

# Appendix C

## Modeled Silviculture Regimes

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## Introduction

Specific goals of Mendocino Redwood Company (MRC) include increasing the size and age of the inventory, improving the conifer stocking ratios with respect to hardwoods, and promoting larger trees and dense canopy closure in watercourse buffers. The following descriptions of Mendocino Redwood Company silviculture policies and modeling logic used to simulate Mendocino Redwood Company policy provide the rationale for applying a specific regime to a stand, as well as the logic used to trigger a silvicultural event and provide for retention. The logic included in the following regime descriptions was used in the modeling methodology to calculate Maximum Sustained Production (MSP).

The development of the logic used in the modeling scenarios considered the California Forest Practice Rules and Mendocino Redwood Company policies. Mendocino Redwood Company policies for silviculture retention meet, and usually exceed, silviculture retention standards stated in the California Forest Practice Rules. A description of Mendocino Redwood Company's silvicultural prescriptions, policies for silviculture triggers, and silviculture retention standards are included in Tables 1, 2, and 3 respectively. MRC foresters are expected to follow the company policies. When exceptions to these policies are sought due to site-specific conditions, a full explanation will be provided in the Timber Harvest Plan (THP).

Following the MRC silvicultural policy tables are the descriptions of how these policies were modeled. Modeled conifer basal area retention standards exceed minimum standards in the California Forest Practice Rules for every modeled regime. The model logic is intended to be unambiguous and fit as closely as possible the silvicultural policies of Mendocino Redwood Company.

A stand is considered for inventory and modeling purposes as a unit of vegetation with similar vegetation features. A quantitative representation of the stand is produced by measuring forest stand variables through field sampling (described in Appendix A). The data obtained from field sampling varies, sometimes widely, between plots. Forest stand conditions, such as trees per acre, timber volume, and basal area are usually defined in terms of the average conditions of the stand. The logic used for assigning silviculture regimes to stands evaluates the quantified representation of the stand in terms of the stand's averages.

The implementation of the silviculture logic developed for modeling, including retention and vegetation management assumptions, is expected to vary among stands in timber harvest plans. Existing field conditions may warrant variance from the standards applied in the modeling activities, in order to meet the overall objectives of Mendocino Redwood Company's silviculture policies. The retention standards identified for the regimes should be considered as an average applied to stands. Some stands will have higher retention values than those specified in the silviculture logic, some will have lower retention values. The average will be at, or above the retention standards specified in the silviculture regimes. Since both pre-harvest and post-harvest stands can be quantified, updating post-harvest stands is expected to be an important monitoring tool for testing compliance with Mendocino Redwood Company silviculture policies.

Table 1. Silviculture descriptions and cross reference to the California Forest Practice Rule silviculture descriptions.

<b>Descriptions of Different Silvicultural Harvest Prescriptions Used by MRC</b>		
<b>Prescription</b>	<b>Description</b>	<b>California Forest Practices Rules Ref. and Label</b>
<b>Uneven-Aged Management</b>		
Single Tree Selection	To establish and maintain multi-storied, uneven-aged stands of redwoods and Douglas-fir by harvesting individual trees more or less uniformly throughout the stand. Provides space for growth of remaining trees and space for growth of new trees.	913.2(a)(2)(A) "Selection System"
Group Selection (Conifer & Mixed)	To establish and maintain multi-storied, uneven-aged stands of redwoods and Douglas-fir by harvesting trees in small (< 2.5 acre) groups. Width of groups is commonly twice tree height of surrounding mature trees to maintain forest influence.	913.2(a)(2)(B) "Group Selection"
High Retention Selection	To accelerate stand development of large trees and closed canopy by harvesting individual trees targeted to result in the growth of larger trees and to create and maintain special habitat elements such as decadent trees, snags, and downed logs.	913.2(a)(2)(A) "Selection System"
Commercial Thinning	To promote timber growth, increase average stand diameter, and improve forest health by the removal of trees in a manner that results in a stand with two or three distinct canopy layers.	913.3(a) "Commercial thinning"
Transition	To develop an uneven-aged stand from an even-aged stand or a stand with unbalanced or irregular stocking. Involves removal of trees individually or in small groups to create a balance of different stand structure and natural reproduction.	913.2(b) "Transition"
<b>Even-Aged Management</b>		
Variable Retention	To rotate stands with poorly stocked conifer volume and relatively high volumes of hardwood, dispersed and/or aggregated retention of 10% to 40% or more of the existing stand to provide for vigorous growth of remaining stand combined with pockets of undisturbed trees to provide for ecological functionality, habitat structure, and forest complexity.	913.6 "Alternative Prescription" "AP/Clearcut"
Seed Tree Removal Step	This step harvests a portion of the seed trees left in an earlier entry and after a fully stocked stand of regenerated trees has become established.	913.1(c)(2) "Seed Tree Removal Step"
Shelterwood Removal Step	This step harvests a portion of the overstory of trees left in an earlier entry for wind and soil stability and after a fully stocked stand of regenerated trees has become established.	913.1(d)(3) "Shelterwood Removal Step"
Rehabilitation	To rehabilitate poorly stocked conifer stands experiencing excessive hardwood competition and allow for site prep and conifer regeneration and transition into well-stocked stand of conifers.	913.4(b) "Rehabilitation"

Table 2. Mendocino Redwood Company Trigger Condition **Policies** for Silviculture Regimes.

Targeted Pre-Harvest Conditions on MRC Forestlands				
Prescription	Species	Pre-Harvest Conifer Basal Area (Feet Squared per Acre)		Other Key Pre-Harvest Factors
Uneven-Aged Management		Lower Limit	Upper Limit	
Single Tree Selection	Conifer/Mixed	120	None	
Group Selection	Conifer	120	None	20% of the Stands' Area May Meet Stocking Standards Using the Point Count Method. The Remaining 80% Must Meet the Pre-Harvest Basal Area Trigger (120 sf per acre).
Group Selection	Mixed	90	None	Hardwood basal area greater than 50 sf/acre. 20% of the Stands' Area May Meet Stocking Standards Using the Point Count Method. The Remaining 80% Must Meet the Pre-Harvest Basal Area Trigger (120 sf per acre).
High Retention Selection	Conifer/Mixed	260	None	Basal Area Present for 70% Absolute Canopy Cover
Commercial Thinning	Conifer	120	None	Will Not Be Applied to a Stand That Has Been Selectively Harvested Within 10 Years
Transition	Conifer/Mixed, Mixed/Hardwood	60	100	
Even-Aged Management*				
Variable Retention	Mixed	25	135	Greater Than 60 sf ba/acre Hardwoods**
Seed Tree Removal	Conifer/Mixed	15	50***	Regeneration @ 300 Point Count
Shelterwood Removal	Conifer/Mixed	25	100***	Regeneration @ 300 Point Count
Rehabilitation	Mixed/Hardwood	None	50	Less than 300 point count. Greater Than 50 sf ba/acre Hardwoods
<p>Note: These recommended silvicultural harvest prescriptions are expected to result over time in an increase in more mature forest types, which is the goal of MRC. If a forester determines that a different silvicultural prescription would better achieve the goals of MRC, then that prescription can be used after consultation with the Chief Forester, Forestlands Manager, or Stewardship Director.</p> <p>* The majority of even-aged management is used in hardwood dominated stands to rotate the stands back to planted conifers.</p> <p>** Due to the variability of hardwood inventory across MRC's forest lands, the pre-harvest hardwood basal area may vary as much as 30% for this prescription.</p> <p>*** Pre-dominant conifer basal area.</p>				

Table 3. Mendocino Redwood Company Stocking, Retention, and Re-entry Policies.

<b>MRC Targets For Stocking, Retention and Re-entry Specifications</b>			
<b>Silviculture</b>	<b>Post Harvest Stocking Levels</b>	<b>Retention Conifer Basal Area (Square Feet of Basal Area per Acre)</b>	<b>Time before next harvesting activities</b>
<b>Uneven-Aged Management</b>			
Single Tree Selection	All Age, evenly distributed	Greater Than 90 sf ba if Pre-Harvest Stocking is Less Than 220 sf ba; Greater Than 140 sf ba if Pre-Harvest Stocking is Greater Than 220 sf ba	At Least 10 Years
Group Selection (Conifer)	Less Than 20% of Pre-Harvest Stand in Clearings	Greater Than 90 sf ba if Pre-Harvest Stocking is Less Than 220 sf ba; Greater Than 140 sf ba if Pre-Harvest Stocking is Greater Than 220 sf ba	At Least 10 Years
Group Selection (Mixed)	Less Than 20% of Pre-Harvest Stand in Clearings	Greater Than 90 sf ba if Pre-Harvest Stocking is Less Than 220 sf ba; Greater Than 140 sf ba if Pre-Harvest Stocking is Greater Than 220 sf ba	At Least 10 Years
High Retention Selection	Greater Than 70% Absolute Canopy Closure, Six Trees At Least 32" dbh or Greater Per Acre, If LWD Deficient, then Permanent Retention per Operating Policy	Greater Than 200 sf ba and Greater Than 75% sf ba of Pre-Harvest Stand	At Least 15 Years
Commercial Thinning	Equal to or Greater Average Tree Diameter Than in Pre-Harvest Stand	> 110 sf ba	Transition to Selection 10-20 Years
Transition	Less Than 20% of Pre-Harvest Stand in Clearings	> 50 sf ba	Transition to Selection 20-30 Years
<b>Even-Aged Management</b>			
Variable Retention	10% to 40% or More Pre-Harvest Acreage in Permanent or Rolling Retention in Representative Forest	Approximately 10% to 40% Depending on the Acreage Retention	Transition to Selection 30-60 Years
Seed Tree Removal Step	10% to 40% or More Pre-Harvest Acreage in Permanent or Rolling Retention in Representative Forest	Greater Than 10 sf ba, if Pre-Harvest Stocking is Less Than 75 sf ba; Greater Than 50 sf ba if Pre-Harvest Stocking is Greater Than 75 sf ba	Transition to Selection 30-60 Years
Shelterwood Removal Step	10% to 40% or More Pre-Harvest Acreage in Permanent or Rolling Retention in Representative Forest	Greater Than 10 sf ba, if Pre-Harvest Stocking is Less Than 75 sf ba; Greater Than 50 sf ba if Pre-Harvest Stocking is Greater Than 75 sf ba	Transition to Selection 30-60 Years
Rehabilitation	10% to 40% or More Pre-Harvest Acreage in Permanent or Rolling Retention in Representative Forest	> 10 sf ba Where Conifer > 10 sf ba Pre-Harvest	Transition to Selection 30-60 Years

## HIGH RETENTION SELECTION MODEL LOGIC

**Description** The goal of this regime is to create and maintain dense, multistoried, uneven-aged stands with a variety of diameter classes. The regime is considered for stands with 50% or more of the stand's overall basal area in trees greater than 16". The regime is applied to sensitive areas, such as watercourse buffers.

**Timing Options** The regime is available for harvest throughout the planning horizon. The minimum re-entry period is 20 years.

**Trigger Conditions** Stands must have a minimum of 260 square feet of conifer basal area per acre to be selected for harvest. The regime is considered for conifer-dominated stands and mixed conifer and hardwood stands. This simulates a canopy closure of at least 70% and a presence of large trees (6 trees 32" DBH or greater). No harvest can occur within a size class unless the following minimum conifer basal area is present in the stand:

First Condition for Harvest	Minimum Total Conifer Basal Area for Harvest Within Stand	
	260 square feet per acre	
Size Class	Stand Size	Minimum Conifer Basal Area for Harvest Within Size Class
2	8 – 16"	51 square feet per acre
3	16 – 24"	51 square feet per acre
4	24 – 32"	51 square feet per acre
5	>32"	51 square feet per acre

Hardwood harvest is triggered if hardwood basal area exceeds 30 square feet of basal area per acre.

**Residual Stand Conditions** Minimum retention of conifer basal area for this regime is 200 square feet per acre. The minimum retention of conifer basal area is, by size class:

Size Class	Stand Size	Minimum Conifer Basal Area Retention by Size Class
2	8 – 16"	50 square feet per acre
3	16 – 24"	50 square feet per acre
4	24 – 32"	50 square feet per acre
5	>32"	50 square feet per acre

The retention basal area for any size class may be less than desired if the pre-harvest stand did not have the minimum retention. If hardwoods are harvested, retention is 15% of the conifer retention, or 30 square feet of basal area per acre.

**Regeneration Assumptions** Natural regeneration and planted seedlings are assumed for this regime. The growth model assumes that post-harvest stands are regenerated with 40 seedlings per acre. The assumed regeneration mimics the species composition of the pre-harvest stand by determining the proportion of redwood trees and Douglas-fir trees present in the pre-harvest stand and assigning the same proportion to the seedlings. The small trees 'grow' in the model with a small tree modeling routine which adds 1 foot height growth per year until the tree achieves 10 feet in height, upon which the trees are assumed to have a DBH of 4". These trees are then grown in the FREIGHTS growth model where the trees are subject to competition and mortality.

**Vegetation Control Assumptions** No vegetation control is modeled with this regime.

### **SELECTION (Low Hardwood Competition) MODEL LOGIC**

**Description** The goal of this regime is to create and maintain continuous cover of multistoried, uneven-aged forested vegetation on the ownership. The regime is applied to stands that are not experiencing a high level of hardwood competition. The regime is designed to develop and maintain a variety of diameter classes.

**Timing Options** The regime is available for harvest throughout the planning horizon. The minimum re-entry period is 10 years.

**Trigger Conditions** Stands must have a minimum of 120 square feet of conifer basal area per acre to be selected for harvest. The regime is considered for both conifer-dominated stands and mixed conifer and hardwood stands. No harvest can occur within a size class unless the following minimum conifer basal area is present within the stand:

First Condition for Harvest	Minimum Total Conifer Basal Area for Harvest Within Stand	
	120 square feet per acre	
Size Class	Stand Size	Minimum Conifer Basal Area for Harvest Within Size Class
2	8 – 16"	31 square feet per acre
3	16 – 24"	31 square feet per acre
4	24 – 32"	31 square feet per acre
5	>32"	31 square feet per acre

Hardwood harvest is triggered if hardwood basal area exceeds 15 square feet of basal area per acre.

**Residual Stand Conditions** Minimum conifer retention for this regime is, by size class:

Size Class	Stand Size	Minimum Conifer Basal Area Retention by Size Class
2	8 – 16"	30 square feet per acre
3	16 – 24"	30 square feet per acre
4	24 – 32"	30 square feet per acre
5	>32"	30 square feet per acre

If hardwoods are harvested, retention is 15% of the conifer retention, or 18 square feet of basal area per acre.

**Regeneration Assumptions** Natural regeneration and planted seedlings are assumed for this regime. The growth model assumes that post-harvest stands are regenerated with 50 seedlings per acre. The assumed regeneration mimics the species composition of the pre-harvest stand by determining the proportion of redwood trees and Douglas-fir trees present in the pre-harvest stand and assigning the same proportion to the seedlings. The small trees 'grow' in the model with a small tree modeling routine which adds 1 foot height growth per year until the tree achieves 10 feet in height, upon which the trees are assumed to have a DBH of 4". These trees are then grown in the FREIGHTS growth model where the trees are subject to competition and mortality.

**Vegetation Control Assumptions** No vegetation control is associated with this regime.

### **SELECTION (High Hardwood Competition) MODEL LOGIC**

**Description**

The goal of this regime is to create and maintain continuous cover of multistoried, uneven-aged forested vegetation on the ownership. The regime is applied to stands experiencing a high level of hardwood competition. The conifer basal area trigger is lower than for the other silviculture regimes in order to enter stands for the purpose of reducing hardwood competition. The regime is designed to develop and maintain a variety of diameter classes.

**Timing Options**

The regime is available for harvest throughout the planning horizon. The minimum re-entry period is 10 years.

**Trigger Conditions**

Stands must have a minimum of 90 square feet of conifer basal area per acre and a maximum of 120 square feet of conifer basal area per acre. Also, stands must have between 50 and 80 square feet of hardwood basal area per acre to be selected for harvest. The regime is considered for mixed conifer and hardwood stands. No harvest can occur within a size class unless the following minimum conifer basal area is present within the stand:

First Condition for Harvest	Minimum Total Conifer Basal Area for Harvest Within Stand	
	90 square feet per acre	
Size Class	Stand Size	Minimum Conifer Basal Area for Harvest Within Size Class
2	8 – 16"	23 square feet per acre
3	16 – 24"	23 square feet per acre
4	24 – 32"	23 square feet per acre
5	>32"	23 square feet per acre

Hardwood harvest is triggered if hardwood basal area exceeds 15 square feet of basal area per acre.

**Residual Stand Conditions**

Minimum conifer retention for this regime is, by size class:

Size Class	Stand Size	Minimum Conifer Basal Area Retention by Size Class
2	8 – 16"	22.5 square feet per acre
3	16 – 24"	22.5 square feet per acre
4	24 – 32"	22.5 square feet per acre
5	>32"	22.5 square feet per acre

Hardwood retention is 15 square feet of hardwood basal area per acre.

**Regeneration Assumptions**

Natural regeneration and planted seedlings are assumed for this regime. The growth model assumes that post-harvest stands are regenerated with 60 seedlings per acre. The assumed regeneration mimics the species composition of the pre-harvest stand by determining the proportion of redwood trees and Douglas-fir trees present in the pre-harvest stand and assigning the same proportion to the seedlings. The small trees 'grow' in the model with a small tree modeling routine which adds 1 foot height growth per year until the tree achieves 10 feet in height, upon which the trees are assumed to have a DBH of 4". These trees are then grown in the FREIGHTS growth model where the trees are subject to competition and mortality.

**Vegetation Control Assumptions**

No vegetation control is associated with this regime.

## VARIABLE RETENTION MODEL LOGIC

<b><i>Description</i></b>	The goal of this regime is to rotate stands with low conifer basal area and relatively high hardwood basal area. The regime is considered an even-aged regime. Pockets of the pre-harvest stand are retained to provide habitat structure and forest complexity. The stand will be managed using uneven-age silviculture in successive entries.
<b><i>Timing Options</i></b>	The regime is available for harvest for the first six decades. The re-entry period is 30 years.
<b><i>Trigger Conditions</i></b>	Stands must have between 50 square feet and 120 square feet of conifer basal area per acre. The stand must also have at least 80 square feet of hardwood basal area per acre. The regime is considered for mixed conifer and hardwood stands and mixed hardwood stands. The stand must have 50% or more of its overall basal area in trees greater than 16" to be considered for harvest.
<b><i>Residual Stand Conditions</i></b>	The modeled retention is 20% of both the conifer and hardwood pre-harvest basal area, representing both the species and size distribution found in the pre-harvest stand.
<b><i>Regeneration Assumptions</i></b>	Natural regeneration and planted seedlings are assumed for this regime. The growth model assumes that post-harvest stands are regenerated with 300 seedlings per acre. The assumed regeneration mimics the species composition of the pre-harvest stand by determining the proportion of redwood trees and Douglas-fir trees present in the pre-harvest stand and assigning the same proportion to the seedlings. The small trees 'grow' in the model with a small tree modeling routine which adds 1 foot height growth per year until the tree achieves 10 feet in height, upon which the trees are assumed to have a DBH of 4". These trees are then grown in the FREIGHTS growth model where the trees are subject to competition and mortality.
<b><i>Vegetation Control Assumptions</i></b>	Vegetation control will reduce approximately 75% of the hardwoods that sprout after each harvest. This is achieved in the model by allowing only 25% of the stumps to sprout. This is determined by analyzing the number of hardwood trees per acre prior to harvest.

## SEED TREE REMOVAL MODEL LOGIC

<b>Description</b>	The seed tree removal regime is the final step in rotating the stand that preceded it. Seed trees are removed when the younger stand established in part by the seed trees fully occupies the stand. While considered an even-aged regime, the developing stand will be treated in subsequent treatments with uneven-age silviculture.
<b>Timing Options</b>	The regime is available for harvest for the first four decades.
<b>Trigger Conditions</b>	Stands must have between 15 and 60 square feet of conifer basal area per acre. The regime is considered for conifer-dominated stands and mixed conifer and hardwood stands. The stand must have 50% or more of its overall basal area in trees larger than 16" DBH, with a vigorous and well-stocked understory stand of smaller trees. Hardwood harvest is triggered if the hardwood basal area exceeds 15 square feet per acre.
<b>Residual Stand Conditions</b>	Minimum conifer basal area retention is 10 square feet of conifer basal area per acre. If hardwoods are harvested, retention is 15 square feet of hardwoods per acre.
<b>Regeneration Assumptions</b>	Natural regeneration and planted seedlings are assumed for this regime. The growth model assumes that post-harvest stands have 300 trees per acre, mimicking the species composition present prior to harvest. The assumed stand has trees which are 4" DBH and 10 feet and height. These trees are then grown in the FREIGHTS growth model where the trees are subject to competition and mortality.
<b>Vegetation Control Assumptions</b>	Vegetation control will reduce approximately 75% of the hardwoods that sprout after each harvest. This is achieved in the model by allowing only 25% of the stumps to sprout. This is determined by analyzing the number of hardwood trees per acre prior to harvest.

## REHABILITATION MODEL LOGIC

<b><i>Description</i></b>	The rehabilitation regime is reserved for those stands experiencing excessive hardwood competition. This regime is considered as an even-aged regime. Rehabilitation removes the hardwood competition and allows conifer regeneration to take place. Successive harvests will incorporate uneven-aged silviculture.
<b><i>Timing Options</i></b>	The regime is available throughout the planning horizon. Subsequent harvest will be treated with uneven-age silviculture. The minimum re-entry period is 30 years.
<b><i>Trigger Conditions</i></b>	Stands must have less than 50 square feet of conifer basal area per acre and more than 50 square feet of hardwood basal area per acre. The regime is considered for mixed conifer and hardwood stands and mixed hardwood stands. The stand must have 50% or more of its overall basal area in trees larger than 8" DBH.
<b><i>Residual Stand Conditions</i></b>	Minimum conifer basal area retention is 10 square feet of conifer basal area per acre. Minimum hardwood retention is 15 square feet of hardwood basal area per acre.
<b><i>Regeneration Assumptions</i></b>	Natural regeneration and planted seedlings are assumed for this regime. The growth model assumes that post-harvest stands are regenerated with 300 seedlings per acre. The assumed regeneration mimics the species composition of the pre-harvest stand by determining the proportion of redwood trees and Douglas-fir trees present in the pre-harvest stand and assigning the same proportion to the seedlings. The small trees 'grow' in the model with a small tree modeling routine which adds 1 foot height growth per year until the tree achieves 10 feet in height, upon which the trees are assumed to have a DBH of 4". These trees are then grown in the FREIGHTS growth model where the trees are subject to competition and mortality.
<b><i>Vegetation Control Assumptions</i></b>	Vegetation control will reduce approximately 75% of the hardwoods that sprout after each harvest. This is achieved in the model by allowing only 25% of the stumps to sprout. This is determined by analyzing the number of hardwood trees per acre prior to harvest.

## TRANSITION MODEL LOGIC

<b><i>Description</i></b>	The goal of the transition regime is to develop uneven-aged stands from even-aged stands and/or to improve stocking levels in understocked stands.
<b><i>Timing Options</i></b>	The regime is available throughout the planning horizon. Subsequent harvest will be treated with selection silviculture. The minimum re-entry period is 20 years.
<b><i>Trigger Conditions</i></b>	Stands must have between 60 and 90 square feet of conifer basal area per acre to be selected for transition. Stands must also have less than 80 square feet of hardwood basal area to be considered for transition. The regime is considered for conifer-dominated stands, mixed conifer and hardwood stands and mixed hardwood stands. Stands must have 50% or more of its overall basal area in trees larger than 16" DBH. Hardwood harvest is triggered if hardwood basal area exceeds 15 square feet of hardwood basal area per acre.
<b><i>Residual Stand Conditions</i></b>	Minimum conifer basal area retention is 50 square feet of conifer basal area per acre. If hardwoods are harvested, retention is 15 square feet of hardwood basal area per acre.
<b><i>Regeneration Assumptions</i></b>	The stand is assumed to have 200 seedlings per acre, representing the pre-harvest conifer species mix. The height growth is at the rate of one foot a year. The trees begin growth in the CRYPTOS model at year 10, when the trees are approximately 4" in diameter and 10 feet in height. They are subject to competition and mortality when they enter the CRYPTOS model.
<b><i>Vegetation Control Assumptions</i></b>	Vegetation control will reduce approximately 50% of the hardwoods that sprout after each harvest. This is achieved in the model by allowing only 50% of the stumps to sprout.