, and are rarely productive enough to actively manage for timber harvest.