HUMBOLDT REDWOOD COMPANY, L.L.C.

SUSTAINABILITY ANALYSIS

MARCH 2016

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Introduction

Humboldt Redwood Company LLC ('HRC') owns and manages 209,200 forestland acres in Humboldt County, California. HRC was formed in August 2008. Previously lands now managed by HRC were managed by The Pacific Lumber Company (PALCO).

From 2010 through 2013 HRC conducted a new forest resource field inventory of all HRC lands in preparation for landscape planning work that is the basis for this Sustainability Analysis document.

A major source of harvest constraints for HRC lands is consistency with land management protocols required by the HRC Habitat Conservation Plan (HCP). This HCP was signed in March 1999 and prescribes conservation measures including special provisions calling for periodic watershed analyses of major drainage basins on these lands, identification of site-specific management prescriptions intended to ensure that watercourse and other aquatic habitat conditions continue to trend toward a Properly Functioning Condition, special monitoring and mitigation provisions for several species of wildlife listed as threatened or endangered under the Endangered Species Act, and other advanced conservation requirements. These special measures are explained in the HCP document and, as appropriate, are incorporated into HRC's landscape planning model.

HRC's forest management policies are integral to its landscape plan. These policies are voluntary measures that are applied to this landscape planning work. HRC's policies include:

- Typical harvests utilize unevenage management – single tree, group selection, and where necessary, transition. Clearcutting is prohibited on company lands. Some Special Prescriptions (as categorized by the Forest Practice Rules) with evenage characteristics – specifically variable retention and rehabilitation - will be used to move stands toward a multi-aged stand condition or to restore conifer dominance in hardwood impacted stands.
- The selection harvest cutting cycle averages 20 years. Exceptions may occur where warranted by specific stand conditions, for example to reduce heavy stocking in two stages (shorter cycle) or to build up stocking in an open stand (longer cycle).
- Old growth trees (as defined by HRC policy) and associated screen trees will not be cut.

Long Term Sustained Yield (LTSY) is defined in the California Forest Practice Rules (14CCR 895.1) as 'the average growth sustainable by the inventory predicted at the end of a 100-year planning horizon'. This Sustainability Analysis document outlines the approach to stocking, growth and yield as modeled in HRC's 100-year landscape plan. The calculated LTSY for this plan is 914,618 net conifer mbf/5-year period, or 951 board feet per acre per year on HRC's 192,421 acres of forest land.

The following sections of this document describe the landscape planning process that is the basis for achieving MSP on HRC lands. These sections include (1) a general description of the Assessment Area, (2) a description of HRC's Forest Resource Inventory and Landscape

Planning process, and (3) the Stocking, Growth and Harvest estimates that are the product of this Landscape Planning process and that comprise the MSP estimate.

Appendices to this document discuss in further detail the vegetation typing and field inventory work that comprise HRC's forest resource inventory, and the modeled harvest constraints, silvicultural prescriptions and planning model process used in landscape planning.

About HRC

Humboldt Redwood Company (HRC) was created in 2008 from lands purchased in Humboldt County with the publicly declared mission to be good stewards of the forest and at the same time run a successful business. We have made significant progress in that regard:

1. Adopting policies to make HRCs forestlands FSC certified;
2. Adding more than 500 million board feet of redwood and Douglas fir trees by lowering the rate of harvest;
3. Defining of old growth down to the level of an individual tree, along with implementation of a policy to protect all individual old growth trees across our property;
4. Elimination of traditional clear cutting from our property;
5. Long term investments to improve habitat for fish across the property by controlling or holding back over 400,000 cubic yards of sediment thru 2015 from the coastal streams flowing through our forest;
6. Upgrading of over 500 miles of roads including over 1400 watercourse crossings;
7. Operating as an open and transparent business; including an open invitation to take interested individuals anywhere in the forest;
8. Completing a substantial rebuild of our Scotia sawmill, assuring that Humboldt County will have infrastructure in the processing of wood products for many years to come; and
9. Employing about 250 skilled employees in Humboldt County earning family-level wages and benefits.

Assessment Area

This Sustainability Analysis covers all forestlands owned by Humboldt Redwood Company LLC. The forestlands are comprised of approximately 209,200 acres situated in the southern half of Humboldt County, California. The lands are mostly contiguous, with occasional inholdings and some scattered outlying tracts and parcels.

The majority of the property drains into the Eel River and its tributaries (Van Duzen River, Yager Creek, Strongs Creek, Larabee Creek). Other significant parts of the property drain into Mad River, Freshwater Creek, Elk River, Bear River and Mattole River.

Elevation on HRC forestlands ranges from 50 feet above sea level near Freshwater Creek to 3600 feet on Rainbow Ridge. Average temperatures range from an average daily high of 74 degrees in July to an average low of 38 degrees in January. Annual precipitation ranges from 50-80"; primarily this is rainfall with occasional snow.

The geology underlying the ownership is composed of sedimentary rocks accreted to the North American plate. Bedrock is highly deformed and fractured creating a structurally weak mélange in the east. In the south and west bedrock is made up of folded, faulted and fractured hard sandstones and argillites. Poorly consolidated young fine-grained silts, clays and sands are found in the north and central portions of the property. Soils are typically well-drained, and shallow to moderately deep.

Conifers on these lands are dominated by coastal redwood and Douglas fir, with grand fir and some minor conifer species also present. Hardwoods are primarily tanoak and red alder. The major variation to this description are HRC lands in the Bear River and Mattole River watersheds – here the forestlands are almost entirely stocked with Douglas fir and tanoak, with prairies and adjacent coast live oak stands interspersed. The January 2016 inventory summary shows the following forest type acreages:

Table 1. Acres by Forest Type

Forest Type	Acres
Redwood	59,479
Redwood/Douglas fir Mix	74,659
Douglas Fir	21,010
Hardwood/Conifer Mix	22,911
Hardwood	22,684
Non-Forest	8,520
totals	209,264

Because of extensive even-age harvest practices in the recent past the age/size classes of trees on the property tend towards the young and small. Again drawing from the January 2016 inventory summary here are acreage estimates by overstory size class:

Table 2. Acres by Size Class

Overstory Size Class	Acres
Size Class 1 – dominated by conifer and hardwood trees < 1" dbh	9,952
Size Class 2 – dominated by conifer and hardwood trees 1 – 8" dbh	75,334
Size Class 3 – dominated by conifer and hardwood trees 8 – 16" dbh	60,675
Size Class 4 – dominated by conifer and hardwood trees 16 – 24" dbh	30,806
Size Class 5 – dominated by conifer and hardwood trees 24 – 32" dbh	17,441
Size Class 6 – dominated by conifer and hardwood trees 32"+ dbh	6,535
Non-Forest	8,520
totals	209,264

Site quality is estimated on HRC lands via some 2700 site trees measured in 2010-2013. The data from these trees indicates that the bulk of HRC lands fall in the site index range of 115-130 (DF 50-yr basis), or a site class 2. Drier parts of the property – Mattole River, Bear River, eastern Larabee Creek – fall in the 105 to 110 site index range (site class 3).

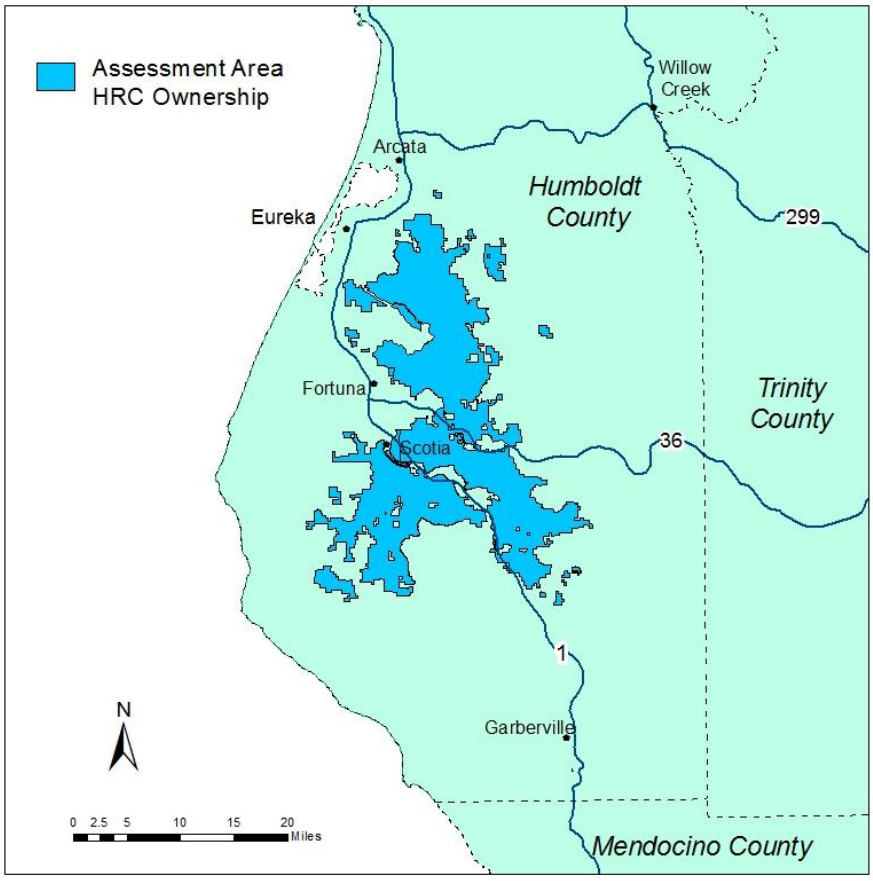

Figure 1. HRC Ownership and Sustainability Analysis Assessment Area

Forest Resource Inventory

HRC maintains an inventory of its forest resources. HRC's forest resource inventory and products derived from this inventory are used for multiple purposes, including:

- Managing business assets,
- Providing data for landscape planning,
- Timber harvest plan layout,
- Characterizing and managing wildlife habitat, in particular generating California Wildlife Habitat (WHR) types, northern spotted owl habitat types, and identifying forests of high conservation value.
- Estimating tree canopy cover over time to model watershed dynamics,
- Monitoring progress toward restoring species composition and build-up of conifer stocking,
- Identifying non-forest resources requiring or deserving protection,
- Providing the best available estimates of growth, potential yield, stocking and regeneration.

HRC's forest resource inventory databases include:

1) A vegetation type GIS layer, and
2) Field sampled inventory data stored in Access database tables associated with ForSee growth-and-yield software. Standard inventory statistics are generated by ForSee. Reporting or maps that are more specific or detailed can be developed via database queries.

More detailed discussion of HRC's forest inventory procedures and data can be found in Appendices A and B of this document. Appendix A describes HRC's Vegetation Type GIS layer and its development process. Appendix B describes the design of HRC's field inventory sampling.

Landscape Planning

Landscape Planning Process and Parameters

HRC's landscape objectives are as follows:

- Bring a multi-age stand structure back to the forestlands that have been managed as even-aged.
- Restore tree species composition to pre-1850 conditions where stand composition has been altered.
- Build up conifer stocking across the property (annual harvests will be less than annual growth until inventory goals are achieved).
- Maintain sustainable log production over the long term.
- Maintain and restore a forested condition beneficial to fish, wildlife, and water quality.

We address HRC landscape objectives through a landscape planning process. This process integrates a number of components including forest resource inventory data, GIS constraint layers, the FORSEE growth-and-yield model, Microsoft Access queries and linear programming software.

General parameters for HRC's landscape planning process are as follows:

- The planning horizon is 100 years.
- Growth, harvest, and reporting is done in 5-year periods. Modeled harvests take place at the mid-point of 5-year periods.
- HRC lands are divided into 13 Sustainability Units (SUs). Each Unit is stand-alone in terms of inventory processes and landscape planning. Each SU is intended to have non-declining yield from one 5-year period to the next. Exceptions may be made when appropriate to achieve long-term goals of increased volume growth or when fire or unusual damage makes deviation from this policy prudent.
- Within SUs lands are divided into Harvest Blocks – areas that are 500-1500 acres in size and may be logical areas for THPs. The planning model output generally assigns all harvestable lands in a Harvest Block to one 5-year period.
- The cutting cycle for selection harvest re-entry is typically 20 years; cycles of 25 or 30 years are allowed in the modeling to help achieve non-declining yield.

There is wide variability in on-the-ground conditions and thus variations in silvicultural strategies. These strategies are used to transition to and maintain HRC's desired stand structure (multi-aged, conifer-dominated, well-stocked forest) on the landscape. Variations in site quality, mix of existing tree species and size, harvest accessibility, and in the amount of bear damage and other defect affect silviculture as it is applied on the ground. HRC is fortunate to manage a landscape that is generally well stocked with conifers and is of above average site quality. However, there are significant challenges to achieving the desired forest landscape, including:

- HRC's 200,000 acres of timbered property include some 65,000 acres that were regeneration harvested (primarily clearcut, with some shelterwood/seed tree removal and rehabilitation cuts) within the past 25 years. The majority of these acres are well-stocked

with conifers and growing well. They are however 10-30 years away from being of merchantable size, and as they become merchantable HRC foresters will have the challenge of transitioning young single-age stands into multi-age stands.

- HRC lands include some 23,000 acres that are heavily dominated by hardwoods and a similar acreage of hardwood/conifer mix. A portion of these lands were historically conifer-dominated and were converted to hardwood by past harvest practices; other lands have historically been hardwood-dominated. HRC intends to restore conifers on such lands that were conifer-dominated in the past, using Variable Retention and Rehabilitation silviculture.
- As a result of Forest Practice Rules, wildlife and geological constraints, HRC's HCP, watershed analysis prescriptions and company policies protecting unique habitats, there are approximately 30,000 acres of 'No Harvest' lands and another 22,000 acres that are restricted to high basal area or high canopy cover retention.
- The remaining ~40,000 acres – which have some additionally challenged areas such as those where roads are marginally feasible, or consist of strips below or within old clearcut blocks - thus comprise the current manageable conifer timberland base. HRC foresters have the challenge of managing these lands to maintain an economically viable business while waiting for younger timber stands to grow to merchantable size.

HRC's landscape planning process incorporates these conditions and constraints together with company policies and objectives to identify a reasonable scenario for future timber harvest schedules. The outcome of this process is a model, and is necessarily a simplification of real-world conditions and management activities. The planning process demonstrates that – given our best available information – landscape objectives can be met in conjunction with specified harvest yield levels.

Figure 2 displays HRC's landscape planning components. The text following briefly discusses each component, referencing them by the letters in each shape of the figure. Additional detail about certain of these components (timber GIS layer, field inventory data collection, harvest constraints, modeled silvicultural prescriptions) can be found in the appendices of this document.

(A) Vegetation Type and Site Quality Layers. HRC's timber (vegetation strata type) GIS layer contains over 18,000 stand polygons, each describing a vegetation type attributed with the species type, size and density of the overstory, or – if no tree cover is present – a descriptor of the non-forest type of the stand. Vegetation types are grouped into vegetation strata. There are approximately 500 strata across the property, and each forested strata is linked to field inventory data. Each strata also has an associated site index value, based on site tree measurements at plots within that strata during field inventory work.

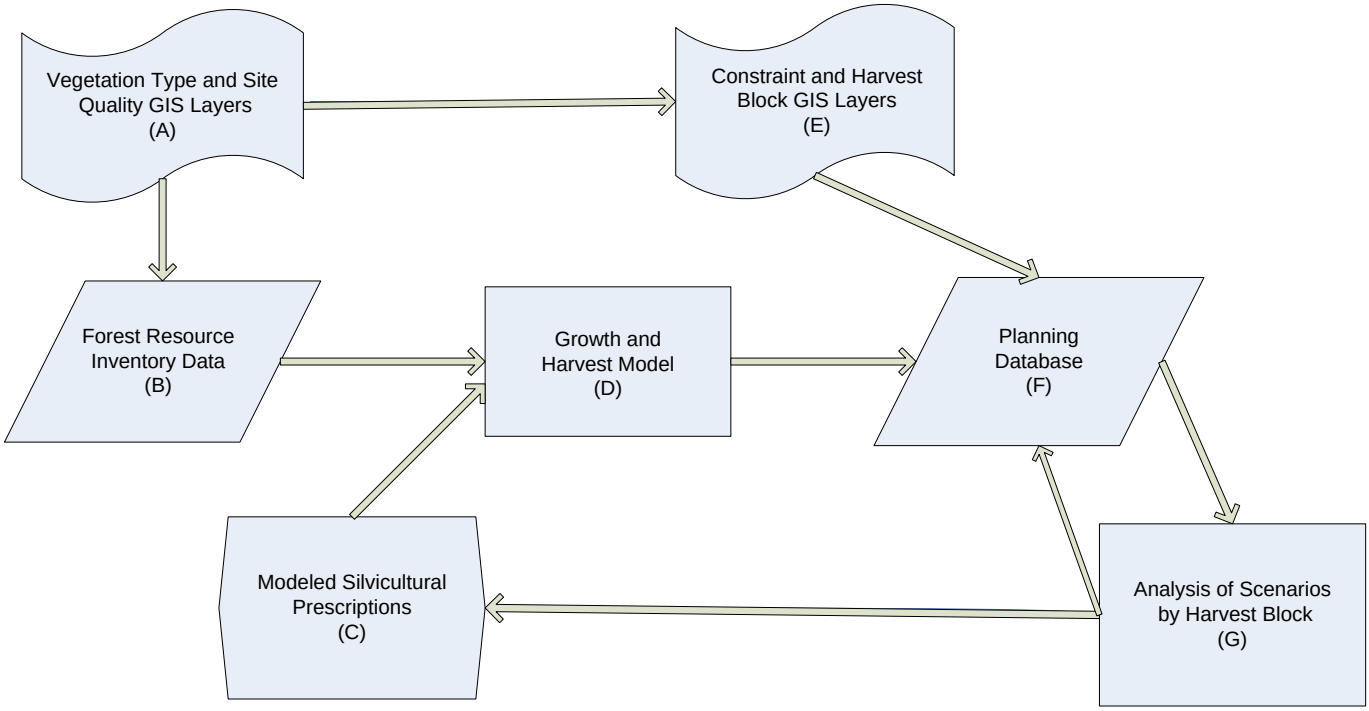

Figure 2. Landscape Planning Model Components

(B) Forest Resource Inventory Data. Inventory data is stored in access databases associated with ForSee growth-and-yield software. Each forested vegetation strata has a 'tree list' linked to it; this tree list consists of tree attributes and dimensions (species, diameter, height, percent of live crown, tree bole defect, number of trees/acre that a given tree represents under the sampling scheme) for trees that were measured on field plots within that strata.

(C) Modeled Silvicultural Prescriptions. ForSee software includes a 'Batch Mode' module that enables the user to write scripts that (based on strata tree list data) evaluate strata and apply appropriate modeled silvicultural prescriptions to those strata over time. The HRC planning model includes three types of silvicultural prescriptions:

- Selection (encompassing both single tree and group selection),
- High Basal Area or Canopy Cover Retention Selection (harvests retaining high levels of basal area or canopy cover as dictated by watershed analysis or other rules),
- Variable Retention and Rehabilitation (typically for use in strata dominated by hardwoods, with the goal of retaining groups of desired trees while removing the less desirable trees). Variable Retention may also be used in conifer stands where appropriate – for example where bear damage is extensive or stands are of poor health or vigor.

(D) Growth and Harvest Model. As noted, HRC uses ForSee as its growth-and-yield model. ForSee is a descendant of the CRYPTOS and CACTOS California models. As shown in

Figure 2, timber inventory data (B) and modeled silvicultural prescriptions (C) are inputs to the growth and harvest model. Using ForSee's batch mode, multiple prescriptions are run on multiple strata types, with the resulting growth, harvest and inventory statistics stored in Access database tables.

(E) Constraint and Harvest Block GIS Layers. GIS layers representing mapped harvest constraints are overlaid with timber/vegetation strata layers to allow spatial analysis of strata occurring in constrained areas. Mappable harvest constraints include Marbled Murrelet Conservation Areas, riparian buffers and associated steep streamside areas and inner gorges, spotted owl protection areas and Habitat Retention Areas, type 1 and type 2 old growth stands, High Conservation Value Forests, Representative Sample Areas and geological/unstable areas. (These constraints are discussed in more detail in Appendix C.) Harvest blocks are a separate GIS layer representing logical areas for harvest plans centered around local road systems. The harvest block layer is also overlaid with the vegetation strata and constraint layers. Unique combinations (aka 'landtypes') of vegetation strata, constraint types, and harvest blocks together with their associated acreages are output to the planning model database.

(F) Planning Database. The outputs of the Growth and Harvest modeling and of the vegetation/constraint/harvest block GIS layers are combined in an Access database. Queries are then applied to this data, allowing determination of the location and acreage of restricted and available lands and of the possible silvicultural prescriptions and harvest yields from those lands. A linear programming run is implemented using this information – this results in a mappable harvest schedule with an optimized yield given the modeled inputs and constraints. This resulting harvest schedule is mapped and reviewed as to whether modifications need to be made before including it in HRC's landscape plan. [Further discussion of this is in Appendix E.]

The property-wide stocking, growth and yield values generated by this landscape plan process are presented in the following section addressing MSP. As described in Appendix D (Modeled Silvicultural Prescriptions), the modeled prescription applied to most unrestricted lands is to harvest via single tree or group selection to an average post-harvest basal area of 75 ft^2/acre in the first 5-year period, with that post-harvest basal area level 'stepping up' to 85 ft2/acre in periods 2-4, higher levels in subsequent periods and reaching 140 ft2/acre by the end of the planning horizon. Because of these initial minimal modeled post-harvest stocking levels and the fact that some legally available but operationally marginal lands are modeled as being harvested in the plan, HRC considers this to be a conservative plan; conservative in the sense that deviations from the plan – particularly in the next 15 years - are likely to be in the direction of less volume harvested, more stocking retained, and (thus) more volume growth. The presented landscape plan thus establishes a maximum cut level and minimum growth levels to demonstrate compliance with MSP, with actual cutting levels and silvicultural standards to be determined by company management over time.

Silvicultural Activities

To maximize current and future tree growth, the following silvicultural practices will be implemented throughout the planned management of HRC lands, and where appropriate are incorporated into the landscape modeling parameters. These practices are intended to ensure appropriate site occupancy, maintain good stand vigor, and provide for adequate regeneration, and are designed to create and maintain healthy stands for continued timber production.

Regeneration activities on HRC lands include tree planting, site preparation work, vegetation management work, and pre-commercial thinning. Site preparation, tree planting and vegetation management (brush control) are done in Rehabilitation units, and in Variable Retention units and Group Cuts where needed to supplement regeneration from and promote growth of redwood sprouts and retained young trees. HRC has in place an active pre-commercial thinning program to treat existing and future young even-age stands.

HRC harvests are planned to encourage healthy and vigorous post-harvest stands. Tree marking guidelines for Selection and Variable Retention harvests prioritize diseased and suppressed trees prior to removing co-dominant and dominant trees, unless the diseased tree provides favorable structural wildlife habitat. The modeled post-harvest stocking in this landscape model (basal area of 75 ft2/acre of young growth conifer trees 12" DBH+) meets Forest Practice Rule minimum selection stocking levels. It is sparse stocking in terms of immediate post-harvest site occupancy, but does provide for reduced tree competition and thus healthy growth of retained trees, redwood sprouts and other regeneration.

Hardwoods are managed in HRC's harvest operations. At least fifteen square feet per acre (averaged across the unit) of the largest hardwood tree basal area existing on the site is retained in all harvests wherever it exists. In keeping with the FPR requirement not to allow group B species to dominate site occupancy post harvest, appropriate vegetation management will be applied to control other hardwood vegetation.
Also as noted previously, some 23,000 acres of HRC land is hardwood type, and a similar acreage is hardwood/conifer mix. A sizeable proportion of this acreage was historically hardwood lands, while another portion of these lands were conifer-dominated in the past and were converted to hardwood by past harvest practices. Treatment of hardwood stands via Rehabilitation or Variable Retention harvest is ongoing in order to restore appropriate lands to more vigorous conifer-dominated stands.

Landscape Plan

Using the landscape modeling framework described in the previous sections, HRC's stocking, growth and yield projections are as displayed in Figure 3 and Table 3. The following notes apply to the values in Table 3:

- All volumes are in net MBF in trees greater or equal to 12" DBH.
- Stocking values are shown at the beginning/end of each 5-year period. Growth and harvest values are shown 'during' the period and represent the total modeled growth/harvest in that 5-year period.
- As noted in Appendix D – description of Modeled Silvicultural Prescriptions – a 10% falldown or waste is assumed for each harvest, encompassing internal defect, logging breakage, ongoing bear damage and general woods-to-mill falldown. Thus the harvest volume values in Table 3 should be divided by .9 to achieve mathematical balance with the stocking and growth values.
- Harvest volume values are modeled to be non-declining over the planning horizon for each Sustainability Unit (SU) and thus for the property as a whole. Because of past management practices on this HRC lands, every SU is currently understocked relative to its potential under sustained-yield management. Overall – as can be seen in Figure 3 and Table 3, the projected harvest levels are constant for the next 10-15 years, then rise steeply over the next 25-30 years as young even-age stands reach harvestable size, then rise more slowly over the final 50 years of the planning horizon as multi-age stand structures stabilize at higher stocking levels.

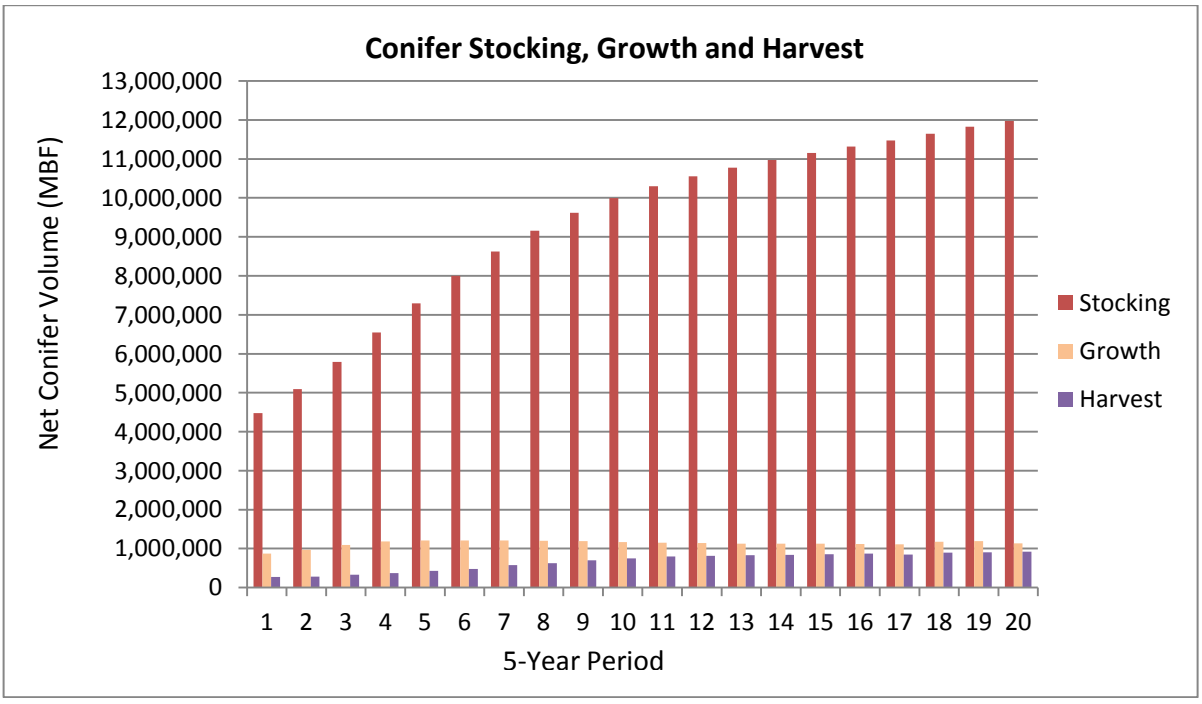

Figure 3. Stocking, Growth and Harvest

Table 3. HRC Landscape Plan Stocking, Growth and Harvest (total net MBF)

	Young Growth Conifer on Available Lands			YG Conifer on NoHarv Lands	Old Growth	Hardwoods	Total Conifer, All Lands	
	Stocking	Grw/Period	Harv/Period	Stocking	Stocking	Stocking	Stocking	Grw/Period
[1/1/16]	2,779,383			873,500	545,227	504,229	4,198,109	
Per1		729,587	275,061					868,610
	3,189,460			1,019,351	552,289	539,623	4,761,099	
Per2		820,357	276,895					969,194
	3,684,685			1,178,554	559,396	581,670	5,422,635	
Per3		941,580	326,261					1,097,915
	4,244,153			1,347,376	566,512	619,713	6,158,041	
Per4		1,022,537	370,526					1,183,223
	4,835,238			1,520,712	573,624	652,186	6,929,573	
Per5		1,047,487	427,073					1,205,284
	5,387,305			1,692,265	580,766	675,022	7,660,336	
Per6		1,057,281	476,937					1,209,132
	5,891,640			1,859,969	587,934	696,293	8,339,542	
Per7		1,062,681	576,707					1,209,896
	6,290,265			2,023,338	595,057	708,045	8,908,660	
Per8		1,061,814	626,699					1,202,503
	6,628,269			2,184,427	602,141	715,065	9,414,837	
Per9		1,053,163	697,195					1,188,310
	6,876,539			2,342,665	609,290	710,012	9,828,494	
Per10		1,042,939	752,221					1,170,656
	7,050,199			2,496,720	616,438	697,855	10,163,357	
Per11		1,034,038	797,734					1,153,566
	7,161,165			2,645,872	623,524	677,513	10,430,561	
Per12		1,028,503	814,173					1,144,974
	7,249,539			2,790,763	630,605	665,830	10,670,907	
Per13		1,027,267	831,435					1,126,519
	7,306,479			2,929,443	637,696	647,039	10,873,619	
Per14		1,028,058	842,555					1,128,428
	7,356,966			3,064,117	644,801	635,308	11,065,884	
Per15		1,028,612	854,993					1,123,378
	7,392,482			3,194,869	651,927	625,213	11,239,278	
Per16		1,027,055	868,519					1,114,924
	7,409,886			3,320,222	659,082	614,407	11,389,190	
Per17		1,034,489	884,732					1,150,471
	7,449,442			3,440,860	666,335	606,651	11,556,636	
Per18		1,047,112	896,369					1,173,205
	7,503,532			3,556,729	673,624	598,580	11,733,885	
Per19		1,050,555	908,436					1,190,038
	7,564,535			3,669,136	680,888	593,985	11,914,559	
Per20		1,046,547	920,800					1,137,512
	7,562,489			3,778,286	688,196	589,154	12,028,970	
(average for periods 19-20			914,618)					

As shown at the bottom of Table 3, the estimated Long Term Sustained Yield value is ***914,618 mbf per 5-year period*** (average yield over the last 10 years of the 100-year planning horizon). On a per-acre basis this could be calculated as:

1) 914,618 mbf /5 years/192,421 net acres (net of roads, large landings) of timberland = ***951 bf/ac/yr***, or
2) 914,618 mbf /5 years/164,384 net acres of timberland that is available for harvest = ***1,113 bf/ac/yr***.

Appendix A – Vegetation Typing

As noted, HRC maintains a vegetation type GIS layer that is the spatial basis for HRC's forest resource inventory. The current vegetation layer was developed in the 2010-2012 period using color 1:12,000-scale aerial photos and orthophotography flown in July of 2010. The layer contains approximately 18,000 polygons.

In this GIS layer vegetation is classified by overstory tree species, size, density, and (where the overstory is sparse) understory species and size. As an example of a vegetation type, the "RW3P/RT2" type describes lands with primarily redwood tree ('RW') overstory of 8-16" DBH (size '3') and 25-40% canopy cover (density 'P') over an understory of redwood and tanoak ('/RT') of 1-8" DBH (size '2').

As noted previously, HRC lands are divided into 13 Sustainability Units (SUs) for inventory and planning purposes. SUs range from 5,000 to 24,000 acres in size. SUs are the primary resource management units for the property. Generally Sustainability Unit boundaries follow watershed boundaries, although in some cases operational efficiencies are also a factor in SU delineation. Inventory data and statistics do not cross SU boundaries.

After initial classification of vegetation overstory and (where appropriate) understory types, the over/understory types are grouped into 'strata' within each Sustainability Unit. Vegetation strata are the basis for field inventory work in that field plots are allocated to and located by strata, and inventory statistics are compiled by strata. Similar over/understory types are grouped to create strata with the goal of having each strata cover a minimum of 100 acres, although exceptions can be made. There are approximately 500 strata across the property, or an average of about 40 strata in each SU.

The vegetation GIS layer is updated annually to reflect harvests and any other major changes that may have occurred during the year. Approximately every 5 years each SU is reviewed via recent aerial photos and orthoimagery to correct vegetation boundary lines and update polygons for growth.

Appendix B - Field Inventory

As noted previously, HRC conducted an initial field inventory in 2010-2013 to develop resource inventory data characterizing vegetation strata. For each SU the following tasks were completed in sequence: (1) vegetation typing (as described in Appendix A), (2) field plot layout, (3) field inventory work, and (4) data review and compilation. Approximately 13,000 plots were established and measured in 2010-2013.

This inventory is continuous – a portion of the plots are retired and new plots added in conjunction with the 5-year imagery/vegetation typing review to keep the inventory data current.

Design features of HRC's forest resource inventory include the following:

- As noted, HRC's inventory is strata-based, and each of HRC's 13 Sustainability Units is treated as a separate inventory unit - thus the vegetation typing, development of strata types, field plot allocation, layout and measurement, and compilation of field data is done on a SU-by-SU basis.
- Targets are established for the number of field plots needed in each inventory strata type within each SU. Strata type target numbers are based on the importance of each strata as determined by the number of strata acres, likely timber volumes, and general operational availability of the timber volume.
- Potential field plot locations are laid out on a grid across each SU. Groups of plot locations are then selected for field measurement based on the strata types into which they fall, keeping in mind the target number of plots allocated to each strata. Selecting plot locations in groups (typically consisting of 6 to many plots in a group) is done to improve operational efficiency in field plot establishment and measurement.
- At plot locations, merchantable conifer and hardwood trees are measured in nested variable-radius plots. Complete measurements (species, DBH, total height, live crown ratio) are recorded for trees that fall in an 'inner plot', while trees in an outer plot have species and DBH only recorded. Sub-merchantable trees, site index trees, snags, and down woody material are also measured and recorded.
- Field plots are temporary. A flag is hung to mark the center of each plot while measurements are being taken, but no permanent stakes or monuments are installed.

As field inventory work is completed for each SU, inventory statistics are compiled and reviewed for all strata within an SU. ForSee growth-and-yield software is used to compile the field data. The general strata-level statistical target is gross volume standard error within 10% of the gross volume mean, but this target is not rigid – for young strata, strata with significant hardwood and/or strata with small acreages larger SE%'s are acceptable. If statistical review indicates that a strata needs additional plots then more plots are allocated and measured.

Appendix C – Modeled Constraints

Mappable harvest constraints are a key component of HRC's landscape planning process. The sources of these constraints are:

- HRC's Habitat Conservation Plan (HCP),
- Watershed analysis prescriptions,
- HRC commitment to Forest Stewardship Council (FSC) principles,
- HRC company policy,
- Operational constraints.

The following paragraphs discuss each of the major constraint types, their source and the harvest restriction(s) that result. Table C-1 summarizes these constraint types and the unique and cumulative acres associated with each.

Marbled Murrelet Conservation Areas (MMCAs). HRC's HCP established MMCAs and associated old growth buffers comprising approximately 6600 acres of lands to be managed for the maintenance and improvement of marbled murrelet habitat. Generally harvest activities are prohibited in the MMCAs. The HCP document allows thinning of second-growth stands in MMCAs – with agency approval - for the purpose of accelerating the development of mature habitat; as yet no such harvests have been implemented in the first 15 years of the HCP. For the purposes of landscape planning these lands are modeled as 'no harvest'.

Northern Spotted Owl Buffers and Habitat Retention Areas (HRAs). As specified by the HCP, no timber operations will occur within a 500-ft buffer around each of approximately 120 active or recently active NSO nest sites. The locations of these nest sites shift occasionally from year to year, but the effect of this shifting is minor in terms of overall availability of acres and volume for harvest. This requirement removes up to 18 acres * 120 sites = ~2,100 acres from the harvestable land base.
In addition a set of 72-acre areas that include nest sites are to be maintained as roosting habitat or better. These areas are more or less stationary and are designated as NSO Habitat Retention Areas (HRAs). For modeling purposes it's assumed that single-tree selection harvests in HRAs must retain a minimum of 60% total canopy cover to maintain roosting habitat. HRAs include approximately 6,600 acres of HRC land, and after overlap with other more restrictive constraints are subtracted, around 4,000 acres are affected by this requirement.

Old Growth Park Buffers. As per the HCP, 300-ft buffers are located on HRC lands where they are adjacent to old growth stands on public lands. The restriction in these buffers requires any harvest to retain at least 240 ft2/acre of conifer basal area. This restriction affects approximately 400 acres.

Riparian Management Zones, and Associated Slopes & Modeled Geologic Features. The HCP specifies a watershed analysis process to be implemented for each major watershed covered by the HCP. An outcome of the watershed analysis process was a set of site-specific prescriptions intended to achieve a properly functioning aquatic habitat condition.

In the years since the HCP was signed, initial watershed analysis has been conducted on each of eight major watersheds encompassing the property: Freshwater Creek, Van Duzen, Lower Eel/Eel Delta, Elk River/Salmon River, Upper Eel, Bear River, Yager Creek and Mattole River . Prescriptions have been established for each watershed.

With extensive use of HRC's property-wide LiDAR data, harvest restrictions prescribed by the watershed analysis process have been mapped for each watershed. Prescriptions typically dictate a combination of No Harvest and Single Tree Selection with post-harvest canopy cover minimums of 50% or 60% for all trees or for conifers. Mapping of the restrictions involves buffering watercourses (the exact location of which can be determined from LiDAR) and analyzing slopes and probable inner gorges and/or headwall swales adjacent to watercourses. As an example, the Van Duzen Wateshed prescriptions are summarized as shown below in Table C-1.

Table C-1. Van Duzen Watershed Prescriptions

	Harvest Restriction
Channel Migration Zone	No Harvest
Class I Inner Band 0-50'	No Harvest
Class I Outer Band 50-75', 50-100' or 50-150' [depends on slope: 0-20%, 20-50%, 50+% respectively]	Retain 50% Total Canopy
Class II Inner Band 0-30'	No Harvest
Class II Outer Band 30-50', 30-75' or 30-100' [depends on slope: 0-20%, 20-50%, 50+% respectively]	Retain 60% Conifer Canopy
Then for Steep Slopes in the Cummings, Healy and Root Creek subbasins:	
Class I 0-100'	No Harvest
Class I 100-200' or to Break-in-Slope	150 ft2/acre BA or 50% of BA, whichever retains most
Class II 0-100'	No Harvest
Class II 100-200' or to Break-in-Slope	150 ft2/acre BA or 50% of BA, whichever retains most
Class III 0-100' or to Break-in-Slope	150 ft2/acre BA or 50% of BA, whichever retains most
Note: Steep slopes in the Cummings/Healy/Root subbasins are defined as: ** Class I and II watercourses – 40+% slope ** Class III watercourses in Hely and Root – 50+% slope ** Class III watercourses in Cummings – 40+% slope	

Lands that drain into the Mad River – in the northeast corner of HRC properties – have not been included in a watershed analysis. These lands are subject to the 'interim HCP prescriptions' – a very restrictive set of watercourse buffers.

Old Growth Type 1 and Type 2 Stands, High Conservation Value Forests, Representative Sample Areas. In accordance with FSC standards, HRC identifies unique stands or vegetation

types and restricts or prohibits harvest in those areas. Definitions of these unique areas (from FSC-US standards) are:

- *Type 1 Old Growth*: 3 acres or more that have never been logged and display old-growth characteristics.
- *Type 2 Old Growth*: 20 acres or more that have been logged, but which retain significant old-growth structure and functions.
- *High Conservation Value Forests (HCVFs*): forest areas containing significant concentrations of biodiversity values, contain rare/threatened ecosystems, provide basic services of nature in critical situations, and/or are fundamental to meeting basic needs or traditional cultural identity of local communities.
- *Representative Sample Areas (RSAs*): ecologically viable samples designated to serve one or more of the following purposes – (1) establish/maintain an ecological reference condition, (2) create or maintain an under-represented ecological condition, (3) serve as a protected area or refugia for potentially rare species or community types not otherwise protected.

Identifying and establishing these areas is an ongoing process at HRC. One HCVF, four Type 1 OG stands and two Type 2 OG stand (outside of MMCAs) in five locations have specifically been identified and designated thus far. Other candidate stands have been mapped and are under consideration and/or waiting for field review. As of the time of the preparation of this document, the five areas for which restrictions have been specified and included in the landscape modeling process are as listed in Table C-2.

Table C-2. Identified HCVFs and OG Stands

Type	General Location	Acres
HCVF	N side of Long Ridge, Mattole Watershed	203
Type 1 OG (2 stands)	Near confluence of Larabee & Pond Creeks	13 & 6
Type 1 OG	East of confluence Larabee & Smith Creeks	145
Type 2 OG	Upper Bear Creek	187
Type 1 & Type 2 OG	Tributary of Nanning Creek	40 & 147

Geologic`/Unstable and other Restricted Areas. Another ongoing process is the mapping of areas that are unstable, steep or have other geologic/terrain issues, are wet or often flooded, have been set aside or lightly cut to maintain good relations with a neighbor and/or provide a public viewscreen, are difficult to access, or have other site-specific issues.

HRC's field foresters are typically the most knowledgeable source of information regarding these sites and their extent. About 150 such sites have been mapped and included in the landscape modeling process. These various sites may be designated No Harvest, Light Harvest (similar to watercourse buffers with high CrownCover or BasalArea retention), Delayed Harvest, or a combination of Light and Delayed Harvest. Forester input and identification of these locations is an ongoing process.

Slivers. 'Slivers' refer to small stands or narrow strips of merchantable timber that are legally available for harvest, but are operationally constrained because they are within or 'behind' much younger sub-merchantable stands. In many cases these slivers came about because the 1999 HCP required wide 'interim' streamcourse buffers until watershed analysis was conducted for each major watershed on the property; in the years immediately following, the landowner clearcut to the edge of those interim buffers. As watershed analysis was completed, the newly prescribed buffers tended to be smaller than the interim buffers, thus leaving legally available timber stranded behind the clearcut areas.

Approximately 3,000 acres of slivers have been identified across HRC lands. A portion of this area is in current outer streamcourse buffers and so is also constrained with regard to the amount of volume that could be harvested.

Slivers do not add acres of No Harvest or Restricted Harvest to the planning model; rather, a delay is imposed on the harvest of those acres, with the assumption being that such lands will next be harvested in conjunction with harvest of the adjacent stand when it grows to merchantable size. Harvests on sliver lands are generally delayed 20 to 30 years, depending on the age/size of the adjacent stand.

Table C-3 summarizes HRC's mappable No Harvest and High Retention Harvest constraints.

Table C-3. Unique and Cumulative Acres – HRC Harvest Constraints

	No Harvest Acres		High Retention Acres	
	Unique	Cumulative*	Unique	Cumulative*
MMCAs	6,630	6,630		
HCVF/OG Stands	742	7,382		
NSO Nest Buffers	2088	9,222		
CMZ/RMZ - NoHarv	21,665	30,376		
OG Park Buffers			503	442
RMZs/Slopes - HiRetn			21,413	18,431
NSO HRAs			6,621	22,198
Geo/Unstable/Other	441	30,746	840	22,788
TOTALS		**30,746**		**22,788**

* Note: the 'cumulative acres' columns in table C-3 count acres just once, so that acres are not counted multiple times in cases where constraints overlap. Where acres are covered by both No Harvest and High Retention constraints, those acres are listed only as No Harvest cumulative acres.

Appendix D – Modeled Silvicultural Prescriptions

HRC harvests are modeled using the batch mode module in ForSee Growth-and-Yield model software. Scripts have been developed for each of HRC's common silvicultural prescriptions, and these scripts are run against the 'stands' (vegetation strata) across HRC's lands. A silvicultural script typically implements the following steps:

a) Checks to determine whether trigger conditions are met,
b) Harvests trees of various species and sizes as dictated by the harvest parameters,
c) Checks to determine whether a minimum conifer harvest volume level has been met,
d) Implements sprouting and other tree regeneration,
e) Grows the stand for a specified number of years,
f) Implements a subsequent harvest, starting with (a) above.

As noted previously, the modeled prescriptions are run for 100 years. Growth, harvest and inventory are reported on for five-year periods, and modeled harvests are implemented at the mid-point of each period.

Each modeled prescription is assigned a prescription number. Prescription number 1 is 'No Harvest'. Other prescription numbers and types described below are:

361 – Selection/Group Selection,
21, 41, 61, 81, 101, 121 & 141 – High Basal Area/Crown Canopy Retention Selection,
601 – Variable Retention,
621 – Rehabilitation.

These modeled silvicultures – Selection/Group Selection, High Retention Selection, Variable Retention and Rehabilitation – are used on the majority of harvested acres by HRC foresters, and are the most prevalent ones to be used in the future. On occasion site-specific on-the-ground stand conditions will dictate other silvicultures – Shelterwood Prep or Removal, Seed Tree Prep or Removal, Transition, Commercial Thin, Alternative Prescriptions, Special Treatment Areas. Typically these other silvicultures will be used as an initial entry, with HRC's ultimate goal being to move all stands toward multi-age structures in which selection silviculture can be applied. For the sake of modeling simplicity, no attempt was made to estimate the number of acres or the precise stand conditions that these unmodeled silvicultures might be applied to in the future; rather, it is assumed (a) that a small percentage of harvested acres per 5-year period will use one of these other silvicultures in the future (and this percentage will decrease over time), and (b) that these silvicultures are similar enough to the modeled silvicultures that growth and yield estimates will not be significantly affected.

As background information, Table D-1 lists the acres harvested by silviculture (as listed in Timber Harvest Plans) by HRC over the past 5 years (2010-2014). As shown, just 7% of HRC's harvested acres over that time were in the unmodeled silvicultures. In a number of cases these were specified in THPs written by the previous owner of HRC lands.

Table D-1. Acres harvested by Silviculture, 2010-2014.

Silviculture Specified in THP	Acres	Percent
Group Selection	**11,463**	**65.5**
Single Tree Selection (includes High Retention Sel)	**3,777**	**21.6**
Variable Retention	**754**	**4.3**
Rehabilitation	**286**	**1.6**
Alternative Prescription - Selection	506	2.9
Commercial Thin	102	0.6
Transition	185	1.1
Special Treatment Area	136	0.8
Shelterwood Prep	68	0.4
Shelterwood Removal	215	1.2
totals	17,492	100.0

During the model processing and analysis, it was found that the combination of (a) strict adherence to a 20-year cutting cycle, (b) an initial post-harvest basal area of 75 ft2/acre throughout the 100-year planning horizon, and (c) a 'bump' in yields around periods 5-8 (as existing young stands reached merchantable size) made it difficult to achieve a non-declining yield for some Sustainability Units over the 100-year horizon. In these cases the model showed an LTSY value (i.e., average yields at the end of the 100 years) that was less than the yields during periods 5-8. To address this issue two modeling changes were made: (1) the model was allowed variations on the 20-year cutting cycle for selection harvests, so that after the first entry a stand could grow 25 or 30 years before a 2nd entry, and (2) the residual basal area for the typical selection/group selection harvest entry (Rx 361) was increased over time. This modeling change is also in accordance with HRC company objectives, as discussed in the next section of this document.

These changes were successful in allowing the model to calculate non-declining yields and keeping harvest levels below the calculated LTSY value.

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Selection/Group Selection – Rx 361

Selection/Group Selection is the primary silviculture used on HRC lands. It's the default silviculture for lands that are stocked with conifers and not restricted to high Basal Area/Canopy Cover retention. As noted above, some site-specific situations may dictate another silviculture as a first entry, but it is HRC's goal to move all stands toward multi-age structures in which selection silviculture can be applied.

Single Tree Selection and Group Selection are grouped as a single ForSee modeled prescription. Group Selection is in many cases preferable over single tree selection for the purpose of developing a multi-age stand structure from HRC's current largely even-age structures; however, (a) the use of group cuts in actual Timber Harvest Plans has so far been quite variable on HRC lands given the variety of stand conditions and of forester THP

implementations, and (b) it is not expected that growth and yield will differ substantially when group cuts are used versus when they are not, assuming that the post-harvest basal area stocking – averaged over the entire area - is held constant. Thus group cuts (areas up to 2.5 acres in which all trees are removed and is replanted as necessary) are not explicitly modeled in the selection/group selection modeled silviculture.

In the first 5-year period of the planning horizon, modeled Rx 361 harvests to an average basal area of approximately 75 ft2/acre in young growth conifers greater or equal to 12" DBH. In subsequent 5-year periods the post-harvest basal area is 'stepped up', as follows:
In periods 2-4, the average post-harvest basal area is 85 ft2/acre,
In periods 5-8, the average post-harvest basal area is 95 ft2/acre,
In periods 9-12, the average post-harvest basal area is 110 ft2/acre,
In periods 13-16, the average post-harvest basal area is 125 ft2/acre,
In periods 17-20, the average post-harvest basal area is 140 ft2/acre.

As noted, these post-harvest averages might be implemented in a THP with uniform stocking across the harvest area or by putting up to 20% of the land area in group cuts and adjusting the post-harvest stocking on the remainder of the land accordingly.

Stepping up post-harvest selection stocking over time conforms with HRC's long-term management goals:

1) To maintain a viable business over the next 15-20 years while young stands are growing to merchantable size, it's necessary to cut heavily in existing merchantable stands to produce sufficient volume to supply HRC's lumber mill, and
2) As a long-term objective, HRC wishes to develop well-stocked stands that approach maximimum growth and yield across the property; in stands with a significant redwood component such as on HRC's lands, post-harvest residual basal areas of 125-150 ft2/acre are appropriate to meet this objective.

Model specifications for Rx 361 are as follows:

Trigger Conditions

- Minimum of 110 ft2/acre or 15% more than the residual post-harvest BA of young growth conifer trees >= 12" dbh (whichever is greater).
- For young even-age stands (i.e., stands created by past regeneration harvests for which a stand origin year is known), harvests may not occur until the period in which a stand reaches 35 years of age.

Harvest Parameters

- Cutting cycle is 20 years.
- The first harvest for a stand may occur in any of the twenty 5-year periods.
- Dimunition Quotient = 1.16. The class width for applying the DQ is 4".
- As described above, residual Stocking of young growth conifers is set to an average basal area of 75 to 140 ft2/acre, depending on the period of harvest.

- The 'Waste Percent' applied to harvests is 10%. This represents tree cull/damage that is not reflected in the gross/net inventory data (common for ongoing bear damage), logging breakage and general 'woods to mill' volume falldown.
- Harvest Priority (within diameter classes) is 'MinCR' (minimum crown ratio). Thus the model harvests trees with smaller crown ratios first. This reflects the typical priority of trees marked for harvest in an HRC THP.
- The 'Pad' variable is set to 'Uniform'. This specifies that when a diameter class is deficient in residual basal area, that class will be 'padded' (compensated for) by leaving appropriate trees from all classes that have a surplus.

Harvest Sequence

1) Retain OG trees.
2) Retain 15 ft2/acre of hardwoods. Retain the largest trees to compose this 15 ft2.
3) Cut any YG conifer trees > 60" dbh.
4) Retain two YG conifer trees in the 42-60" dbh range if they exist. These represent wildlife trees, 'leave trees', live cull trees It is assumed that in many cases they are damaged trees. If trees 42-60" exist and are retained, adjust the residual stocking ba downward with a maximum adjustment of 20 ft2/acre.
5) Apply a selection harvest (using stated DQ to the established residual ba stocking) to all YG conifer trees in the 12-42" dbh range.
6) Reduce (cut) the conifers 6-12" dbh to 20 ft2/acre to represent logging damage and reduce modeled stocking where necessary. No 'harvested volume' comes from this cut.

Harvest Test

- Check the conifer harvest volume per acre yielded from this modeled harvest. If it is the first modeled harvest for this stand, then a minimum of 6,000 bf/acre must be harvested. If less than 6,000 bf/acre is harvested then the possible harvest is eliminated.
- If it is the second or later harvest for this stand and less than 6,000 bf/acre is harvested then the harvest is eliminated; the stand is grown for an additional 10 years and the harvest is tried again. [Note: this situation – where a 2nd or 3rd harvest would not meet the 6,000 bf/acre minimum after 20 years of growth - is a rare occurrence, but does occasionally happen where the stand structure is imbalanced.]

Regeneration

- Following harvest, 80% of harvested redwood trees sprout and 50% of cut hardwoods sprout (hardwood control with moderate success is assumed),
- Following harvest, 40 trees per acre are regenerated, evenly split between redwood and Douglas fir (except in the Mattole and Bear River SUs, where 100% of the regen is Douglas fir.

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High Basal Area/Crown Canopy Retention – Rx's 21, 41, 61, 81, 101, 121, & 141

As described in Appendix C, there are eight categories of harvest constraints on HRC lands that allow only single tree selection harvest with high basal area or crown canopy retention levels. Primarily these harvest constraints are specified by prescriptions resulting from watershed analysis of the major watersheds encompassing HRC lands.

Seven modeled silvicultural prescriptions have been developed to address these categories of harvest constraint. The prescription number, constraint type, and estimated number of acres for each are listed in table D-2. (The requirement for 80% total tree canopy applies to just 29 acres and so has been lumped in with the most closely related constraint – 65% conifer canopy.)

Table D-2 – High BA/CC Retention Prescriptions

Rx Number	Constraint (post-harv retention requirement)	Estimated Acres
21	60% conifer tree canopy	7,192
41	50% conifer tree canopy	3,375
61	60% total tree canopy	5,033
81	50% total tree canopy	2,348
101	65% conifer canopy, (80% total tree canopy)	1,125 (+ 29) = 1,154
121	150 ft2/acre basal area	2,281
141	240 ft2/acre basal area	823

Modeled specifications are as follows:

Trigger Conditions

(For Crown Canopy retention Rx's)

- Check to see if pre-harvest estimated non-overlapping crown canopy (for conifer or total canopy) is at least 13% higher than the post-harvest retention canopy level,
- Check to see if pre-harvest yg conifer basal area (12-60") is at least 130 ft2/acre,
- Check to see if pre-harvest yg conifer volume (12-60") is at least 20,000 bf/acre.

(For Basal Area retention Rx's)

- Check pre-harvest basal area: must be 170 ft2/acre yg conifer >= 12" dbh [for Rx 121] or 270 ft2/acre all trees [for Rx 141].

Harvest Parameters

- Cutting cycle is 20 years.
- The first harvest for a stand may occur in any of the twenty 5-year periods.
- Dimunition Quotient = 1.1. The class width for applying the DQ is 4".
- Residual Stocking is set to the post-harvest retention requirement as displayed in Table D-2.

- The 'Waste Percent' applied to harvests is 10%. This represents tree cull/damage that is not reflected in the gross/net inventory data (common for ongoing bear damage), logging breakage and general 'woods to mill' volume falldown.
- Harvest Priority (within diameter classes) is 'MinCR' (minimum crown ratio). Thus the model harvests trees with smaller crown ratios first. This reflects the typical priority of trees marked for harvest in an HRC THP.
- The 'Pad' variable is set to 'Uniform'. This specifies that when a diameter class is deficient in residual basal area, that class will be 'padded' (compensated for) by leaving appropriate trees from all classes that have a surplus.

Harvest Sequence

1) Retain OG trees.
2) Retain 20 ft2/acre of hardwoods less than 32" dbh. Retain all hardwoods greater than 32" dbh.
3) Apply a selection harvest to all trees > 12" dbh to the specified residual level for that prescription. Thus Rx 21 cuts to 60% conifer crown canopy, and so on.

Harvest Test

Post-harvest the following checks are made:

- If Rx's 21-101, confirm that the non-overlapping crown canopy percent meets the prescription requirement.
- If Rx's 121 or 141, confirm that the basal area meets the prescription requirement. If Rx's 21-101, confirm at least 90 ft2/acre of basal area retention in yg conifer trees 10" and larger.
- Confirm that at least 8,000 bf/acre was harvested.

Regeneration

- Following harvest, 70% of harvested redwood trees sprout and 40% of cut hardwoods sprout (assumed that a denser overstory canopy will retard sprouting more than in normal selection harvests),
- Following harvest, enough trees are regenerated to bring the 'point count' (as defined in the CA Forest Practice Rules) of each plot up to 350, if the plot has less than 350 after harvest. This regeneration is evenly split between redwood and Douglas fir (except in the Mattole and Bear River SUs, where 100% of the regen is Douglas fir).

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Variable Retention – Rx 601

As per HRC's silvicultural guidelines, variable retention ('VR') is generally applied to stands with some conifer (50-125 ft2/acre) and a significant hardwood component (50+ ft2/acre). The intent of this harvest type is to reduce hardwood competition, and to harvest merchantable conifer volume while maintaining some structural elements and retaining advanced conifer regeneration. VR may also be applied to conifer-dominated stands in specific cases after

internal approval; for example when a stand is dominated by grand fir and the HRC forestry staff wishes to re-establish RW/DF stocking, or when bear damage is so significant that a VR cut is the most prudent silviculture. VR as applied in THPs may either be dispersed or aggregate retention; VR as modeled here retains an average of 30 ft2/acre basal area in trees 4-28" DBH.

Following the modeled Variable Retention harvest, conifers are regenerated (via redwood sprouts and/or planted trees). Silvicultural activities – hardwood/brush control, pre-commercial thinning – are applied as appropriate (these activities are not explicitly modeled). The regenerated stand is grown for 40 years and then entered for selection/group selection harvest as described in Rx 361.

Modeled specifications are as follows:

Trigger Conditions

- Between 50 and 125 ft2/acre in young growth conifer trees over 12" dbh.
- Over 50 ft2/acre of hardwood trees.

Harvest Parameters

For the Variable Retention harvest:

- The first harvest for a stand may occur in any of the twenty 5-year periods.
- The DQ is 1.2, applied to 4" dbh classes.
- The residual conifer basal area is 30 ft2/acre of trees in the 4-28" diameter range.
- The 'waste percent' is 10% - reflects tree cull/damage that is not reflected in the gross/net inventory data (esp bear damage), plus logging breakage and general 'woods to mill' volume falldown.
- The harvest priority within diameter classes is 'MinCR' (harvest trees with smaller crown ratio first).
- The 'Pad' variable is set to 'Uniform' – diameter class deficits will be padded by leaving trees from all classes that have a surplus.

For subsequent Selection/Group Selection harvests:

- The stand is grown for 40 years. The subsequent cutting cycle is 20 years.
- The DQ is 1.16, applied to 4" dbh classes.
- Residual Stocking of young growth conifers is set to 90 ft2/acre of trees 10-42" DBH.
- .The 'waste percent' is 10%.
- The harvest priority within diameter classes is 'MinCR' (harvest trees with smaller crown ratio first).
- The 'Pad' variable is set to 'Uniform' – diameter class deficits will be padded by leaving trees from all classes that have a surplus.

Harvest Sequence

1) Retain all OG trees.
2) Retain 15 ft2/acre of hardwoods. Retain the largest trees to compose this 15 ft2.
3) Cut all YG conifer trees larger than 28" dbh.
4) Apply a selection harvest to all YG conifer trees in the 4-28" dbh range.

Harvest Test

For the Variable Retention harvest:

- Harvested volume must be at least 4,000 bf/acre. If less than 4,000 bf/acre is harvested then the possible harvest is eliminated.

For subsequent Selection/Group Selection harvests:

- Harvested volume must be at least 6,000 bf/acre. If it is not the harvest is eliminated; the stand is grown for an additional 10 years and the harvest is tried again.

Regeneration

- Following harvest, 80% of harvested redwood trees sprout and 50% of cut hardwoods sprout (hardwood control with moderate success is assumed).

For the Variable Retention harvest:

- Following harvest and sprouting, enough trees are regenerated to bring the 'point count' (as defined in the CA Forest Practice Rules) of each plot up to 300. This regeneration is evenly split between redwood and Douglas fir (except in the Mattole and Bear River SUs, where 100% of the regen is Douglas fir.

For subsequent Selection/Group Selection harvests:

- Following harvest and sprouting, 40 trees per acre are regenerated, evenly split between redwood and Douglas fir (except in the Mattole and Bear River SUs, where 100% of the regen is Douglas fir).

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Rehabilitation – Rx 621

As per HRC's silvicultural guidelines, rehabilitation is applied to stands with conifer stocking less than 50 ft2/acre and a significant hardwood component (20+ ft2/acre). This prescription is intended to restore conifer stocking to lands that historically had a strong conifer component that has been lost because of past harvesting or other disturbances.
Following the Rehabilitation harvest, conifers are regenerated (via redwood sprouts and/or planted trees). Silvicultural activities – hardwood/brush control, pre-commercial thinning – are applied as appropriate (these activities are not explicitly modeled). The regenerated stand is grown for 40 years and then entered for selection/group selection harvest as described in Rx 361.

Modeled specifications are as follows:

Trigger Conditions

- Less than 50 ft2/acre in young growth conifer trees over 12" dbh.
- At least 20 ft2/acre of hardwood trees.

Harvest Parameters

For the modeled Rehabilitation harvest, a harvest is applied that leaves 10 ft2/acre of

young growth conifer between 4 and 16" dbh (if it exists). Other parameters of this harvest:

- The first harvest for a stand may occur in any of the twenty 5-year periods.
- The 'waste percent' is 10%.
- The harvest priority is 'MinCR'

For subsequent Selection/Group Selection harvests:

- The stand is grown for 40 years. The subsequent cutting cycle is 20 years.
- The DQ is 1.16, applied to 4" dbh classes.
- Residual Stocking of young growth conifers is set to 90 ft2/acre of trees 12-42" DBH.
- .The 'waste percent' is 10%.
- The harvest priority within diameter classes is 'MinCR' (harvest trees with smaller crown ratio first).
- The 'Pad' variable is set to 'Uniform' – diameter class deficits will be padded by leaving trees from all classes that have a surplus.

Harvest Sequence

1) Retain all OG trees.
2) Retain 15 ft2 of hardwoods. Retain the largest trees to compose this 15 ft2.
3) Cut all YG conifer trees larger than 16" dbh.
4) Apply a harvest to all YG conifer trees in the 4-16" dbh range, leaving 10 ft2/acre.

Harvest Test

For the Rehabilitation harvest there is no minimum harvest volume.

For subsequent Selection/Group Selection harvests:

- Harvested volume must be at least 6,000 bf/acre. If it is not, then the harvest is eliminated; the stand is grown for an additional 10 years and the harvest is tried again.

Regeneration

Following harvest, 80% of harvested redwood trees sprout and 50% of cut hardwoods sprout (hardwood control with moderate success is assumed).

For the Rehabilitation harvest:

- Following harvest and sprouting, enough trees are regenerated to bring the 'point count' (as defined in the CA Forest Practice Rules) of each plot up to 300. This regeneration is evenly split between redwood and Douglas fir (except in the Mattole and Bear River SUs, where 100% of the regen is Douglas fir.

For subsequent Selection/Group Selection harvests:

- Following harvest and sprouting, 40 trees per acre are regenerated, evenly split between redwood and Douglas fir (except in the Mattole and Bear River SUs, where 100% of the regen is Douglas fir).

Appendix E – Planning Model

The Planning Databases (there is a set of planning databases for each Sustainability Unit) are a key component of the landscape planning process. Two major sets of data go into these databases:

1) Information about *Landtypes*, which are unique combinations of vegetation strata, mappable constraints, and harvest blocks. Landtype information comes directly from GIS layer attribute tables, and includes the strata code, constraint type, harvest block ID and the number of acres in that landtype.
2) *Yield stream* data from ForSee, including net BF volume values for stocking, growth and harvest for each period for every combination of strata and modeled silvicultural prescription for which harvest trigger conditions were met. Yield stream data is linked to landtypes via the strata code.

Within the planning databases these data are processed and formatted for input into linear programming software. In particular, yield streams data are eliminated for silvicultural prescriptions that are not allowed for specific landtypes; for example, landtypes that are constrained to 'No Harvest' can only be assigned to Rx 1, landtypes that are constrained to 'Selection with residual of 60% conifer canopy' can only be assigned to Rx 1, 21, 101 and 141, and so on. As noted in Appendix D, each allowed landtype/prescription combination has up to 16 timing options for the linear program to choose between; for example if a landtype is eligible for Rx 361, then Rx 361 may first be applied in the 1^{st}, 2^{nd}, 3^{rd}….. to 16^{th} period, subject to meeting silvicultural trigger conditions for each of those periods.

Harvest Blocks are an added component to the process. The purpose of including harvest blocks (i.e., delineated areas of 500-1500 acres that logically might encompass a Timber Harvest Plan) is to help produce landscape model 'answers' that are relatively realistic from an operational perspective. Yield streams and acres of landtypes that fall within each harvest block are compiled to produce a 'harvest block regime yield stream' for each timing choice. The linear program then chooses between harvest block regimes (instead of landtypes), and – while the linear program does on occasion choose to 'split' a harvest block between two or more regimes or timing choices, for the most part the linear program answer assigns a harvest block to a single regime.
[As an aside, a linear program 'answer' that optimizes a harvest schedule on a landtype basis (as opposed to harvest blocks) typically produces a result that spatially is a shotgun scatter of small harvest polygons across a landscape – not an answer that could be operationally implemented. Scheduling by harvest blocks – while not perfect – generates a more useful landscape plan.]

Following is a simplified set of tables illustrating an example of database processing from landtypes/yield streams to harvest block regimes.

Table E-1. Sample Table of Landtypes (from GIS)

SU	Landtype ID	Strata	StrataCode	Constraint	HarvBlock	Acres
SHV	L001	RW3M	S001	none	1	10
SHV	L002	RW3M	S001	NoHarv	1	5
SHV	L003	RD4P/CT3	S002	none	1	15
SHV	L004	RD4P/CT3	S002	Sel_HiCC_60con	1	8
SHV	L005	RD4P/CT3	S002	Sel_HiCC_60con	2	5
SHV	L006	RD2M	S003	none	2	20
SHV	L007	RW3M	S001	none	2	12

Table E-2. Sample Table of Harvest Yield Streams (from ForSee)

StrataCode	Rx	Start Period	Per1 Harv BF/acre	Per2 Harv BF/acre	Per3 Harv BF/acre	Per4 Harv BF/acre	Per5 Harv BF/acre	… .	Per16 Harv
S001	361	1	15,000	0	0	0	10,000		0
S001	361	2	0	17,500	0	0	0		0
S001	361	3	0	0	21,000	0	0		0
…		…							
S002	361	1	24,000	0	0	0	15,000		0
S002	361	2	0	28,000	0	0	0		0
S002	361	3	0	0	33,000	0	0		0
…									
S003	361	4	0	0	0	10,000	0		0
S003	361	5	0	0	0	0	14,000		0
S003	361	6	0	0	0	0	0		0
…									

Table E-3. Linked Landtype & Yield Stream Tables

Land Type	Strata Code	Constraint	Harv Block	Acres	Start Period	Rx	Per1 Harv	Per2 Harv	Per3 Harv	Per4 Harv	…
L001	S001	none	1	10	na	1	0	0	0	0	
L001	S001	none	1	10	1	361	15,000	0	0	0	
L001	S001	none	1	10	2	361	0	17,500	0	0	
L001	S001	none	1	10	3	361	0	0	21,000	0	
L001	S001	none	1	10	…	361	…				
L002	S001	NoHarv	1	5	na	1	0	0	0	0	
L003	S002	none	1	15	na	1	0	0	0	0	
L003	S002	none	1	15	1	361	24,000	0	0	0	
L003	S002	none	1	15	2	361	0	28.000	0	0	
L003	S002	none	1	15	3	361	0	0	33,000	0	
L003	S002	none	1	15	…	361	…				
L004	S002	Sel_60c	1	8	na	1	0	0	0	0	
L004	S002	Sel_60c	1	8	1	21	10,000	0	0	0	
L004	S002	Sel_60c	1	8	…	21	…				

Table E-4. Harvest Block Table

Harv Block	Acres	Start Period	Regime	Per1 Harv (total bf)	Per2 Harv (total bf)	Per3 Harv (total bf)	…
1	38	na	R001	0	0	0	
1	38	1	R361	510,000	0	0	
1	38	2	R362	0	690,000	0	
1	38	…					

Note that in Table E-3 landtype L002 - which has a NoHarv constraint – is only allowed to use Rx 1. In Table E-4 the Harvest Blocks are summed into harvest block 'regimes'; Regime R361 assumes that harvests will take place in period 1 wherever possible, Regime R362 starts in period 2 and so on. An expanded version of Table E-4 is formatted for the linear program, and the linear program can then 'choose' to allocate the 38 acres in Harvest Block 1 to Regime R001, R361, R362 etc., in combination with the choices being made for all other Harvest Blocks in this Sustainability Unit.

The set-up work for the linear program also includes specifying the allowed percentage increase or decrease in yields between periods, and specifying a volume 'discount rate', i.e., the relative 'value' of a board foot harvested now compared to a board foot harvested in the future.

A linear program run may be infeasible if the constraints specified are such that there is no possible yield schedule. If the run is feasible, then the linear program returns an answer file listing of the number of acres in each Harvest Block that is allocated to each regime. Linking this answer backwards through the tables in the Planning Databases it's then possible to (1) map the resulting landscape plan alternative in GIS, and (2) query ForSee output tables to generate a variety of tables displaying trends in stocking, growth, basal area, canopy cover, carbon storage, etc., as well as harvest yields. These maps and data are then reviewed to determine whether modifications to constraints, prescriptions, or database processes are needed.