Final Report

Montana Department of Natural Resources & Conservation

State Trust Lands Sustainable Yield Calculation

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MB&G

Natural Resource Consultants Since 1921

Final Report

Montana Department of Natural Resources & Conservation:

State Trust Lands Sustainable Yield Calculation

Contents

List of Figures

List of Tables

List of Acronyms

**ARM: ** Administrative Rules of Montana. Agency regulations, standards or statements of applicability that implement, interpret, or set law or policy. DNRC has adopted ARMs that address Forest Management on forested state trust lands.

BA: Basal Area. The cross-sectional area of the bole of a tree measured at breast height, expressed in square feet per acre.

BBF: Billion Board Feet. A unit of measure for timber volume expressed in billions of board feet.

CCRX: Clear-Cut Management Prescription. An aggregate term for even-aged management pathways (EARX) that terminate in a regeneration harvest, which leaves 4 trees per acre (leave trees) as an over-story contribution towards the regenerated stand. These leave trees are not reduced with a second entry harvest.

CE: Central Land Office. A DNRC administrative office that includes all the administrative units from the central part of Montana. Units included in the Central Land Office are Bozeman (BOZ), Conrad (CON), Dillon (DIL) and Helena (HEL).

CT: Commercial Thinning. A silvicultural treatment incorporated into even-aged management pathways (EARX), which calls for a partial harvest that reduces the trees per acre down to a predetermined threshold. Volume removed is considered commercial since harvest is scheduled at an age which should produce merchantable trees. The purpose of this treatment is to reduce the competition between trees for resources, allowing the retained trees to potentially accelerate growth.

DBH: Diameter at Breast Height. A measure of the diameter of a tree at 4.5 feet above ground level (breast height).

DNRC: Department of Natural Resources and Conservation. The state agency tasked with managing the Montana trust lands to create revenue for the beneficiaries, while considering environmental factors and protecting the future income-generating capacity of the land.

EA: Eastern Land Offices. A collective term for the Land Offices and administrative units from the eastern part of Montana. Land Offices included are Southern, Northeastern and Eastern. Units included are Billings (BIL), Glasgow (GLA), Havre (HAV), Lewistown (LEW) and Miles City (MIL).

EM: Eastern Montana. A term used in reference to the Forest Vegetation Simulator (FVS) variant for the eastern parts of Montana (Central and Eastern Land Offices).

EARX: Even-Aged Management Prescription. An aggregate term for management pathways terminating in a regeneration harvest, during which the majority of trees are removed, resulting in a single-age regenerated stand (single canopy structure). Some of these pathways include options to do pre-commercial and commercial thinning.

FIA: United States Forest Service Forest Inventory and Analysis. A program of the United States Forest Service, tasked with running a continuous national census on forest land, and predicting the future state of forests.

FVS: Forest Vegetation Simulator. A growth and yield simulator developed by the United States Forest Service for predicting the future forest conditions. It was used in the 2015 sustainable yield calculation to predict the future yields from DNRC lands under various management pathways.

GIS: Geographic Information System. A computerized system for storing and analyzing spatial data. GIS was used extensively in the 2015 sustainable yield calculation to establish the location of stands for growth modeling, as well as their participation in various wildlife and habitat constraints.

GORX: Grow-Only Management Prescription. A management pathway with no active management anywhere along the planning horizon (i.e. no regeneration harvest, thinning, or selection harvest).

GZB: Grizzly Bear. A term commonly used in this report, which refers to various habitat constraints applied that mitigate adverse effects to grizzly bears.

HCP: Habitat Conservation Plan. A plan prepared under Section 10 of the Federal Endangered Species Act to conserve threatened and endangered species. The HCP is a 50-year cooperative plan with the United State Fish and Wildlife Service that contains minimization and mitigation measures for grizzly bear, Canada lynx, bull trout, west-slope cutthroat and Columbia red-band trout. These conservation measures are applied to minimize effects to the covered species from implementation of forest management activities. Applicable constraints were developed for these measures and applied in the calculation model.

IE: Inland Empire. A term used in reference to the Forest Vegetation Simulator (FVS) variant for the western parts of Montana (Northwestern and Southwestern Land Offices).

LMA: Lynx Management Area. A key geographic area in the context of DNRC ownership that is of notable importance for lynx. LMAs are delineated zones that contain forested trust lands where increased levels of lynx conservation commitments are applied. Within these areas, records indicate that lynx are likely present (or have been in the relatively recent past) or lands are considered important for maintenance of resident lynx populations.

LP: Linear Programming. A mathematical programming technique used to solve problems that contain a series of linear equations, which can be subdivided into an objective function that needs to be optimized, and a set of constraints that limits the extent of the optimization.

MB&G: Mason, Bruce & Girard. A natural resource management consultancy based in Portland, OR which was hired by the DNRC to perform the 2015 sustainable yield calculation.

MCA: Montana Code Annotated. Codification and compilation of existing Montana state general and permanent law.

MBF: Thousand Board Feet. A unit of measure for timber volume expressed in thousands of board feet.

MMBF: Million Board Feet. A unit of measure for timber volume expressed in millions of board feet.

NW: Northwestern Land Office. A DNRC regional administrative office that includes all the administrative units from the north-western part of Montana. Units included in the Northwestern Land Office are Kalispell (KAL), Libby (LIB), Plains (PLN), Stillwater (STW) and Swan (SWN).

NDY: Non-Declining Yield. A term used in context of harvest scheduling and controlling the period-on-period difference in harvest volumes, where the volume for each planning period is allowed to increase from one period to the next, but not decrease.

OGRX: Old-Growth Management Prescription. An aggregate term for all old-growth management pathways that include a selection harvest (partial harvest). Harvests occur on a periodic basis (30 or 50 years) and trees are selected for harvest based on a basal area target for the stand as a whole, as well as a trees per acre target for large trees (large defined by a DBH threshold). The objective of these management pathways is to allow selection harvest from old-growth stands, while sustaining the ecological condition and maintaining their old-growth status.

OS: Over-Story. The trees that are kept after the regeneration harvest on even-aged management pathways (EARX) for the purposes of aiding the regeneration of the next stand of trees. The composition of the over-story is dependent on the even-aged management objective (CCRX, STRX, or SWRX), as well as the timing and intensity of removal during the second entry harvest.

PCT: Pre-Commercial Thinning. A silvicultural treatment in seedling/sapling stands incorporated into even-aged (EARX) and uneven-aged (UERX) management pathways, which calls for a partial harvest that reduces the trees per acre down to a predetermined threshold.

QMD: Quadratic Mean Diameter. A measure of the diameter at breast-height for the tree of average basal area in a sample of trees.

RMZ: Riparian Management Zone. Under the DNRC HCP and Forest Management Administrative Rules (ARMs 36.11.401 through 36.11.450), an RMZ refers to streamside buffer established when forest management activities are proposed on sites with high erosion risk or on sites that are adjacent to fish-bearing streams or lakes (ARM 36.11.425).

SDI: Stand Density Index. A measure of tree stocking, expressing the degree to which trees are utilizing the available growing space. Calculation is based on the number of trees and the diameter at breast height of the tree with average basal area.

SFLMP: State Forest Land Management Plan. A programmatic plan adopted by DNRC in 1996 that provides the philosophical basis and technical rationale for DNRC's forest management program on state trust lands. The resource management standards contained in the selected alternative were adopted into administrative rules in 2003.

SLI: Stand Level Inventory. The DNRC's central repository for all stand register data. Each record in this database represents a single stand, with a stand defined as a piece of land that is uniform with regards to the properties of its vegetation and is identified through a known stand boundary. These stand boundaries are contained within the agency's Geographic Information System (GIS), which is fully integrated with the SLI.

STRX: Seed-Tree Management Prescription. An aggregate term for even-aged management pathways (EARX) that terminate in a regeneration harvest, which leaves 8 trees per acre (leave trees) as an over-story contribution towards the regenerated stand. On approximately half of the stands treated with this prescription, the leave trees are reduced to 4 trees per acre with a second entry harvest, 10 years after the regeneration harvest.

SW: Southwestern Land Office. A DNRC regional administrative office that includes all the administrative units from the south-western part of Montana. Units included in the Southwestern Land Office are Anaconda (ANA), Clearwater (CLW), Hamilton (HAM), and Missoula (MSO).

SYC: Sustainable Yield Calculation. A calculation that represents the harvest volume that can be sustained over the planning horizon, given the projected stand yields, habitat constraints, and an inventory of standing trees in the final planning period that can theoretically sustain the same harvest volumes beyond the planning horizon.

SWRX: Shelter-Wood Management Prescription. An aggregate term for even-aged management pathways (EARX) that terminate in a regeneration harvest, which leaves 25 trees per acre (leave trees) as an over-story contribution towards a regenerating stand. On approximately half of these stands, leave trees are reduced to 4 trees per acre with a second entry harvest, 20 years after the regeneration harvest.

TPA: Trees per Acre. The estimated count of trees (stems) on one acre of land.

UERX: Uneven-Aged Management Prescription. An aggregate term for management pathways that include a selection harvest (partial harvest). Such harvests occur on a periodic basis (30 or 40 years) and trees are selected for harvest based on a pre-determined DBH distribution. This distribution is an abstraction of what a multi-aged stand (heterogeneous canopy structure) would look like, and trees are selected for harvest in such a manner as to move the stand closer to this distribution. Some of these pathways include options to do pre-commercial and commercial thinning.

UMZ: Unique Management Zone. Land parcels with unique management considerations, due to their inclusion in Conservation Agreements & Easements, as well as Federal Wild & Scenic River Corridors.

USFS: United States Forest Service. The agency of the U.S. Department of Agriculture charged with managing the national forests.

List of Technical Terms

Commercial Forest Land: Timber land capable of growing commercial crops of trees. Land that can grow 20 cubic feet of timber volume per acre per year.

Cruise: To take field measurements of trees in a timber stand. Cruising is a statistical sampling technique.

Deferred Land: Timber land not managed for timber production due to other administrative uses, topographic constraints, and/or other physical factors, accessibility problems, or high development costs relative to timber values.

Even-Aged Management: A management regime culminating in a final harvest. Trees in the newly regenerated stand will be of a similar age.

Even-flow: A term used in context of harvest scheduling and controlling the difference between subsequent periods in harvest volumes, where the volume for each planning period has to be exactly the same.

Forest Vegetation Simulator (FVS) -A forest growth and yield model developed and maintained by the U.S. Forest Service. FVS provides a platform to simulate and estimate the effects of various forest management activities on forest conditions, growth, and yield. FVS uses geographic variants to estimate potential forest growth for different regions in the U.S. The Inland Empire (IE) and Eastern Montana (EM) variants were used for this calculation.

Grizzly Bear Security Zones: Areas within the DNRC Stillwater Unit intended to provide security for grizzly bears, which generally meet the Interagency Grizzly Bear Committee definition of "Core." For this calculation, the Security Zone Areas were based on land areas identified in a negotiated settlement (August 20, 2015) between DNRC and Plaintiffs in a lawsuit involving the DNRC Forest Management Habitat Conservation Plan. Of the 22,007 acres of security zones identified in the settlement agreement, 20,370 commercial acres were identified and deferred from harvest.

Land Board: The State Board of Land Commissioners consists of Montana's five top elected officials who direct the management of State trust lands administered by the Department of Natural Resources and Conservation.

Maximum Biological Potential: The highest level of timber harvest that could be sustained, assuming all commercial timber land is available for harvest, and optimal management regimes could be implemented. This is a measure used to benchmark the productivity of a forest.

Management Regime: A schedule of specific management actions to be applied to a timber stand over time. Management actions may include activities such as natural regeneration, pre-commercial thinning, commercial thinning, regeneration harvest, selection harvest, etc.

Old Growth: A timber stand is designated as "old growth" if it meets the old-growth minimum criteria found in Green *et al*. (1992) as adopted by the DNRC.

Planning Horizon: The number of years, or planning periods, for which a strategic planning effort makes future predictions.

Second Entry Harvest: The second harvest associated with even-aged management pathways (EARX), where the over-story of trees kept after the regeneration (first) harvest are reduced to the final number of trees per acre.

Sustainable Yield: "…the quantity of timber that can be harvested from forested state lands each year in accordance with all applicable state and federal laws, including but not limited to the laws pertaining to wildlife, recreation, and maintenance of watersheds, and in compliance with water quality standards that protect fisheries and aquatic life and that are adopted under the provisions of Title 75, chapter 5, taking into account the ability of state forests to generate replacement tree growth." (MCA 77-5-221)

Tariff Equations: Equations that the DNRC uses to calculate Scribner board foot volumes for a tree, given the species, height and DBH of the tree.

Timber Stand: A tract of forest land relatively homogenous with respect to species mix, size and stocking of tree species. The minimum stand size is five acres.

Timber Type: A code assigned to each timber stand describing the existing species mix, size class and stocking class.

1 Acknowledgements

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Finally, we acknowledge the contributions of Dave Mason, founder of our firm in 1921. His early and zealous advocacy for sustainable forest management practices have had long lasting impacts on how our society views and manages our forest resources.

2 Executive Summary

The Trust Land Management Division of the Montana Department of Natural Resources (DNRC) manages approximately 750,000 commercial forest acres for the benefit of the Common Schools and other endowed institutions. Management activities on those lands focus on providing a consistent and long-term revenue source for the trust beneficiaries, which is generated by selling a consistent annual timber volume. The amount of timber sold annually is determined through a sustainable yield calculation (MCA 77-5-223).

The last sustainable yield calculation was performed in 2015 in conjunction with the acquisition of approximately 67,000 acres of land to the DNRC's timber base. The passage of Senate Bill 154 in the 2013 Montana Legislative Session required DNRC to conduct this calculation, which set a sustainable harvest level of 56.9 million board feet (MMBF) annually. Mason, Bruce, and Girard, Inc. performed that calculation.

Since that last calculation in 2015, DNRC has acquired ±13,000 acres of former industry-owned timber land, primarily in the Stillwater Unit. Pursuant to state law (MCA 77-5-222), requiring that an independent third party conduct the calculation, the DNRC contracted with Mason, Bruce & Girard in 2019 to perform the calculation.

For this sustainable yield calculation, the DNRC relied on data collected from its own lands in 2014 and 2018 and used FVS growth model calibrations developed by the U.S. Forest Service and MB&G. For this calculation the DNRC also emphasized using the professional expertise of its field staff for several facets of the project, including updating areas deferred from active management, identifying lands suitable for helicopter and cable logging, designing management regimes, and verifying growth and yield projections. The DNRC used the Inland Empire and Eastern Montana variants of the Forest Vegetation Simulator[1], both of which are specific to Montana forests, for growth and yield projections.

For this calculation, MB&G evaluated two scenarios. The first scenario incorporated all of DNRC's commercial timber acres, including newly acquired lands, and all of DNRC's programmatic and operational management constraints, resulting in an annual sustainable harvest level of 68.3 MMBF.

The second scenario was designed to determine the impact of the ±13,000 recently acquired acres on the sustainable yield. For that scenario, the acquired lands were withdrawn from the model developed for the first scenario where all commercial forest acres were available for management, resulting in an annual sustainable harvest level of 66.8 MMBF and inferring that the addition of those lands contributes 1.5 MMBF to the annual sustainable yield.

For all scenarios, acres identified as suitable only for helicopter logging did not contribute to the annual sustainable yield and were considered to provide an opportunistic amount of volume

[1] Documentation and software available at https://www.fs.fed.us/fvs/index.shtml

above and beyond the calculated yields when markets permit. When market conditions are feasible for helicopter logging, those lands could contribute an additional 1.4 MMBF to the annual sustainable yield.

The results of this calculation show an increase of approximately 20 percent in the annual sustainable harvest volume compared to the previous calculation from 2015 (68.3 MMBF vs. 56.9 MMBF). There are several important factors that distinguish this effort from the prior effort and that provide a significant contribution to these results. DNRC carefully examined its inventory data and associated cruise plot data used for growth and yield modeling and found weak correlation between the timber strata as identified in its inventory and as described by the cruise plots for sampled stands. To improve the correlation of inventory and cruise data and therefore the accuracy of the calculation, DNRC re-stratified both its inventory data and plot data into new species groups and stocking classes for this calculation. DNRC also re-evaluated the calibration used in the FVS growth and yield model, and for this calculation used western root disease model calibrations for the IE variant of FVS developed by the U.S. Forest Service, and a calibration developed by MB&G and the Custer-Gallatin National Forest for the EM variant of FVS. DNRC also re-evaluated acres deferred from management in the 2015 calculation and made many of those acres, particularly in the Central and Eastern areas, available for harvest.

3 Purpose, Need and History

3.1 Purpose of and Need for the Sustainable Yield Calculation

The Trust Land Management Division of the Montana Department of Natural Resources and Conservation (DNRC) Forest Management Program manages approximately 930,000 forested acres for the benefit of the Common Schools and other endowed institutions. Of those 930,000 acres, approximately 750,000 acres are commercial forest land. Commercial forest land includes those lands that are dominated by commercial conifer species and have potential productivity greater than 20 cubic feet/acre/year. DNRC manages trust lands to "produce revenues for the trust beneficiaries while considering environmental factors and protecting the future income-generating capacity of the land."[2]

On forested trust lands, the DNRC's management standards and philosophy are guided by the State Forest Land Management Plan (SFLMP)[3], associated Administrative Rules (ARM)[4] and the DNRC's Forested State Trust Lands Habitat Conservation Plan (HCP)[5]. Management is based on maintaining biodiversity and sustainability, while utilizing active forest management[6]. Annual activities on forested state trust lands are aimed at generating income, monitoring and improving practices, investing in the future productivity of forested stands, and conserving an array of resources.

Revenue from forested state trust lands is primarily derived from the sale of forest products. State law directs the DNRC to sell a consistent amount of timber each year, as determined by the annual sustainable yield calculation, which in turn provides a consistent revenue source for the trust beneficiaries.[7] State law also requires that the DNRC, under the direction of the State Board of Land Commissioners (Land Board), commission an independent third party to calculate the annual sustainable yield for forested state trust lands at least once every 10 years.[8] Annual sustainable yield is defined as:

"…the quantity of timber that can be harvested from forested state lands each year in accordance with all applicable state and federal laws, including but not limited to the laws pertaining to wildlife, recreation, and maintenance of watersheds, and in compliance with water quality standards that protect fisheries and aquatic life and that are adopted under the provisions of Title 75, chapter 5, taking into account the ability of state forests to generate replacement tree growth."[9]

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[2] Mission Statement, Trust Lands Management Division, Montana Department of Natural Resources
[3] Montana DNRC, State Forest Land Management Plan, 1996
[4] Administrative Rules of Montana for Forest Management, 2003
[5] Montana DNRC, Forested State Trust Lands Habitat Conservation Plan Record of Decision, December 2011.
[6] Montana DNRC, Trust Lands Management Division Annual Report FY 2014
[7] Montana Code Annotated (MCA) 77-5-223
[8] MCA 77-5-222
[9] MCA 77-5-221

Periodic recalculation of sustainable yield is necessary to incorporate changes in management intensity or emphasis, or as new laws and regulations are applied.

In 2019, the DNRC contracted with Mason, Bruce & Girard, Inc. (MB&G) to perform the sustainable yield calculation. Established in 1921, MB&G is a natural resources consulting firm located in Portland, Oregon. MB&G has performed similar calculations for a variety of federal, state, private and tribal landowners across the US. MB&G performed the DNRC's previous three sustainable yield calculations in 2004, 2011, and 2015.

3.2 History

3.2.1 Past Sustainable Yield Calculations

DNRC has calculated a sustainable yield six times in the past 40 years. Table 1. provides summary information for the five prior calculations.

Table 1: Past Sustainable Yield Calculations

Year	Sustainable Yield	Acres Receiving Management
1983[10]	50.0 MMBF	399,700
1996[11]	42.2 MMBF	363,769
2004[12]	53.2 MMBF	430,784
2011[13]	57.6 MMBF	469,159
2015	56.9 MMBF	570,511

The last sustainable yield calculation was completed in September 2015 by MB&G. That study determined that the annual sustainable harvest level was 56.9 MMBF.[14]

From FY 1997 through FY 2003, the DNRC based the timber sale program on the 1996 calculation. In 2003, the Legislature directed the DNRC to sell 50 MMBF annually.[15] In 2004, the annual sustainable yield was calculated to be 53.2 MMBF; this calculation also served as the baseline for the no-action alternative for DNRC's HCP. The DNRC based its annual timber sale requirement on the 2004 calculation until 2012 when its HCP was adopted, increasing the annual sustainable yield to 57.6 MMBF. Between 2011 and 2015, DNRC acquired approximately 67,000 acres of commercial forest land, prompting a new calculation to incorporate production from those acres into DNRC's annual sustainable yield. At the same time, the DNRC resolved a lawsuit regarding

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[10] Sheartl, Dick, Montana Department of Natural Resources, Allowable Cut Report, August 26, 1983

[11] Arney, James D., The Annual Sustained Yield of Montana's Forested State Lands, December 1996.

[12] Mason, Bruce & Girard, 2004 Sustained Yield Calculation, State of Montana Department of Natural Resources, November 20, 2004.

[13] Montana DNRC, Forested State Trust Lands Habitat Conservation Plan Record of Decision, December 2011.

[14] MBF – thousand board feet; MMBF – million board feet; BBF – Billion board feet, all in Scribner measure. A typical log truck holds 4-5 MBF.

[15] 77-5-222 MCA, 2003

the HCP that resulted in the creation of "security zones" for grizzly bears in the Stillwater Unit, and the terms of the settlement of that lawsuit were included in the calculation, resulting in an annual sustainable yield of 56.9 MMBF.

The annual timber sale program since 1997 is shown in **Figure 1**.[16] In some years, sold volumes exceeded the basis provided by the sustainable yield calculation due to timber salvage activities following wildfires or insect infestations that required timely entry to capture the value of the standing dead timber, or less frequently due to resale of unsold volume that was offered for sale in prior years.

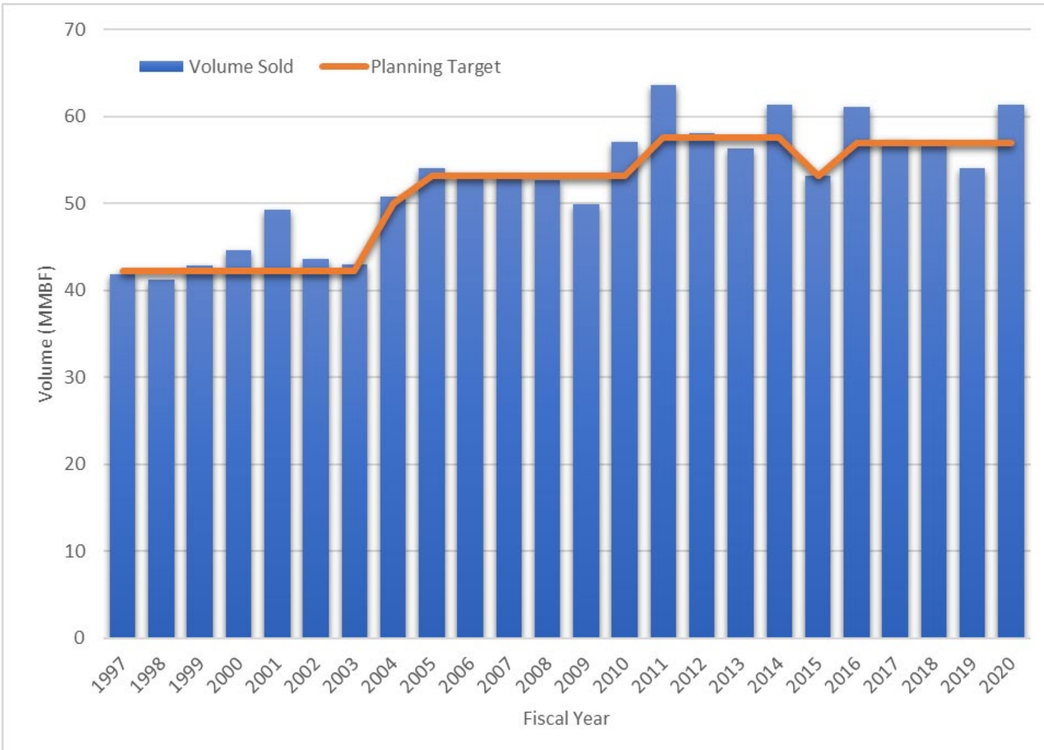

Figure 1: Volume sold from State Lands, FY 1997-2020 (MMBF, saw timber)

3.2.2 Changes since the 2015 Sustainable Yield Calculation

In the report for the 2015 calculation, MB&G made three recommendations to the DNRC to improve on the efforts made for that calculation as well as previous efforts:

1. Collect cruise information in areas/strata that have not been cruised and collect additional plot data to strengthen future inventory calculations.
2. Improve stand inventory data, particularly stand age and productivity estimates
3. Continue and expand FVS calibration

[16] Note that Figure 1 shows volume sold, not volume harvested. While revenues ultimately flow to the beneficiaries based on harvest, the volume sold is a more direct measure of DNRC annual timber sale effort. Volume sold for FY 2015 is estimated.

In response to those recommendations and to produce improved results over prior sustainable yield calculation efforts for this calculation, DNRC initiated several steps to increase its understanding of conditions on, and affecting forested state trust lands, as well as the quality of its data:

- DNRC expanded on its 2014 cruise information by cruising stands belonging to timber strata in the NWLO, SWLO, and CLO that had no or minimal cruise information. This cruise was conducted in 2018 and included 43 stands with a total of 765 plots, resulting in a grand total of 358 stands and 6,058 plots representing 53 timber strata (not including productivity class designations within strata) in the NWLO, SWLO, and CLO. Approximately 89 percent of acres in the NWLO, SWLO, and CLO are in strata that have at least one stand that has been cruised [the EA area relies on U.S. Forest Service Forest Inventory and Analysis Data (FIA) as the source of tree list data for growth and yield models; DNRC has not conducted any cruise sampling in that area].
- DNRC carefully examined its inventory data and associated cruise plot data used for growth and yield modeling. To improve the correlation of inventory and cruise data and therefore the accuracy of the calculation, DNRC re-stratified both its inventory data and plot data into new species groups and stocking classes for this calculation. This resulted in a significant reduction in the number of timber strata compared to the 2015 calculation, and also necessitated the development of a new set of yield tables for growth and yield modeling.
- DNRC has kept its Stand Level Inventory (SLI) current through monthly updates each year. Updates are based on harvest activities or on re-visitation of individual stands. DNRC also collected new stand-level inventory on its newly acquired acres in the Stillwater and Libby Units in 2019 for inclusion in this calculation.
- DNRC updated its productivity classes to a consistent statewide standard that matches the productivity classes used by the U.S. Forest Service FIA program as opposed to defining separate productivity classes for each Land Office.
- DNRC updated its growth and yield model calibration using western root disease model calibrations developed by the U.S. Forest Service for the IE variant of FVS, and used a calibration developed for the Custer-Gallatin National Forest by MB&G for the EM variant. DNRC also opted to use the IE variant of FVS for the CLO as opposed to the EM variant that was used in 2015; the EM variant is now used only in the EA area. These calibrations resulted in increased growth rates across all Land Offices compared to 2015 and that are in line with published growth rates for Montana as well as anecdotal growth rates from industrial private forest landowners in Montana.
- DNRC undertook measures to update several other data sources, including road and hydrology GIS layers, which resulted in a more accurate representation of the amount and location of those features and their impacts on management.
- DNRC used an ArcGIS online project with its foresters to review and reclassify stands that are deferred from management. For this exercise, DNRC reviewed and revised stand

deferral criteria, resulting in a more accurate representation of stands that are not currently available for management due to factors including topography, wet areas, low productivity, low timber value combined with high development costs, inaccessibility, timber conservation licenses, and other land uses, among others.

3.3 Uses & Limitations

This sustainable yield calculation is based on a great deal of spatial and tabular data about the forest. Some of the data are site specific, other data are more generalized. A Forest Management Model was designed to address strategic level questions.[17] Specifically, the model was designed to provide a reasonable and defensible estimate of:

- A sustainable harvest level from DNRC lands, along with associated revenues;
- The interaction between management, and wildlife habitat and water resource constraints; and
- A projection of forest conditions across DNRC lands.

Given the data and effort invested in the modeling effort, it may be tempting to try to use the model for purposes beyond the stated objectives. As discussed below, however, the model has limited spatial capabilities. Readers are cautioned against trying to use the model for more tactical, operational or site-specific tasks. While the model might be used to analyze general management strategies, for example, it should not be used to locate harvests into specific stands or under specific management regimes.

[17] Strategic questions: How should we manage this forest to meet objectives? What kinds of management regimes are most compatible with our objectives? How important are current investments for meeting future harvest objectives?
Tactical questions: Which roads should we build and which stands should we harvest first?
Operational questions: Where should the landing go?

4 Data and Methods

In this section, we discuss the source data for each component of the 2020 calculation and relevant differences between the models used for the 2020 and 2015 SYCs. Included are a general overview of the modeling approaches describing the main components of the models and their relationship to each other. This is followed by a detailed discussion of the components with emphasis on describing the land information used, how this was compiled into an inventory estimate, growth predictions, and optimization of the sustainable yield calculation.

4.1 Overview of the Forest Management Model

The objective of the forest management model is to find the optimum sustainable harvest for the land managed by the DNRC, subject to fulfilling the agency's obligations towards wildlife habitat, water resources, managing the land towards a desired future condition, and the operational constraints inherent to the organization.

The data and methods used in this analysis will be discussed in detail below. In short, the modeling effort consisted of combining the cruise and SLI data through a stratification process into an inventory estimate, which described the current state of the forest. The data from this process were used in FVS in conjunction with management pathways to make future yield projections. These projections were used within a LP modeling framework to optimize the sustainable harvest level subject to meeting wildlife, water resource, and operational constraints.

4.2 Land Base

The description of the land base provided estimates of acres, content (what is on these acres) and location (where is it) used in the modeling framework, and it played a pivotal role in stratification, inventory calculation, management pathway allocation and setting the starting condition for the LP optimization model. Within the DNRC Forest Management Program, the SLI is the central repository for all land data.

4.2.1 The Stand Level Inventory (SLI)

The DNRC's Stand Level Inventory is the central repository for all of the agency's stand inventory data. The SLI is contained within DNRC's Geographic Information System (GIS). Each record in the SLI represents a single stand defined by a boundary that has uniform site characteristics (slope, aspect, elevation, habitat type, etc.) and vegetation. The SLI contains approximately 29,800 stand records, of which approximately 27,890 are commercial forested land. Each SLI record contains data describing numerous attributes of each stand; of those, the following were essential to this calculation:

Table 2: List of Key SLI Parameters

Land Office	The DNRC administrative Land Office to which the stand belongs
Unit	The DNRC administrative unit, within a Land Office boundary, to which the stand belongs
Species	A description of timber type, in terms of major species
Size	The existing dominant tree (timber) size in inches
Stocking	The density of trees in the stand expressed as trees per acre
Age	An estimated average age for the stand
Productivity	The expected average productivity of a stand in terms of ft^3/acre/year
Habitat Type	The stand's habitat type classification following Pfister et al. (1977)[18]
Acres	The net acres contained within the stand

SLI data is typically gathered by directly visiting a stand ("walk-through") or photo interpretation data gathering. The SLI database used in this analysis was current as of September 2019.

4.2.2 Other Information about the DNRC Commercial Forest Land Base

Several GIS layers were used to incorporate wildlife habitat and operability considerations into the model. The following data were incorporated into the model through a series of GIS overlay analyses:

Table 3: Additional DNRC Forested Land Base Information

Deferred	Acres deferred from management, due to operational issues such as legal access, topography, excessively wet areas, and cabin site leases.
Riparian Management Zone (RMZ)	"No harvest" zones established immediately adjacent to Class 1 streams and lakes in accordance with the DNRC Forest Management HCP.
Unique Management Zone (UMZ)	Conservation Agreement & Easement areas, as well as Federal Wild & Scenic Corridors.
Helicopter Harvest Acres	Stands only operationally feasible to be logged by helicopter.

[18] Pfister, R.D, B.L. Kovalchik, S.F. Arno, R.C. Presby. 1977. Forest Habitat Types of Montana. USDA Forest Service, Gen. Tech. Rep. INT-34, Intermountain Research Station, Ogden, UT.

Cable Harvest Acres	Stands only operationally feasible to be logged using cable (skyline) harvest systems.
Sensitive Watersheds	DNRC parcels that lie within watersheds that are designated as sensitive to increases in water yield. Harvest levels in these watersheds need to be managed within the ARMS and HCP commitments governing cumulative watershed effects.
Grizzly Bear	Two defined land areas exist (1. Recovery Zone, and 2. Non-recovery Occupied Habitat lands) that contain DNRC lands, where distinct constraint sets relevant to habitat management for grizzly bears are required.
Lynx Management Areas	Seven defined areas of notable importance for lynx conservation containing DNRC ownership. Several habitat parameters must be maintained above minum threshold levels in these areas requiring a specific suite of management constraints.
Potential Lynx Habitat	Stands of appropriate Habitat Type (Pfister et al. 1977) that are, or have the potential to become, lynx habitat, with management actions aimed at attaining habitat attributes.
Bald Eagle Nesting Site	Bald eagle nest locations on or near DNRC lands, which must be managed to maintain the suitability of the site for nesting.

4.2.3 Source of Stand Table Data

For the NWLO, SWLO, and CLO (hereafter NW, SW, and CE) Land Offices, cruise data collected from DNRC land in 2014 and 2018 served as the source data to describe timber strata and develop stand tables for those Land Offices. For the NELO, SLO and ELO (hereafter EA Land Offices), the same FIA data used in the 2014 calculation was used. Descriptions of the cruise design and data collected can be found in Chapter 4 of the 2015 SYC report.

Following MB&G's recommendation in the 2015 SYC report, DNRC collected supplemental cruise data from strata in the NW, SW, and CE areas in 2018 to collect or strengthen information for strata that had no or minimal cruise data. When combined with the cruise data collected for the 2015 SYC, DNRC sampled 358 stands with 6,058 individual plots (Table 4).

Table 4: Number of Stands Sampled and Plots Collected by Land Office

Land Office	Stands Sampled	Plot Count
CE	48	801
NW	184	3,134
SW	126	2,123
Total	**358**	**6,058**

DNRC used the same FIA plot data to develop tree lists for DNRC's East-side timber strata that was used in the 2015 SYC.

4.2.4 Stratification of Timber Types

As with the 2015 SYC, a strata-based approach, rather than a stand-based approach, was used to generate both inventory, and growth and yield information for the 2020 SYC. Each stand in the SLI was grouped into a stratum defined by a unique combination of Land Office, species, size class, stocking, and productivity class.

To improve correlation between the cruise information and SLI and produce more accurate inventory and growth and yield model estimates, DNRC re-stratified both the inventory cruise data collected in 2014 and 2018 and its SLI. The forest types defined in the SLI were grouped according to forest types that occupy similar sites (e.g., ponderosa pine and Douglas-fir on warm/dry sites or grand fir, western redcedar, western hemlock, and western white pine forests on moist sites), and the "moderate-" and "well-stocked" classes were grouped into a single "adequate" stocking class. Adjustments were also made to size class information for some stands, particularly stands classified as sawtimber in the SLI that had been previously harvested using even-aged methods and that were dominated by seedling/sapling or poletimber-sized trees.

After the new strata defined by the re-stratification process were applied to the SLI and cruise data, the cruise plot data within a given strata were compiled to produce a tree list representing an average condition. This process did not deliver a tree list for every stratum, because in some cases there were no plot data within certain strata. In such cases, these empty strata were assigned a substitute tree list from a stratum with plot data that were closest in terms of vegetation, with priority given to matching species, size class, and stocking, respectively.

To estimate differences in site productivity within each stratum, low, medium and high productivity variants of each stratum were generated by producing three copies of the tree list for the stratum and then growing each with a different estimate of future growth potential corresponding to low, medium, and high-productivity sites. Estimates of future growth potential were differentiated by using different habitat types and site index depending on the productivity class (see 0).

4.2.5 *Timber Cruise Compilation and Initial Inventory Estimate*

As described in Section 4.2.3, two sets of cruise data were used to produce tree lists and stand tables for each stratum:

- DNRC SYC cruise data for the NW, SW, and CE Land Offices
- USFS FIA inventory data for the Eastern Land Office.

Using the final version of each set of cruise data, an MBGTools[19] database was built to process the data for each Land Office. All the cruise data was compiled and merchandized using MBGTools utilities. The following merchandizing specifications were specified by DNRC:

- Minimum DBH = 6 inches
- Stump Height = 1.0 foot
- Log Length = 16 feet
- Minimum Top DIB = 6 inches
- Minimum Log Length = 8 feet
- Trim Amount – 2.5 percent
- Observed tree defect from inventory data
- Unseen cull & breakage default value by species
- Scribner Decimal C Short Log Rule

Following cruise compilation for each stratum in MBGTools, the compiled results for each stratum were multiplied by the number of acres in each stratum and aggregated to produce an initial estimate of standing inventory.

4.2.6 *Yield Table Development*

This section describes the process of calibrating the growth and yield model and applying management actions to the growth predictions to create the yield projections required for the LP model.

4.2.6.1 FVS Variants

As with the 2015 SYC, FVS was used to predict future forest conditions, growth, and yield associated with various types of management actions. For the NW, SW, and CE Land Offices, the Inland Empire (IE) variant of FVS was selected, and the Eastern Montana (EM) variant was selected for EA Land Offices. Initially, the EM variant was selected for the CE Land Office; however, the results were unsatisfactory for certain strata, so the IE variant was selected for some strata in the CE Land Office despite being outside the geographic range defined for that variant.

[19] MBGTools is a comprehensive software system for stand-based forestry inventory data compilation and management.

4.2.6.2 Background

All yield tables were created in MBG's YTGTools application. This is a custom application created by MBG, which utilizes FVS to grow tree lists forward on a period-by-period basis.

A period length of 10 years was used, implying that the difference between subsequent model periods represents ten years of growth. The only exception to this was period one, which represented five years of growth (from period zero to period one). The rationale in this was that the yield table for each stratum should represent the average condition over the ten-year time span; by setting the first growth interval to five years, the quantities in the yield tables reflect the periodic mid-point average in all subsequent periods. Each yield table was grown for 20 periods, thereby representing 200 years of growth.

All yield tables were post-processed to perform a gross to net volume adjustment on inventory and harvest volumes using DNRC's tariff equations.

4.2.6.3 Habitat Types

Forest habitat type information (Pfister et al. 1977) is used extensively in both the IE and EM FVS variants to parameterize site species, site index, and maximum basal area, all of which are crucial determinants of potential growth.

The SLI contains habitat type information for most stands and was used to allocate habitat types to the low, medium, and high productivity classes within each stratum based on the predominance of the habitat types within each stratum. Please see Appendix L: for the final allocation of habitat types.

4.2.6.4 Productivity Classes and Site Index

Site Index is another means to quantify site quality and potential productivity, and it is described in terms of the expected height of dominant or co-dominant trees at a base or index age.[20] It is used in conjunction with habitat type in the IE and EM variants to predict expected future growth.

Determining site index began by assigning a productivity class (Low, Medium or High) to each stand based on its expected average productivity (ft^3/acre/year). The expected average productivity for each stand was extracted from the SLI database, while the productivity classes were provided by the DNRC. In the 2015 SYC, productivity classes were defined for each Land Office; however, for the 2020 SYC DNRC chose to define productivity classes at the statewide level using classes that match those used by the FIA program. The productivity classes are differentiated by the potential growth in a stand at culmination of mean annual increment (Table 5).

[20] Helms, JA, ed. 1998. *The Dictionary of Forestry*. Society of American Foresters, Bethesda, MD.

Table 5: Productivity Classes (ft³/ac/yr.)

Productivity Class	Low
Low	20 – 49
Medium	50-84
High	85+

Next, the stand level productivity estimates were aggregated up to an area weighted average productivity, for each unique combination of Land Office and productivity class. The resulting weighted productivity averages are shown in Table 6.

Table 6: Average Productivity (ft³/ac/yr.)

Land Office	Low	Medium	High
CE	38	56	85
EA	32	–	–
NW	33	69	101
SW	30	67	95

Site index was derived by assigning each SLI stand a potential productivity rating (ft3/ac/yr.) and then calculating the weighted average productivity estimate for each site class and Land Office. Potential productivity was converted to site index (DF site index base age 50) using conversion factors published by Brickell (Int-75)[21]. Results were reviewed for logical consistency within and between Land Offices. The resulting site index values are shown in Table 7:

Table 7: Site Index

Land Office	Low	Medium	High
CE	42	50	60
EA	30	50	--
NW	50	55	70
SW	50	55	65

4.2.6.5 Stand Age

Stand age is not a required parameter for using either variant of FVS, but it is an important parameter for allocating the silvicultural treatments that accompany some management

[21] Brickell, James E.,Equations and Computer Subroutines for Estimating Site Quality of Eight Rocky Mountain Species", Intermoutain Forest and Range Experiment Station, USDA Forest Service Research Paper INT-75, 1970, 22 pages.

pathways. In addition, the linear programming model is age-based, and therefore needs to keep track of age throughout the planning horizon to optimize the harvest level subject to the constraints.

The SLI contains an estimate of average age for most stands. These values were used as a starting point to determine age, resulting in an area weighted average age by Land Office, timber size class and productivity class. These age allocations were reviewed by the DNRC for accuracy, and manually adjusted where necessary. For final implementation, these ages were rounded to the closest mid-decade point (15, 25, 35, etc.), which accommodated the five-year growth period between periods zero and one and allowed subsequent ages to fall on full decadal values (20, 30, 40, etc.). Please refer to Appendix M: Strata Starting Age, for more detail regarding age.

4.2.6.6 Location Code

FVS utilizes geographic location in several ways to determine localized growth rates. One of these mechanisms is the location code, which matches growth to observed growth on a corresponding USFS National Forest. Each stratum was therefore assigned a location code, using the following scheme:

Table 8: Location Codes

Land Office	USFS National Forest	FVS Location Code
CE	Helena (ie)	112 (maps to 116)
EA	Custer (em)	108
NW	Flathead (ie)	110
SW	Lolo (ie)	116

The analytical steps described in section 4.2.5 resulted in a tree list for each stratum at each productivity class level. The final step before taking these tree lists into FVS was to assign each combination of strata and productivity class with a habitat type, site index, age and location code. These parameters were the result of the analytical processes described in sections 4.2.6.3 through 4.2.6.6.

4.2.6.7 Growth Model Calibration

At this time, DNRC does not have sufficient information regarding growth rates on its land that could be used for growth and yield model calibration. For the 2020 SYC, DNRC selected calibrations for FVS developed by outside sources. For the IE variant, DNRC used a series of FVS keyword files designed to simulate varying levels of western root diseases on forest growth and yield that were developed by personnel in the U.S. Forest Service[22]. For the EM variant, DNRC used an FVS calibration developed by MB&G and the Custer-Gallatin National Forest.

The first set of yield tables consisted of a complete set of grow-only tables (not inclusive of any management treatments such as pre-commercial thinning, commercial thinning and selection harvest) that established a reference point for future calibration by focusing on growth without the influence of active management. These tables were reviewed by a team of DNRC foresters and adjustments were made to either the selected root disease keyword file and/or habitat type until results fell into an acceptable range of expected growth. Productivity classes were also properly ordered within each stratum (i.e.—predicted volumes/growth on low productivity did not exceed those on moderate productivity sites, and moderate did not exceed high). After the full set of grow-only yield tables was complete, a set of yield tables reflecting the application of management activities was produced. At that point, MT DNRC developed factors to adjust volumes reported by FVS, using published growth rates from the FIA program for areas within each Land Office (Appendix O: Growth Rates by Land Office), and aligned with the distribution of acres in each productivity class relative to other Land Offices. These factors were applied to both grow-only and regime yields for the appropriate Land Office. The factors applied were as follows: CE—0.71, EA—1.46, NW—0.96, SW—0.75. Following application of those factors, calibration of FVS was complete.

4.2.6.8 Management Regimes

Three types of management pathways were formulated for the 2020 SYC: even-aged prescriptions (EARX), uneven-aged prescriptions (UERX), and old growth prescriptions (OGRX). The EARX incorporate a regeneration harvest removing most of the overstory in a single harvest with the objective or regenerating a new age class of trees, while the UERX incorporate a partial harvest of the overstory on a repeated cutting cycle. For old-growth strata in the NW and SW area, OGRX were developed that incorporate an uneven-aged harvest with residual tree targets aimed at maintaining old growth status. Some EARX pathways included a precommercial thinning (PCT) treatment modeled as a thin-from-below (remove smallest trees until target is reached) and/or commercial thinning (CT) modeled as a weighted thin (remove equal proportions from all DBH classes until target is reached). Minimum harvest thresholds for both tractor- (ground) and cable- (skyline) based systems in each Land Office were applied so all thinning treatments falling short of the threshold were skipped (Table 9).

Table 9: Minimum harvest thresholds by Land Office (Mbf/ac)

Land Office	Tractor	Cable
CE	2.0	5.0
EA	0.5	6.0
NW	1.0	3.0

[22] https://www.fs.fed.us/foresthealth/applied-sciences/fvs-models/index.shtml

SW	1.0	3.5

Three different types of EARX pathways were developed: clear-cut prescriptions (CCRX), seed-tree prescriptions (STRX) and shelter-wood prescriptions (SWRX). These three types were distinguished by the amount of over-story that was retained after regeneration harvest, with CCRX retaining 4 trees per acre (TPA), STRX 8 TPA and SWRX 25 TPA. These types were further subdivided by the type of management treatments applied, which varied the inclusion and timing of PCT, CT, and overstory removal. The availability of these pathways to individual strata was defined by Land Office, forest type (species), size class, productivity class. A detailed summary of all the EARX pathways can be found in Appendix D: Management Pathways.

Two different types of UERX pathways were developed for forests occupying dry and moist/wet sites. Eligibility for these types was determined by Land Office and forest type. Both UERX pathways simulated selection harvest by periodically removing trees every 30 or 50 years according to a target DBH distribution, depending on prescription type. The target distributions were generated by defining the total BA, the Q-factor for the distribution, the DBH range and the DBH class size. A tiered approach was then used to incrementally reduce BA in each entry until the target level was reached. A detailed summary of all the UERX pathways can be found in Appendix D: Management Pathways, and Appendix E: Selection Harvest Reversed J-Curves, contains a detailed description of the tiered approach used to incrementally reduce BA. The UERX also included the ingrowth of young trees following a selection harvest, simulating the development of regeneration and understory development following harvesting. The tree lists used for ingrowth were the same as those used for the 2015 SYC.

The OGRX were formulated in a similar manner to the UERX and consisted of periodic selection harvests that reduced the trees to a minimum BA threshold. In addition, the residual trees had to contain a certain number of large individuals defined by a minimum DBH threshold. Periodic entries ranged from 30 to 50 years, depending on old growth type. A detailed summary of all the OGRX pathways can be found in Appendix D: Management Pathways.

4.2.6.9 Regeneration Yields

Regeneration yield tables are required to fully model the application of even-aged regimes (EARX). The EARX regimes result in a complete stand replacement after final harvest, with age resetting to zero, resulting in a transition from the yield table for the existing stand to a new yield table representing the regenerated stand.

For the 2020 SYC, regeneration yield tables were based on the existing adequately-stocked size class 7 (seedling/sapling) stratum for a given species group. All records for trees greater than 5” were removed from the existing size class 7 stratum to compose a new tree list reflecting trees expected to regenerate following harvesting. Large trees representing the remaining overstory associated with each of the EARX groups by stratum (CCRX—4 trees/acre, STRX—8 trees/acre, SWRX—25 trees/acre) were added to the regenerating trees to compose the full tree list for the regeneration yield table. For the STRX and SWRX pathways that included overstory removal (OSR), OSR was applied as a thinning treatment to leave four remaining overstory trees following the OSR harvest. OSR is not applied in the CCRX group. For the STRX pathways that included overstory removal (OSR), 4 of the 8 overstory trees were designated for removal, and for the SWRX, 21 of the 25 overstory trees were designated for removal, resulting in 4 remaining leave trees for each group following OSR.

When transitioning from existing to regenerated strata following the application of EARX, the assumption was made that poorly stocked strata would regenerate as adequately stocked strata. In some cases a species change was also implemented to represent expected natural processes and DNRC's management toward desired future cover types. These species[23] changes are summarized in Table 10: Regeneration Species changes.

Table 10: Regeneration Species changes

Existing Species	CE	EA	NW	SW
DPMC	DPMC	DPMC	n/a	n/a
GFRC	n/a	n/a	GFRC	GFRC
LP	LP	LP	LP	LP
NS	DMPC	DPMC	WLDF	PPDF
OGW1	n/a	n/a	PPDF	PPDF
OGW4	n/a	n/a	WLDF	WLDF
OGW6	n/a	n/a	SFC	SFC
PPDF	n/a	n/a	PPDF	PPDF
SF	LP	LP	n/a	n/a
SFC	n/a	n/a	SFC	SFC
SFM	n/a	n/a	SFM	SFM
WLDF	n/a	n/a	WLDF	WLDF

For the regeneration yield tables, all of the PCT and CT options were made available in addition to the over-story treatments described above.

[23] DPMC – Douglas-fir/ponderosa pine/mixed conifer, GFRC – grand fir/western redcedar/western hemlock/western white pine, LP – lodgepole pine, NS – non-stocked, OGW1 – West-side Old Growth Type 1, OGW4 – West-side Old Growth Type 4, OGW6 – West-side Old Growth Type 6, SF – Engelmann spruce/subalpine fir, SFC –Engelmann spruce/subalpine sir/whitebark pine cold site, SFM –Engelmann spruce/subalpine fir moist site, WLDF – western larch/Douglas-fir

4.3 Formulation of the Montana Forest Management Model

The following sections describe the general structure of the optimization model, followed by a detailed discussion of the various components.

4.3.1 Structure of Forest Management Optimization Model

For the 2020 SYC, the optimization model used for the 2015 calculation was applied, with some modifications. This model uses a linear programming (LP) formulation that is well suited to strategic/tactical level harvest optimizations, since optimization solutions can typically be formulated through a system of linear equations. In addition, given a feasible problem, the LP will always solve to the absolute optimum, which ensures that the greatest volume possible solution is always found. The LP model used for this SYC was built in Remsoft's Spatial Planning System.

The main structure of the model consists of four components: analysis areas, actions and transitions, yield projections, and objectives plus constraints. Analysis areas describe the existing condition of the land, as well as alternatives that could be realized in the future. Actions and transitions are responsible for placing land onto various management pathways and converting existing conditions into future conditions. Yield projections quantify the contribution that one acre of land in a given condition would make to various parameters being tracked. These parameters take on several forms, ranging from timber volume to wildlife habitat, and are used to calculate various outputs used in the objectives and constraints component of the model. Objectives and constraints are the model elements respectively used for optimizing the model and constraining the solution to be within certain parameters. For this SYC the objective was to maximize the total harvest volume across the planning horizon, while the constraints limited the management activities and required various habitat thresholds to be maintained. DNRC explored an option maximizing present net value (NPV) across the planning horizon but testing with that objective function produced essentially no difference compared against maximizing NPV.

Model results were reported by planning period, with one period representing 10 years. The planning horizon was 20 periods, resulting in the model scheduling activities for the next 200 years.

4.3.2 Analysis Areas

The analysis area used for this study is defined as all commercial forest land on State Trust Lands throughout Montana, partitioned into administrative units and areas of special consideration. Analysis areas describe both the existing condition of the land, as well as the future options. As such this section of the model is initialized through an imported GIS layer, while the future options are created through a series of actions and transitions. The GIS layer used in this SYC was based on one provided by the DNRC. This layer essentially contained all the stand boundaries (coded for Land Office, unit, species, size, stocking and productivity class), intersected with the boundaries of various operational and wildlife features (deferred acres, grizzly bear, lynx management areas, etc.). MBG passed this GIS layer through several processes to convert the data into thematic layers, each of which describes a unique feature, that is compatible with the LP model. A total of 25 themes were created in this way. Table 11 provides a description of each of these themes, as well as whether it was ultimately used in the model. Appendix C: Acres in the Forest Management Model, contains a summary of the acres in various themes subdivided by thematic codes.

Table 11: LP Model Thematic Layers (Themes)

Theme	Name	Description	Used
1	Strata ID	A four-part code, denoting the Land Office, species, size and stocking of the stratum that the stand belongs to.	No
2	Land Office	The Land Office that the stand belongs to.	Yes
3	Unit	The administrative unit that the stand belongs to.	Yes
4	Species	The species code used by the stratum to find the appropriate yield table. Not necessarily the same as the one in Strata ID.	Yes
5	Size	The size code used by the stratum to find the appropriate yield table. Not necessarily the same as one in Strata ID.	Yes
6	Stocking	The stocking code used by the stratum to find the appropriate yield table. Not necessarily the same as one in Strata ID.	Yes
7	Productivity Class	The stratum productivity class.	Yes
8	Start Age	The age of the stratum in period zero.	No
9	Deferred	Designates the land parcel as deferred or not.	Yes
10	Rx	The management pathway allocated to the land parcel. All start off on grow-only (E++++GO).	Yes
11	Timing	The timing option associated with the given Rx that was selected. Created the option to delay the start of the treatments associated with a management pathway.	Yes
12	Rotation	Denotes whether the land parcel has existing or regenerated tree cover.	Yes
13	Sensitive Watershed	Denotes whether a land parcel is in a sensitive watershed or not, as well as the name of the watershed.	Yes
14	UMZ	Designates whether the land parcel is within a unique management zone or not.	Yes
15	Logging System	Designates whether the land parcel is within an area requiring helicopter, tractor, or cable logging.	Yes
16	RMZ	Designates whether the land parcel is within a riparian management zone or streamside management zone or not.	Yes

Theme	Name	Description	Used
17	GZB Visual	Designates whether the land parcel is within a grizzly bear visual buffer or not.	Yes
18	GZB Class A	Designates whether the land parcel is within a grizzly bear Class A area or not, as well as the name of the Class A area.	No
19	GZB Security Zones	Designates whether the land parcel occurs within one of seven Grizzly Bear Security Zone located on Stillwater Unit or not.	Yes
20	GZB Subzone	Designates whether the land parcel is within an HCP grizzly bear Management Subzone on the Swan River State Forest or not, as well as the identifying number of the subzone.	No
21	LMA	Designates whether the land parcel is within a Canada lynx management area (LMA) or not, as well as the name of the LMA.	Yes
22	Potential Lynx	Designates whether the land parcel is flagged as potential Canada lynx habitat or not.	Yes
23	Eagle	Designates whether the land parcel is part of a known bald eagle nesting area or not.	Yes
24	OG Recruit	Designates whether the land parcel could be recruited into OG or not.	No
25	OG Current	Designates whether the land parcel is currently OG or not.	Yes

Several themes featured in the 2015 SYC model architecture were not directly used for calculations in the 2020 SYC, including GZB Class A, GZB Subzone, and OG Recruit. These themes were retained to allow comparison to SYC 2015 or in future models to re-enable the functionality.

In addition to the thematic layers described above, the model also required the surface area (acres) of each land parcel and the age at period zero. Age was obtained from the strata data, while the area was already calculated in the GIS layer. Once all of this data was complete, the LP model imported the data and created existing development types. Development types are a way for the model to aggregate data and reduce the computational overhead. This aggregation is done on unique combinations of thematic codes and age (i.e.—all land parcels with the same combination of thematic codes and age would have been grouped into the same development type). Many separate polygons may share a development type, and the model operates on the acres within a development type aggregated across relevant polygons. In total, the model imported 747,280acres from 47,235 polygons, of which 9,966 polygons (21.1%) were less than 1 acre in area. From this the model created 6,048 development types representing the existing land.

4.3.3 Actions & Transitions

A series of actions and transitions were incorporated into the model to generate the various management pathway options that the model could utilize. These actions and transitions generated additional development types, collectively called future development types. In total, 183,648 development types were generated, of which 177,600 (96.7%) were future development types.

Two main forms of actions and transitions were used. Occurring only in the first period was an action to re-assign each development type from its initial grow-only trajectory onto a potential management pathway. An action and transition were created for every unique combination of management prescription and timing option. The actions were used to filter out those acres that possessed thematic codes appropriate for the action being considered, while the transitions placed the acres onto the new prescription and timing option.

The second set of actions and transitions determined when a regeneration harvest would occur for the even-aged regimes. These could occur anywhere along the planning horizon, given that enough harvest volume was available (see Table 9) and the minimum harvest age of 80 years had been reached. In addition, the actions also filtered the acres to apply the regeneration harvest only to those acres which had the appropriate thematic codes. The transitions were responsible for taking acres from their existing yield table and placing them onto the regenerated yield table, by changing the appropriate thematic codes. In some cases, this meant a change in species and stocking codes. In all cases this meant resetting age to zero and changing size class to seedling-sapling (size class 7).

Most transitional elements were retained from the 2015 model. For example, currently older existing strata set to even-aged management were allowed to select regeneration pathways that may have differed from their original assignment, staying within the broader silviculture method (e.g. STRX, followed by STRX with CT).

In addition, to reduce model size and solve times while maintaining flexibility to explore management scenarios, only permissible development types were created. For example, only LP and SF in the NW, SW, and CE Land Offices were eligible for CCRX, so no other strata were included in the CCRX action. Some scenarios like BioGross and BioNet required access to CCRX, while others restricted CCRX based on thematic components.

Several new action-transition classes were introduced with this model:

1. Regimes including a PCT or CT can be conducted economically on gentle topography, so actions specifying either of these methods were limited to Tractor ground via Theme 15, Logging System.
2. Minimum harvest volumes (Table 9) were imposed by Land Office, so each action was specified for a single Land Office if the harvest threshold was unique, or by Land Office aggregates of the harvest threshold was shared.

3. STRX and SWRX are to be managed as 50% with OS removal and 50% with OS retention. Any action specifying a transition to these even-aged pathways was modified by a percentage allocation, setting half of the acreage to removal and half to retention.

4.3.4 Yield Projections

Yield projections in this model represent the contribution of one acre of land in a given planning period to harvest volume and standing inventory. Yields can represent harvest volumes, interpreted as to wildlife habitat values, or converted to revenues. In terms of LP modeling, yield projections can be described as the coefficients that are associated with variables tracking the number of acres allocated to a given development type in a given period. Yield projections are therefore specified for a specific development type (or group of development types) in a specific period. A total of 3,650 yield tables were developed through this process, each with 20 yield projections representing each decade in the planning horizon. Additional information about the number and distribution of yield tables can be found in Table 12.

Table 12: Existing and Future Yield Table Counts by Prescription

Development Type	Rx Type	Silviculture	Count
Existing	GORX	---	227
	EARX	CCRX	87
		STRX	672
		SWRX	661
	UERX	Dry	364
		Moist	129
	OGRX	W1	56
		W4	152
		W6	86
Future	EARX	CCRX	32
		STRX	640
		SWRX	544
Total			3,650

The following yield projections were associated with these yield tables:

- Age in years
- Standing inventory in MBF/Acre before harvest, after defect and tariff equations
- Timber volume removed in MBF/Acre through commercial thinning and selection harvest, after defect and tariff equations
- Standing inventory of Douglas-fir and western larch in MBF/Acre before harvest, after defect and tariff equations (DF)

- Standing inventory of grand fir and western hemlock in MBF/Acre before harvest, after defect and tariff equations (HF)
- Standing inventory of ponderosa pine in MBF/Acre before harvest, after defect and tariff equations (PP)
- Standing inventory of western redcedar in MBF/Acre before harvest, after defect and tariff equations (RC)
- Standing inventory of Engelmann spruce and lodgepole pine in MBF/Acre before harvest, after defect and tariff equations (SP)
- Standing inventory of western white pine in MBF/Acre before harvest, after defect and tariff equations (WP)
- Standing inventory of subalpine fir, mountain hemlock and whitebark pine in MBF/Acre before harvest, after defect and tariff equations (WW)
- Basal area in ft^2/Acre after harvest
- Total stems per acre after harvest
- Stems per acre larger than or equal to 13" DBH after harvest
- Stems per acre larger than or equal to 17" DBH after harvest
- Stems per acre larger than or equal to 21" DBH after harvest
- A PCT flag, used in certain outputs to determine if a PCT harvest occurred or not
- Valid yield table flag, used to prevent the model from assigning acres to development types that do not have a valid yield table

The matter of overstory removal was resolved differently in this model versus the 2015 version. Previously, a generic overstory removal yield was provided by stratum, and all CCRX, STRX, and SWRX pathways received OS removal. In the current version, the OS volume is modeled directly into the yield table. If OS removal is to occur, then the thinning volume represents the OS, and it is removed if this volume exceeds a minimum 1.0 Mbf/ac. If OS retention is specified, then the OS volume remains in the tree list and those trees continue to influence growth rates in the residual stand. Structure of the residual overstory was comparable to 2015, where STRX retaining 8 TPA for two periods and removed 4 TPA at final harvest; SWRX retained 25 TPA for two periods and removed 21 TPA at final harvest. In all pathways, 4 TPA remained permanently.

Another important difference from the 2015 model was the interpretation of the yield for regeneration harvest types. Previously, the regeneration harvest and the separate stratum level OS removal volume were combined into a harvest at a single time point. The 2020 SYC, in contrast, continues to use the volume for regeneration harvest types to represent the harvested timber at the time a regeneration treatment is initiated, but the OS removal, if specified, occurs two periods later. This approach accurately represents the volume removal over time. Minimum harvest volume was determined by the actions section (see section 4.3.3 and Table 9), and the regen harvest yield was set to zero when stand age was less than 80 years.

Yields for the 2015 SYC used uncalibrated FVS variants and UERX built to a TPA target, while the 2020 SYC used a different FVS calibration, WRD modifiers, and UERX built to BA targets. In general, 2020 UERX yields rivaled or exceeded the most productive even-aged regimes. Whereas the 2015 LP model favored EARX and required threshold limits on EARX to control this tendency, the 2020 LP model favored UERX. The mechanisms from the 2015 model to limit EARX were repurposed in the 2020 model to limit UERX. DNRC relied on observed silviculture frequency and estimated application of UERX in the SFLMP to support limiting UERX to less than 40% of the acreage.

Economic data were also incorporated into the LP model through a series of yield projections. Stumpage revenues were used in both the 2015 and 2020 SYC models to represent economic value of the harvested timber, with average stumpage updated through 2019 for the 2020 SYC. Average bid price ($/Mbf) on sales and permits, weighted by volume, were provided by the DNRC on a Land Office basis for the period from 2015 to 2019 for use in the 2020 SYC (Table 13). These values were in nominal terms. These values were incorporated into a stumpage revenue for each Land Office. In early LP model experiments, it was demonstrated that maximizing Harvest Volume resulted in an identical SYC to maximizing Net Present Value using these stumpage rates. As this model assumes an implicit logging cost, optimizing revenue and volume is functionally equivalent.

Table 13: Stumpage ($/Mbf) for the 2015 SYC and updated for 2020 SYC.

Area	2014 Stumpage/MBF	2020 Stumpage/MBF
CLO	146.42	114.80
Eastern Land Offices	70.71	34.25
NWLO	239.37	189.80
SWLO	221.29	159.80

4.3.5 Objectives and Constraints

Within the LP modeling framework, objectives are the mechanism whereby results are optimized, while constraints limit the solutions to pre-defined thresholds. An LP solution will therefore always contain an objective function that has been optimized, subject to meeting the constraints that were established.

The objective of the 2020 SYC was to maximize total harvest volume, where total harvest volume was defined as the sum of the harvest volume in each period across the planning horizon (20 periods). Periodic harvest volume was calculated as the sum of the periodic harvest volumes from even-aged pathways and uneven-aged pathways. The sum of the periodic harvest volumes from even-aged pathways was inclusive of volumes from commercial thinning, regeneration harvest (net volume from first harvest) and over-story removal volume (second harvest volume).

All these volumes were inclusive of the volume from helicopter acres, which implies that the helicopter acres participated in the objective function.

To ensure equity between current and future beneficiaries of the forested State trust lands, it is important to maximize the short-term harvest that can be sustained over the 200-year planning horizon. However, it is also important to know whether future harvests could be sustained at a higher level, perhaps because of investments in stand improvement, forest regulation, etc. The LP objective function, therefore, must emphasize the short-term harvests, while also recognizing benefits from long term improvements. This dual objective is achieved by discounting the harvest of each period. We used a discount rate of 2%. A typical discount rate of 4% or 5% might be used for forestry investments in which the primary objective is maximized value. For State-owned forestlands serving a variety of constituents, a lower value of 2% is acceptable. Moreover, a 2% discount rate likely captures the growth rate at the time when many DNRC stands are harvested. The difference in annual sustainable yield between 2% versus 4% discount rate in a maximum production scenario is only 93.15 MMbf versus 93.55 MMbf, or just 0.4 MMbf. When all DNRC management constraints are imposed, the differential due to discount rate selection was not meaningful.

Several constraints were established to limit the optimal solution to pre-determined limits. All constraints were applied on a per period basis. The purpose of these constraints can be classified as either non-declining yield (NDY), protection of wildlife habitat, water resources, application of silvicultural regimes, operational limits, or LP error control.

A single NDY constraint was established to ensure that the optimum harvest levels can be maintained over the length of the planning horizon. In this case a non-declining flow constraint (period-on-period increase allowed, but never decreasing) was used, as opposed to an even-flow constraint (equal period-on-period volumes). The rationale behind this was that it could be theoretically possible for the model to harvest more volume in the future as new and improved development types became available. Using the NDY constraint would make this extra volume accessible, since the SYC level can increase (not decrease); while the even-flow constraint would make it inaccessible since no fluctuation is allowed. The NDY constraint also excluded the volume from helicopter logging acres. The fact that these acres were included in the objective function resulted in them being scheduled for harvest, but not contributing to the sustainable yield level. Their contribution is therefore purely opportunistic, which is consistent with current operating and market conditions.

Whereas the 2015 LP model featured an overall NDY constraint, the 2020 updated model applies the NDY constraint over each Land Office. Sustaining yields at the Land Office level was deemed an important goal for 2020, rather than allowing fluctuation by Land Office, which even in the case of Statewide NDY could mean declining yields in some periods for certain Land Office(s).

Table 14: Non-Declining Yield Constraint

Constraint	Group	Description
Non-Declining Yield	NDY	Total harvest volume exclusive of volume from helicopter acres can increase period-on-period but cannot decrease.

The wildlife habitat, water resource, and management constraints were directed towards protecting water resources by maintaining water quality, maintaining the levels of existing wildlife habitat, or limiting the intensity of management on existing habitat, or requiring certain levels of habitat development. The wildlife habitat, water resource, and management constraints are summarized in Table 15: Wildlife Habitat, Water Resource and Management Constraints. Please refer to section 4.2.2 for more detail on each constraint theme. Appendix B: Compatibility Matrix, contains additional information pertaining to the constraints. All listed endangered, threatened, sensitive, and big game species for which DNRC has management obligations under administrative rules were considered during the development of constraints for the calculation. Appendix N: Wildlife Habitat , contains information and notes regarding constraint development, and inclusion/exclusion rationale for all species considered in this study.

Table 15: Wildlife Habitat, Water Resource and Management Constraints

Constraint	Group	Description
Snags	BIO NET	Requirements for the retention of snags and snag recruits were addressed in the design of the management regimes for this calculation. Volume necessary for snag maintenance was constrained as a part of the residual volumes and trees per acre retained in each allowable prescription. See Appendix D: Management Pathways.
Deferred	DEF	No treatment was assigned to deferred acres. All deferred acres (Theme 9 = Y) must be assigned to grow-only management pathways.
RMZ	RUMZ	All riparian management zone (RMZ) and Streamside Management Zone (SMZ) acres (Theme 16 = Y) must be assigned to grow-only management pathways.
UMZ	RUMZ	No unique management zone (UMZ) acres (Theme 14 = Y) can be assigned to even-aged management pathways.
Swift BPA	RUMZ	Acres in the BPA portion of the Lazy-Swift acquisition in the Stillwater Unit must be assigned to uneven-aged management pathways.

<table>
<tr><th>Constraint</th><th>Group</th><th>Description</th></tr>
<tr><td>Old Growth</td><td>OG</td><td>At least 8% of acres must meet the old-growth criteria for the NW and SW Land Offices on a unit basis, and 4% of acres must meet the old-growth criteria for the CE Land Office on a unit basis. Old-growth acres were contributed from two sources, namely existing old-growth and recruitment. Existing old-growth acres are existing acres classified as either OGW1, OGW4 or OGW6, prior to receiving an even-aged harvest. Recruitment acres are those acres not currently classified as existing old-growth but that met the old-growth criteria at a future point in the planning horizon. For the NW and SW Land Offices these acres could be recruited into either OGW1, OGW4 or OGW6, with the following criteria:
<table>
<tr><td>Group</td><td>Species</td><td>Age</td><td>BA</td><td>TPA</td></tr>
<tr><td>OGW1</td><td>PPDF</td><td>160</td><td>60</td><td>8 @ 21”</td></tr>
<tr><td>OGW4</td><td>GFRC, SFM, WLDF</td><td>170</td><td>80</td><td>10 @ 21”</td></tr>
<tr><td>OGW6</td><td>LP, SFC</td><td>170</td><td>60</td><td>10 @13”</td></tr>
</table>
For the CE Land Office recruitment acres had to meet the following criteria:
<table>
<tr><td>Species</td><td>Age</td><td>BA</td><td>TPA</td></tr>
<tr><td>DPMC</td><td>180</td><td>50</td><td>5 @ 17”</td></tr>
</table>
The age used in these classifications were average stand age, as opposed to the age of the oldest trees used in Green et al.[24], and will therefore be lower than the published criteria.</td></tr>
<tr><td>Sensitive Watersheds</td><td>SEN</td><td>No more than 36% of acres in sensitive watershed areas may be younger than age 40 years.</td></tr>
<tr><td>GZB Visual Buffers</td><td>GZB</td><td>Only uneven-aged management pathways are available. No even-aged management pathways in grizzly bear visual buffers (Theme 17 = Y)</td></tr>
<tr><td>GZB Security Zones</td><td>GZB</td><td>All Grizzly Bear Security Zone acres in Stillwater Unit (Theme 19 = Y) must be assigned to grow-only management pathways.</td></tr>
<tr><td>Lynx Management Area LM1</td><td>LMA</td><td>At least 65% of acres in each LMA must meet canopy cover criteria, which is defined as 180 TPA when age < 40 years, or BA 60 when age >= 40 years.</td></tr>
<tr><td>Lynx Management Area LM2</td><td>LMA</td><td>No more than 15% of acres (per period) in each LMA can receive a regeneration harvest from an even-age pathway.</td></tr>
<tr><td>Lynx Management Area LM31</td><td>LMA</td><td>At least 20% of acres in each LMA must be in the saw-log size class, with BA at least 60, and must possess inventory in either HF, SP, or WW (see pages 38-39 for definitions of these species groups).</td></tr>
<tr><td>Lynx Management</td><td>LMA</td><td>Limit PCT to 12,000 acres per period across all LMA’s, allocated proportional to each LMA based on LMA acres.</td></tr>
</table>

[24] Green, P, J. Joy, D. Sirucek, W. Hann, A. Zack, and B. Naumann. Old-Growth Forest Types of the Northern Region. USDA Forest Service, Northern Region, Missoula, MT, 1992.

Constraint	Group	Description
Area ITP		
Potential Lynx Habitat	POT	On non-LMA lands, at least 65% of acres flagged as potential lynx habitat (Theme 22 = Y), must meet canopy cover criteria, which is defined as >=180 TPA when age < 40 years, or BA 60 when age >= 40 years.
Bald Eagle	EAG	All bald eagle nesting site acres (Theme 23 = Y) must be assigned to either uneven-aged or moist-site management pathways, as well as maintain 60 BA.

The purpose of the silvicultural regime constraints was to steer the land base towards the desired condition by limiting the acres that can be allocated respectively to even- and uneven-aged management regimes. These limits tie-in with the management allocations defined in the yield projections.

Table 16: Silvicultural Regime Constraint

Constraint	Group	Description
Even-Age Rx	EAR	Acres allocated to CCRX, STRX, SWRX and UERX cannot exceed the allowable thresholds established for each species and pathway group by DNRC administrative Unit (see Appendix K: Silvicultural Regime Acre Constraints).

The operational limits constraint limited the amount of harvest acres from cable-based harvesting and harvest volume from helicopter acres to levels that are feasible considering market limitations assessed over the last 20 years.

Constraint	Group	Description
Cable	HEL	Total harvest acres from cable ground cannot exceed 18% of the periodic harvest acres for each period
Helicopter	HEL	Total harvest volume from helicopter acres (Theme 15 = Y) cannot exceed more than 2% of the periodic harvest volume for each period exclusive of volume from helicopter acres (NDY volume).

The LP error control constraint prevented the model from allocating acres to development types that were ineligible, with ineligibility defined as development types without a yield projection for growth.

Constraint	Group	Description
Valid Yield	VAL	All acres must be assigned to a yield table with a valid flag value (1).

5 Results

5.1 Qualifications

The LP model used in this sustainable yield calculation can produce detailed stand-level results; however, these results should not be interpreted as indicators of how each stand should be managed, and what could be expected from each stand along its management pathway since the data used to run these models were aggregated by strata. The inventory data used in this analysis were collected from plots distributed over a range of stands, which were aggregated and mapped into strata, resulting in an average condition for each stratum. The results represent the average condition across a range of stands within a given stratum, as opposed to the condition within a particular stand. Furthermore, the objective of this study was to determine a strategic direction for the DNRC in terms of sustainable annual harvest. The results of this study should be interpreted at the strategic planning level, since site-specific operational constraints were not considered in this analysis.

The interpretation of the model results should, however, not be limited only to the annual harvest level, since it is also important to examine the factors that contribute towards a given sustainable harvest level. In this regard it is essential to take note of the management pathways that were selected by the model, and the importance of these pathways in achieving the calculated harvest level. It would be inappropriate to conclude that all acres should be managed exactly like the modeled acres. However, if a general shift towards managing along a given group of pathways is observed in the model results, then it should be considered for incorporation into the DNRC's tactical and operational selection of harvest treatments that are applied on the ground.

5.2 Discussion of Model Results

The final runs of the LP model were conducted at a Land Office level where the model is solved in four separate parts (one for each Land Office or Land Office aggregate), as opposed to a statewide approach with all acres optimized in a single model. In the 2015 SYC, early versions of the calculation were performed in four discrete LP models and the statewide result was composited from the summary of the four separate models. The final 2015 SYC was defined at the statewide level with no NDY by Land Office. In contrast, the 2020 SYC is constructed as a single LP model with a separate NDY constraint declared for each Land Office, so that statewide constraints can still be imposed without leading to model infeasibilities. The NDY by Land Office approach restricts the number of options that the model can select, resulting in slightly lower yield outputs for the statewide land base. DNRC managers chose to select the outputs from the Land Office level to provide an increased level of certainty and minimize fluctuation in Land Office harvest planning target levels given DNRC's current operating environment, to ensure that harvest planning targets in each Land Office reflect the present availability of timber within that

Land Office, and to prevent over- or under-harvesting in certain Land Offices as a result of other Land Offices compensating for planned volume from other Land Offices.

MB&G modeled two scenarios for the 2020 SYC. The first included all commercial forest acres and management constraints to determine annual sustainable yield, and the second withdrew newly acquired acres in order to determine the impact of recent land acquisitions.

5.2.1 Scenario 1 – Fully Constrained Model

In this scenario, all commercial forest acres were available for management subject to the model constraints described in Section 4.3.5. The model was run at the Land Office level and in a step-wise manner, incrementally adding constraints to assess their impact. These incremental steps are discussed and illustrated in the following sections and Figure 2. With all constraints applied (EAG model), a total of 583,889 acres were allocated to management regimes (included in solution), and 163,391 acres were excluded from management. Under this scenario a harvest level of 68.3 MMBF/Year can be maintained.

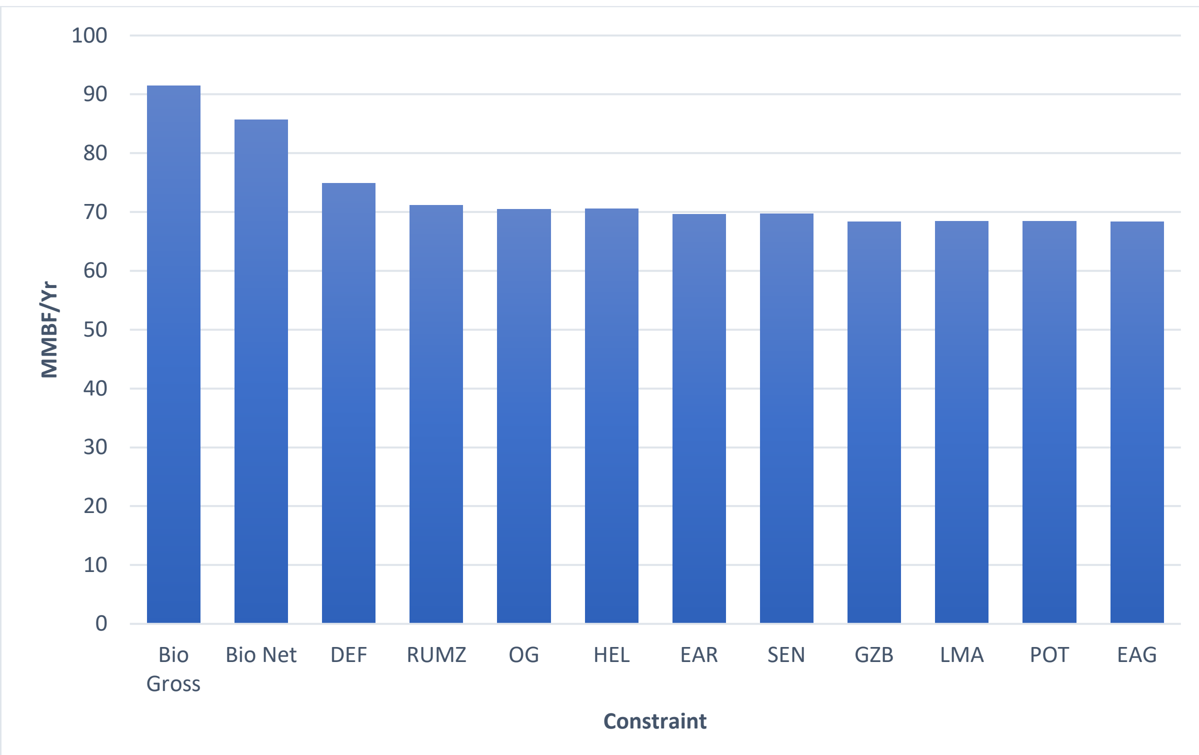

Figure 2: Sequential Reduction in Harvest Volume by Constraint

5.2.1.1 GO – Grow Only

During the grow-only run all constraints were switched off, and the model was forced to send all acres to no-management pathways by maximizing the acres in no-management. The results were used to assess growth, inventory and the ability of the model to meet constraints. The average growth across the state was 123 Bf/Acre/Year. Growth rates observed at the Land Office level were 171 Bf/Acre/Year for the NW, 117 Bf/Acre/Year for SW, 52 Bf/Acre/Year for CE and 85 Bf/Acre/Year for EA. Inventory (standing volume) started at 4.4 BBF in period zero, and increased to 15.0 BBF by the end of period 20.

5.2.1.2 BIO GROSS – Maximum Biological Potential

The purpose of this model run was to determine the highest biologically achievable harvest level by removing all constraints. Instead of using the non-declining yield constraint, an even-flow constraint was used in this model run. The harvest volume included leave trees, meaning that the over-story component associated with even-aged pathways, which is normally left standing after a regeneration harvest, was harvested and reported in the harvest volume. The resulting model returned a sustainable harvest of 91.4 MMBF/Year. Inventory increased over time to 4.7 BBF by period 20. On this run 4,481 acres were allocated to no-management, while 742,799 acres received a pathway with active management. The model had the option to schedule these acres but elected not to do so since they did not contribute to an increase in the harvest level.

5.2.1.3 BIO NET – Leave Tree and Snag Requirements

The purpose of this model run was to show the impact of the leave trees, which include snags, snag recruits, and other un-harvested over-story trees, on the biological potential. It is exactly the same as BIO GROSS, with exception that the leave tree volumes are removed from the sustainable harvest level. As such it shows the decrease harvest volume attributable to the leave trees. The resulting model returned a sustainable harvest of 85.7 MMBF/Year, a decrease of 6.4%. Inventory decreased over time to 4.1 BBF at period 20. This run allocated 2,018 acres to no-management, while 745,262 acres received a pathway with active management.

5.2.1.4 DEF – Deferrals

The purpose of this model run was to show the impact of the deferred acres on the sustainable harvest level. All deferred acres are limited to grow-only pathways, resulting in 92,055 acres being removed from managed pathways and assigned to grow-only pathways. The resulting sustainable harvest level was 74.9 MMBF/Year, a decrease of 12.5%. Inventory increased over time to 5.7 BBF at period 20. On this run, 112,050 acres were assigned to no-management, while 635,230 acres received a pathway with active management. The no management acres resulted from the deferred acres that were added to this run, plus a portion of the no management acres that were carried over from the BIO GROSS and BIO NET runs.

5.2.1.5 RMZ/UMZ- Riparian and Unique Management Zone Constraints

This run showed the impact of RMZ and UMZ acres on the sustainable harvest level. The constraints associated with these acres call for no-management on the RMZ and SMZ acres, and no even-aged management on the UMZ acres. There are a total of 30,284 RMZ acres, and 3,617 UMZ acres. The resulting sustainable harvest level was 71.2 MMBF/Year, a decrease of 5.0%. Inventory increased over time to 6.1 BBF at period 20. On this run, 135,719 acres were assigned to no-management, while 611,561 acres received a pathway with active management. The no management acres resulted from the RMZ acres that were added to this run, plus the no management acres that were carried over from the DEF run.

5.2.1.6 OG – Old Growth Constraints

This run showed the impact of constraints associated with OG, which called for 8% OG on each unit in the NW and SW Land Offices, and 4% OG on each unit in the CE Land Office. Existing amounts of old growth in some Units were below the targeted amounts of 8% for NW and SW or 4% for CE, due to the effects of past disturbances including wildfires, forest insect and disease outbreaks, and past timber management. In those Units, as with the 2015 SYC, the old growth constraint was adjusted to require that each Unit currently below the intended target percentage meet that percentage by the same period that the grow only model run was able to meet the constraint. For all units currently below the intended percentage, the grow only model met the percentage requirement in period 5, so the constraint was adjusted to require units below the intended percentage to meet the constraint by period 5. This required the model to maintain existing old growth in accordance with the management regimes applicable to old growth stands while also assigning management pathways to non-old growth stands that facilitated their development into old growth in a sufficient amount to meet the Unit's percentage requirement by the period required, which ensured that the intended old growth amount was met as quickly as possible. The target old growth acres for each unit are shown in Table 17.

Table 17: Old Growth Target Acres per Unit

Land Office	Unit	Target Acres
CE	BOZ	764
	CON	188
	DIL	1,136
	HEL	2,172
NW	KAL	4,008
	LIB	2,398
	PLN	3,975
	STW	9,834
	SWN	4,111
SW	ANA	2,072
	CLW	5,316
	HAM	1,813
	MSO	6,534

The resulting sustainable harvest level was just below 70.5 MMBF/Year, a decrease of 0.05%. Inventory increased over time to 6.2 BBF at period 20. On this run, 135,874 acres were assigned to no-management, while 611,406 acres received a pathway with active management.

5.2.1.7 HELI – Helicopter Harvest Constraint

The helicopter harvest constraint limited the volume that can be harvested from helicopter acres, by capping the helicopter harvest volume to 2% of the total harvest volume within any given time period (exclusive of helicopter volume). The helicopter volume is seen as opportunistic, and it is therefore excluded from the NDY constraint, but included in the objective function. In addition to the helicopter constraint, this scenario introduced a constraint to limit the acreage of cable logging to not more than 18% in any period. The sustainable harvest level was 70.5 MMBF/Year, a decrease of 0.9%. The associated threshold helicopter harvest volume was 1.4 MMBF/Year (i.e., when available, the model could harvest a maximum of 1.4 MMBF/Year from helicopter acres). Inventory increased over time to 6.1 BBF at period 20. On this run, 136,122 acres were assigned to no-management, while 611,158 acres received a pathway with active management.

5.2.1.8 EAR – Even-Aged Harvest Constraint

The even-aged harvest constraint limited the number of acres that could be managed under CCRX, STRX, SWRX, in accordance with estimated amounts described in the SFLMP and ARM aimed at applying appropriate silvicultural treatments in reasonable proportions by cover type. Table 18 shows the constraint levels used. The resulting sustainable harvest level was 69.6 MMBF/Year, a decrease of 0.05%. Inventory increased over time to 6.2 BBF at period 20. On this run, 152,096 acres were assigned to no-management, while 595,184 acres received a pathway with active management.

Table 18: Threshold Acres for EAR Constraint

Rx Group	Threshold Acres
CCRX	48,471
STRX	114,479
SWRX	190,193
UERX	242,040
GORX	152,097
Total	**747,280**

5.2.1.9 SEN – Sensitive Watershed Constraint

The purpose of this run was to show the impact of the sensitive watershed constraints, which limited the amount of acres less than age 40 years to 36% of the sensitive watershed acres. This target was imposed for all sensitive watersheds to limit the minimum acres of age classes less than 40 years to 39,900 acres. The resulting sustainable harvest level was 69.7 MMBF/Year, a decrease of 1.2%. Inventory increased over time to 6.2 BBF at period 20. In this run, 149,545 acres were assigned to no-management, while 597,735 acres received a pathway with active management.

5.2.1.10 GZB –Grizzly Bear Habitat Constraints

This run showed the impact of the Grizzly Bear constraints, including the Grizzly Bear Visual Buffer and the Grizzly Bear security zones, on the harvest level. The visual buffers totaled 4,978 acres, while the security zones totaled 20,370 acres of commercial forest. The resulting sustainable harvest level was just under 68.4 MMBF/Year, a decrease of 0.05%. Inventory increased over time to 6.4 BBF at period 20. On this run, 163,857 acres were assigned to no-management, while 583,423 acres received a pathway with active management.

5.2.1.11 LMA – Canada Lynx Management Area Constraints

The purpose of this run was to show the impact on the harvest level of HCP constraints applied within the LMAs. This constraint consisted of various subsets of constraints, each dealing with a different aspect of Lynx habitat (LM1, LM2, LM31, and ITP). The acreage thresholds associated with these constraints are shown in Table 19. The resulting sustainable harvest level was 68.4 MMBF/Year, a decrease of 1.8%. Inventory increased over time to 6.4 BBF at period 20. In this run, 167,222 acres were assigned to no-management, while 580,058 acres received a pathway with active management.

Table 19: LMA Constraint Targets

LMA	**LM1** - Retain 65% Suitable Habitat	**LM2** - Restrict Suitable Habitat Conversion to 15% per Decade	**LM31** - Retain 20% Winter Foraging Habitat	**ITP** - Pre-Commercial Thinning Cap
Coal Creek (CC)	9,323	2,152	2,869	1,019
Garnet (GA)	5,632	1,300	1,733	616
Stillwater East (SE)	23,794	5,533	7,377	2,622
Seeley Lake (SLA)	7,728	1,783	2,377	845
Stillwater West (SW)	24,189	5,584	7,446	2,626
Stillwater South (SS)	5,668	1,308	1,744	620
Swan	33,219	7,666	10,221	3,632

5.2.1.12 POT – Suitable Canada Lynx Habitat Constraint on Scattered Lands

This constraint required the maintenance of suitable habitat with ample cover on at least 65% of all total potential habitat acres, at a Land Office level outside of LMA boundaries. The target acres for each Land Office associated with this constraint are shown in Table 20. The resulting sustainable harvest level was 68.4 MMBF/Year. There was no detectable reduction in sustainable harvest level associated with this constraint. Inventory increased over time to 6.5 BBF at period 20. In this run, 173,263 acres were assigned to no-management, while 574,017 acres received a pathway with active management.

Table 20: Suitable Lynx Habitat Target Acres

Land Office	Target Acres
CE	32,935
EA	3,783
NW	48,896
SW	24,306

5.2.1.13 EAG – Bald Eagle Habitat Constraint

The results of this run showed the impact of bald eagle habitat constraints on the harvest level. This constraint called for habitat in eagle nesting and primary use areas to be maintained on 6,675 acres with basal area exceeding 60 ft^2/acre. The model was unable to meet the threshold requirement of 6,675 acres due to the fact that some stands did not meet the minimum requirement of 60 ft^2/acre of BA from the onset (period 0), despite being classified as bald eagle habitat; while others never grew beyond 60 ft^2/acre of BA. The primary cause of this is that the model utilized strata level yield tables, which represented the average condition of all stands in the strata (i.e., the actual stand probably achieved the threshold value, and hence the fact that it was classified as bald eagle habitat). With no management (grow only), the model was able to meet the constraint on a statewide basis by period seven, so in order to provide the model with a workable solution that incorporated management, the starting period for the constraint was changed to period seven and the threshold was reduced to 6,650 acres to maintain the greatest level of constraint possible. Although the eagle habitat constraint was intended to emphasize uneven-aged management pathways with sustained basal area exceeding 60 ft^2/acre, this constraint conflicted with the cap imposed on uneven-aged acres by the EAR constraint (§0). No additional acreage could be diverted to uneven-aged at this point, so the model sought the eagle habitat acres in even-aged silvicultural regimes that met the criteria of exceeding 60 ft^2/acre at all times. These even-aged pathways are effectively managed as uneven-aged because they are not harvested. Consequently, the final sustainable harvest level was 68.3 MMBF/Year, a decrease of 0.1% despite an increase in the total acres under active management. Inventory increased over time to 6.5 BBF at period 20. In this run, 163,857 acres were assigned to no-management, while 583,889 acres received a pathway with active management.

5.2.2 Scenario 2 – Impact of Acquired Lands

A model run was conducted to determine the impact of the acquired acres on the sustainable yield. For this scenario, the acquired lands were withdrawn from the Fully Constrained Model

(Section 5.2.1), resulting in an annual sustainable harvest level of 66.8 MMBF and inferring that the addition of those lands contributes 1.5 MMBF to the annual sustainable yield.

6 Recommendations for Future Calculations

The 2020 SYC represents the latest refinement to a harvest scheduling model devised in 2004. During the 2015 SYC update, MB&G identified several avenues to improve the result. The DNRC has implemented aspects of the 2015 recommendations, which we will review in the next section. During the last five years, other developments have emerged that justify new recommendations, with which we close this section.

6.1 Revisiting Recommendations from 2015 SYC

Each of the recommendations below are condensed from the 2015 SYC report, with further comments regarding DNRC progress toward each objective and opportunities for updates.

Inventory program: Implement annual inventory program first focused on capturing data from unrepresented or under-represented strata, eventually to update all strata on a regular basis.

> Progress: DNRC undertook a significant effort to re-stratify existing stands by species composition and forest structure more suited to the ownership. Additional inventory data from 2018 were included in the 2020 SYC. The 2015 report recommended expansion of inventory to the Eastern Land Office, but that has not yet been possible.
>
> Update 1: Extend inventory to the Eastern Land Office and update the tree lists for each EA stratum, including testing FVS calibration to anticipate impacts of change to tree lists.
>
> Update 2: Extend inventory to strata that are currently represented by substitutions—affects 115 strata across all of the Land Offices.

Augmenting SLI with habitat typing and stand age: Refine the habitat typing and stand age assignment in the SLI, recognizing that defining stand age is challenging for uneven-aged management types that are widely represented in DNRC ownership.

> Progress: The habitat type code is among the strongest drivers of growth in the Inland Empire and Eastern Montana variants of FVS. The re-stratification undertaken for the 2020 SYC required new habitat code assignments for all strata. Similarly, re-stratification necessitated new age assignment by stratum.
>
> Update 1: Both habitat type and age are effectively acting as FVS calibration proxies in the 2020 SYC, and may not derive from observations for all strata due to the new stratification method. Habitat can be assigned during annual inventory efforts.
>
> Update 2: The set of stand ages used in the 2020 SYC was inherited from the 2015 SYC and may be refined to better represent the age classes of the new strata.

Calibrate FVS more specifically for DNRC lands: The out-of-the-box FVS IE and EM variants are typically unsuited to particular locations and should be calibrated.

Progress: The 2020 SYC adopted FVS calibrations developed for the Custer Gallatin and Helena Lewis and Clark National Forests, as well as Western Root Disease modules devised for several productivity classes.

Update 1: The EM variant of FVS should be best suited for the CE and EA Land Offices, but the calibration was not always acceptable without strata substitutions, habitat reassignment, or conversion to IE variant. For a future SYC, the DNRC annual inventory program could be leveraged to provide tree list data helpful for a DNRC-specific EM calibration.

Update 2: Both EM and IE variant yield forecasts required additional modifications even after application of CG, HLC, and WRD key word sets, but could be further calibrated to DNRC specifications using standard key word modifiers.

6.2 Additional Recommendations

The DNRC has already implemented various elements of the recommendations from the 2015 SYC report. Changes to stratification in the 2020 effort will necessitate a review of the habitat type and age assignments prior to the next SYC update. Beyond the updates recommended in the previous section, which were chiefly a continuation of the ongoing programs, there are several areas where DNRC may consider new approaches.

The revised stratification scheme in the 2020 SYC is more appropriate, but sampling intensity was not explicitly discussed in the 2015 report. Certain strata in certain Land Offices (NW, SW) produce the bulk of the timber volume and value. If there is an economic imperative for revenue generation rather than simply proportionally representing acreage, sampling could be emphasized in Land Offices or districts where this is the case.

Each LP from 2004, 2015, and 2020 was constructed as a stratum-based model, but the DNRC GIS consists of individual stands, which could afford the opportunity to upgrade to a stand-based model, assuming sufficient resolution on inventory. Budget may not support a traditional timber cruising program to update the SLI at the time scale necessary for a stand-based model, but remote sensing approaches may be an option in the near future. The DNRC system relies on the combination of SLI, tree lists, and FVS, however, it is not clear that the USFS itself is anticipating that FVS will remain its yield projection system of choice.

Rapidly declining costs for acquisition of detailed satellite imagery and LiDAR data are leading the USFS to look to these total coverage data types to describe their entire ownership. As a State agency, DNRC could be in a good position to collaborate with USFS on data acquisition and analysis. A remote sensing approach could gain relevance as USFS devotes only limited resources to maintenance and active development of FVS. Proportionally greater emphasis is being placed on remote sensing data collection, suggesting a strategic shift from mechanistic individual-tree modeling to recurrent and complete "wall to wall" observations. The modeling framework to project future yields and stand structure from these remote sensing products has not been developed, however, and it is unclear what form these will ultimately take.

7 MB&G Certification

I certify that to the best of my knowledge and belief that:

- The statement of facts contained in this report is true and correct.
- The reported analyses, opinions, and conclusions are limited only by the reported assumptions and limiting conditions and reflect my personal, unbiased professional analyses, opinions and conclusions.
- We have no present or prospective interest in the resource that is the subject of this report.
- Engagement in this assignment was not contingent upon developing or reporting predetermined results.
- Compensation for completing this assignment is not contingent upon the development or reporting of a predetermined result or direction in result that favors the cause of the client.
- Significant professional assistance was provided to the persons signing this certification as follows: and Jessica Burton-Desrocher.

___________________________	___________________________
Tom Baribault	Mark L. Rasmussen
Mason, Bruce & Girard, Inc.	**Mason, Bruce & Girard, Inc.**

8 Appendix A: Summary of Model Runs

8.1 Fully Constrained Model

The following charts show selected results from the final Fully Constrained LP model run.

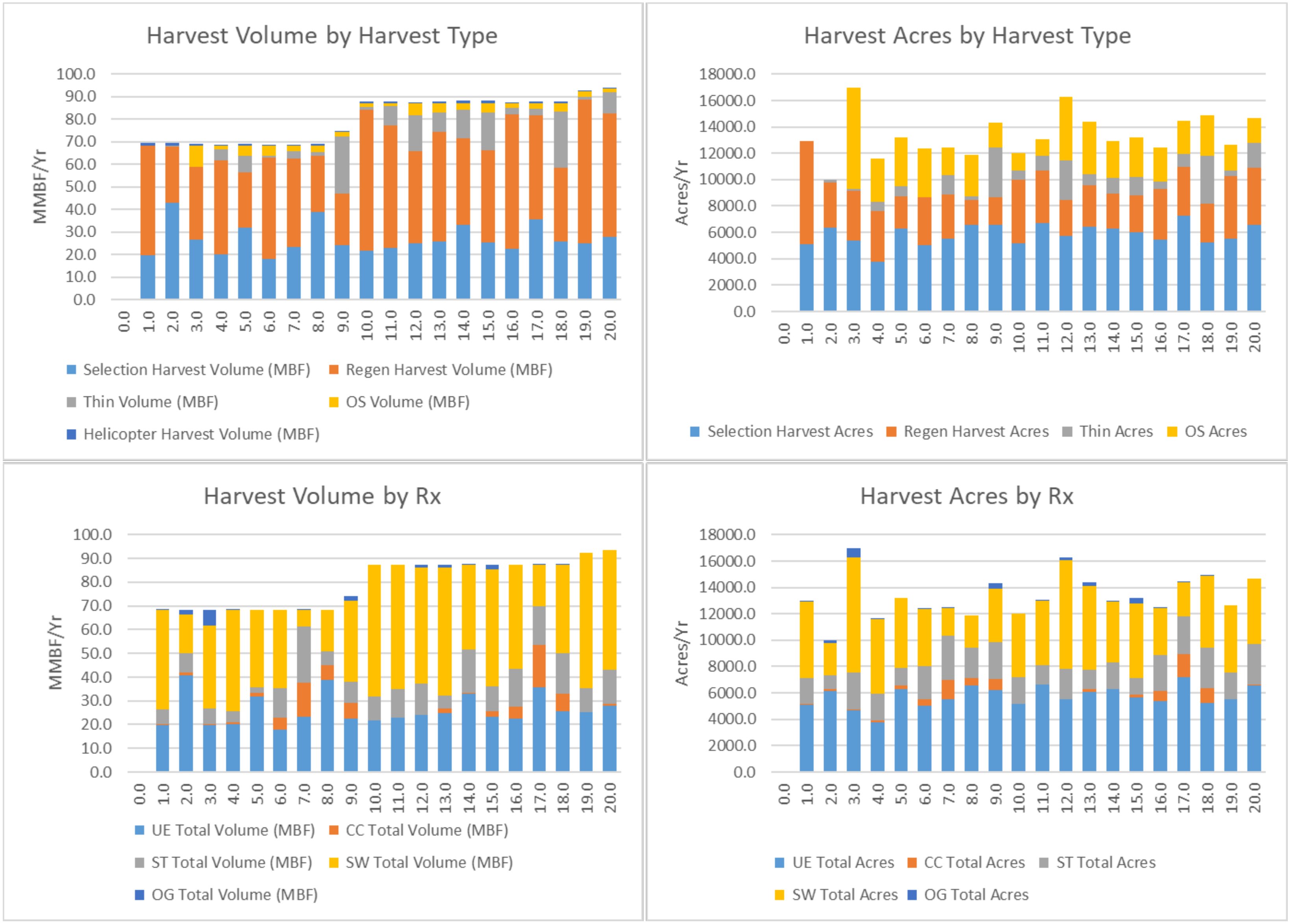

Figure 3: Fully Constrained Model Results – Page 1

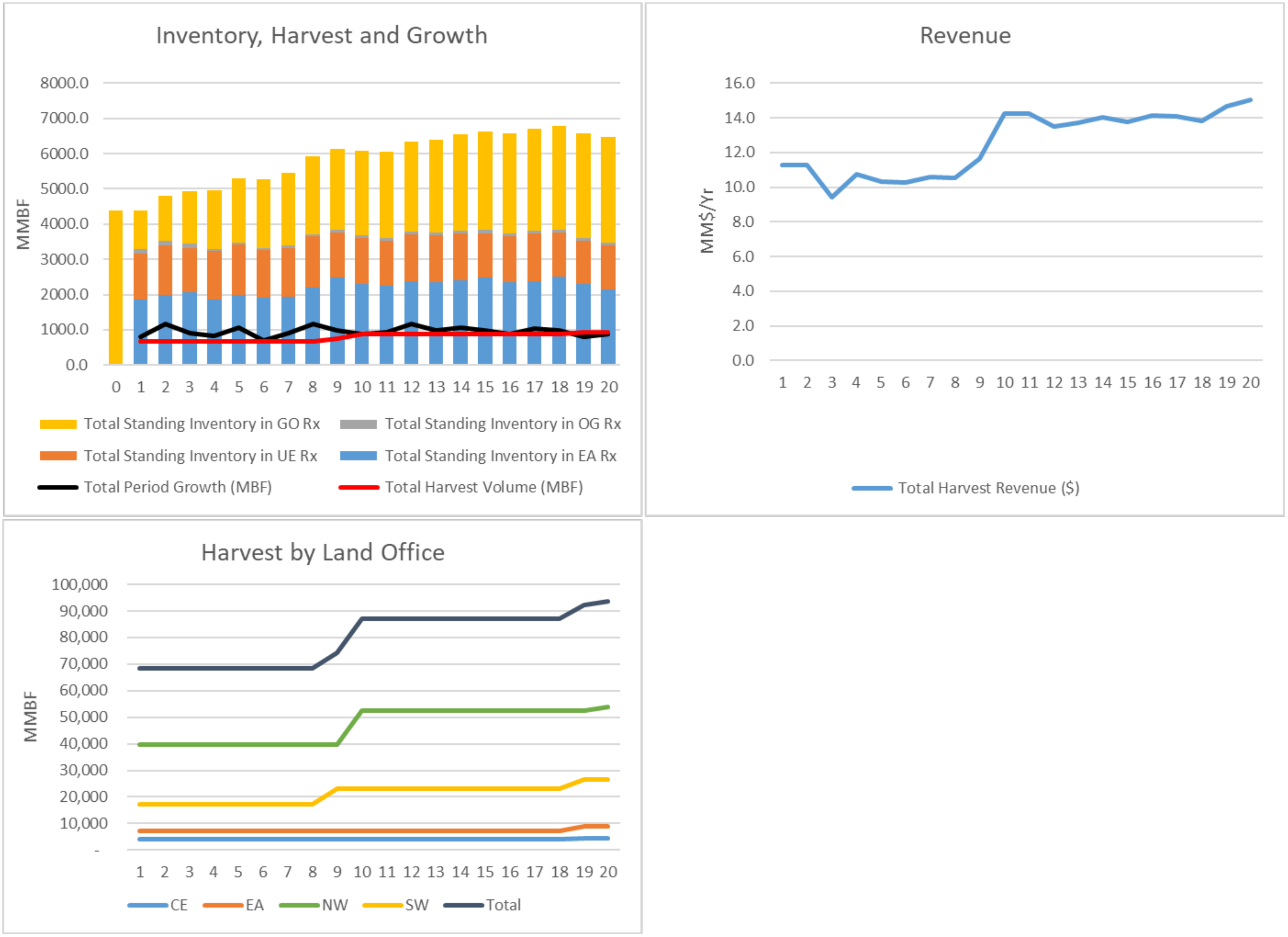

Figure 4: Fully Constrained Model Results – Page 2

9 Appendix B: Compatibility Matrix

The following matrix shows the relationship between the various LP model thematic layers and the major management pathway groups

- GORX. Grow only management pathways with no active management or silvicultural treatments.
- CCRX. Even-aged management pathway (EARX) that terminates in a clear-cut regeneration harvest.
- STRX. Even-aged management pathway (EARX) that terminates in a seed-tree regeneration harvest.
- SWRX. Even-aged management pathway (EARX) that terminates in a shelter-wood regeneration harvest.
- UERX. Uneven-aged management pathway with multiple selection harvests.
- OGRX. Old-growth management pathway with multiple selection harvest entries, which aim to maintain old-growth status.

In this table a "?" indicated that the given thematic layer was not limiting with regards to the pathway, while an "N" indicates that only areas coded as not part of the thematic layer could participate in the pathway. Additional details for the land office, species and productivity themes are provided in Appendix D.

Theme	Description	GORX	CCRX	STRX	SWRX	UERX	OGRX
1	Strata ID	?	?	?	?	?	?
2	Land Office	Appendix D	Appendix D	Appendix D	Appendix D	Appendix D	Appendix D
3	Unit	?	?	?	?	?	?
4	Species	Appendix D	Appendix D	Appendix D	Appendix D	Appendix D	Appendix D
5	Size	?	?	?	?	?	?
6	Stocking	?	?	?	?	?	?
7	Productivity Class	Appendix D	Appendix D	Appendix D	Appendix D	Appendix D	Appendix D
8	Start Age	?	?	?	?	?	?
9	Deferred	?	N	N	N	N	N
10	Rx	?	?	?	?	?	?
11	Timing	?	?	?	?	?	?
12	Rotation	?	?	?	?	?	?
13	Sensitive Watersheds	?	?	?	?	?	?
14	UMZ	?	N	N	N	?	?
15	Helicopter	?	?	?	?	?	?
16	RMZ	?	N	N	N	N	N
17	GZB Visual Buffer	?	N	N	N	?	?
18	GZB Security Zone	?	N	N	N	N	N
19	GZB Subunits	?	?	?	?	?	?
20	LMA	?	?	?	?	?	?
21	Potential Lynx Habitat	?	?	?	?	?	?
22	Eagle	?	N	N	N	?	?
23	OG Recruitment	?	?	?	?	?	?
24	OG Current	?	?	?	?	?	?

10 Appendix C: Acres in the Forest Management Model

The following tables show the acres present in various thematic layers, and how the acres were classified within each. The thematic layer represented in each table is labeled in the top right corner of each table. The data within each table is organized as cross-tabulations, with thematic values in the rows and land management unit in the columns (except for the first table which has land office in the columns).

The table "Unit Acres" contains a cross-tabulation of management unit acres by land office. Table 21 shows the various codes used for unit and land office:

Table 21: Key to Codes for Land Office and Unit

Land Office	Name
CE	Central
EA	Eastern
NW	North-Western
SW	South-Western

Unit	Name
ANA	Anaconda
BIL	Billings
BOZ	Bozeman
CLW	Clearwater
CON	Conrad
DIL	Dillon
GLA	Glasgow
HAM	Hamilton
HAV	Havre
HEL	Helena
KAL	Kalispell
LEW	Lewiston
LIB	Libby
MIL	Miles City
MSO	Missoula
PLN	Plains
STW	Stillwater
SWN	Swan

The thematic codes used in the "Strata Acres" table consists of three components, namely species (vegetation type), size class and stocking. The code "WLDF7A" therefore represents the strata for western larch/Douglas-fir species (WLDF), seedling-sapling size class (7), and adequate stocking (A). Species is represented by a two-, three-, or four-digit code, while size and stocking are always represented by a single digit. The old-growth strata (OGW1, OGW4 and OGW6) do not follow this classification scheme and are only represented by their four-digit codes. Please refer to section 4.3.5 for a definition of the old growth codes. Table 22 shows the various codes used for species, size and stocking:

Table 22: Key to Codes for Species, Size and Stocking

Species	Land Office	Name
DPMC	CE, EA	Douglas-fir/Ponderosa Pine/Mixed Conifer
GFRC	NW, SW	Grand fir/Western Redcedar/Western Hemlock/Western White Pine
LP	ALL	Lodgepole Pine
NS	ALL	Non-stocked
PPDF	NW, SW	Ponderosa Pine/Douglas-fir
SF	CE, EA	Engelmann spruce/Subalpine fir
SFC	NW, SW	Engelmann spruce/Subalpine fir/Whitebark Pine Cold Site
SFM	NW, SW	Engelmann spruce/Subalpine fir Moist Site
WLDF	NW, SW	western larch/Douglas-fir

Size	Name
6	Non-Stocked
7	Seedling - Sapling
8	Pole-Timber
9	Saw-Timber

Stocking	Name
N	Non-Stocked
A	Adequate
L	Low

Some thematic layers were labeled with either a “yes” (Y) or “no” (N) value to indicate whether a given acre was part of the constraint or not. Therefore, in the tables below a row value of “In (Y)” was used to flag the acres that were part of the thematic layer, while “Out (N)” was used to flag the acres outside of the thematic layer. For instance, in the Deferred Acres table, the acres associated with the “In (Y)” row were deferred, while the acres associated with the “Out (N)” row were not deferred.

Finally, the following codes in Table 23 were used to identify acres in sensitive watersheds and lynx management areas (LMA).

Table 23: Key to Codes for Sensitive Watersheds and LMA's

Sensitive Watershed	Name
(UPWH)	Upper Whitefish
(SFLS)	South Fork Lost-Soup
(POWO)	Porcupine-Woodward
(LICR)	Lion Creek
(LACR)	Lazy Creek
(GOCR)	Goat Creek
(STCC)	Stillwater-Coal Creek

LMA	Name
(CC)	Coal Creek
(GA)	Garnet
(SE)	Stillwater East
(SLA)	Seeley Lake
(SW)	Stillwater West
(SS)	Stillwater South
Swan	Swan

Unit	Acres by Land Office			
	CE	EA	NW	SW
ANA	-	-	-	25,895
BIL	-	52,720	-	-
BOZ	19,107	-	-	-
CLW	-	-	-	66,453
CON	4,692	-	-	-
DIL	28,407	-	-	-
GLA	-	4,741	-	-
HAM	-	-	-	22,662
HAV	-	4,402	-	-
HEL	54,289	-	-	-
KAL	-	-	50,103	-
LEW	-	30,239	-	-
LIB	-	-	29,979	-
MIL	-	47,916	-	-
MSO	-	-	-	81,670
PLN	-	-	49,688	-
STW	-	-	122,930	-
SWN	-	-	51,389	-
Total:	**106,495**	**140,018**	**304,089**	**196,681**

Stratum	Acres by Unit																	
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN
CEDPMC7A	-	-	117	-	32	85	-	-	-	946	-	-	-	-	-	-	-	-
CEDPMC7L	-	-	158	-	-	308	-	-	-	566	-	-	-	-	-	-	-	-
CEDPMC8A	-	-	1,039	-	1,651	1,222	-	-	-	5,256	-	-	-	-	-	-	-	-
CEDPMC8L	-	-	1,554	-	286	2,295	-	-	-	7,917	-	-	-	-	-	-	-	-
CEDPMC9A	-	-	8,174	-	795	15,392	-	-	-	25,736	-	-	-	-	-	-	-	-
CEDPMC9L	-	-	2,516	-	5	2,694	-	-	-	5,641	-	-	-	-	-	-	-	-
CELP7A	-	-	374	-	-	368	-	-	-	365	-	-	-	-	-	-	-	-

Stratum	Acres by Unit																	
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN
CELP7L	-	-	135	-	-	167	-	-	-	173	-	-	-	-	-	-	-	-
CELP8A	-	-	445	-	-	665	-	-	-	894	-	-	-	-	-	-	-	-
CELP8L	-	-	67	-	-	140	-	-	-	47	-	-	-	-	-	-	-	-
CELP9A	-	-	1,515	-	114	1,464	-	-	-	2,520	-	-	-	-	-	-	-	-
CELP9L	-	-	77	-	-	376	-	-	-	43	-	-	-	-	-	-	-	-
CENS6N	-	-	1,986	-	1,808	1,124	-	-	-	3,958	-	-	-	-	-	-	-	-
CESF7L	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-
CESF8A	-	-	46	-	-	95	-	-	-	70	-	-	-	-	-	-	-	-
CESF8L	-	-	49	-	-	292	-	-	-	39	-	-	-	-	-	-	-	-
CESF9A	-	-	855	-	-	1,642	-	-	-	64	-	-	-	-	-	-	-	-
CESF9L	-	-	-	-	-	68	-	-	-	55	-	-	-	-	-	-	-	-
EADPMC7A	-	14	-	-	-	-	-	-	-	-	-	163	-	122	-	-	-	-
EADPMC7L	-	241	-	-	-	-	-	-	-	-	-	116	-	151	-	-	-	-
EADPMC8A	-	659	-	-	-	-	115	-	296	-	-	652	-	891	-	-	-	-
EADPMC8L	-	6,774	-	-	-	-	850	-	784	-	-	3,601	-	7,078	-	-	-	-
EADPMC9A	-	19,499	-	-	-	-	2,185	-	1,891	-	-	17,475	-	19,100	-	-	-	-
EADPMC9L	-	14,109	-	-	-	-	1,504	-	1,360	-	-	6,571	-	10,135	-	-	-	-
EALP7A	-	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EALP7L	-	-	-	-	-	-	-	-	10	-	-	10	-	-	-	-	-	-
EALP8A	-	10	-	-	-	-	-	-	-	-	-	214	-	-	-	-	-	-
EALP8L	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EALP9A	-	536	-	-	-	-	-	-	52	-	-	1,021	-	-	-	-	-	-
EALP9L	-	740	-	-	-	-	-	-	-	-	-	65	-	-	-	-	-	-
EANS6N	-	10,094	-	-	-	-	87	-	8	-	-	350	-	10,439	-	-	-	-
NWGFRC7A	-	-	-	-	-	-	-	-	-	-	378	-	207	-	-	114	4,658	760
NWGFRC7L	-	-	-	-	-	-	-	-	-	-	22	-	10	-	-	-	594	1,021
NWGFRC8A	-	-	-	-	-	-	-	-	-	-	329	-	177	-	-	116	3,608	2,356
NWGFRC8L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	189	554
NWGFRC9A	-	-	-	-	-	-	-	-	-	-	3,221	-	984	-	-	2,207	9,065	6,019
NWGFRC9L	-	-	-	-	-	-	-	-	-	-	245	-	-	-	-	715	599	2,769

Stratum	Acres by Unit																	
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN
NWLP7A	-	-	-	-	-	-	-	-	-	-	368	-	254	-	-	785	6,464	731
NWLP7L	-	-	-	-	-	-	-	-	-	-	39	-	-	-	-	165	406	61
NWLP8A	-	-	-	-	-	-	-	-	-	-	1,029	-	717	-	-	486	7,633	786
NWLP8L	-	-	-	-	-	-	-	-	-	-	11	-	19	-	-	75	194	-
NWLP9A	-	-	-	-	-	-	-	-	-	-	153	-	249	-	-	10	1,512	532
NWLP9L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	89	79	232
NWNS6N	-	-	-	-	-	-	-	-	-	-	711	-	1,226	-	-	985	2,496	471
NWOGW1	-	-	-	-	-	-	-	-	-	-	597	-	798	-	-	33	876	17
NWOGW4	-	-	-	-	-	-	-	-	-	-	1,614	-	1,774	-	-	328	10,998	7,660
NWOGW6	-	-	-	-	-	-	-	-	-	-	-	-	21	-	-	129	3,906	161
NWPPDF7A	-	-	-	-	-	-	-	-	-	-	828	-	951	-	-	1,142	444	28
NWPPDF7L	-	-	-	-	-	-	-	-	-	-	98	-	111	-	-	132	308	24
NWPPDF8A	-	-	-	-	-	-	-	-	-	-	1,121	-	2,568	-	-	1,101	709	180
NWPPDF8L	-	-	-	-	-	-	-	-	-	-	63	-	86	-	-	140	150	-
NWPPDF9A	-	-	-	-	-	-	-	-	-	-	17,132	-	12,484	-	-	20,112	4,400	2,711
NWPPDF9L	-	-	-	-	-	-	-	-	-	-	2,484	-	1,465	-	-	5,098	1,161	304
NWSFC7A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,229	-
NWSFC7L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	202	-
NWSFC8A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,612	31
NWSFC8L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26	84
NWSFC9A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,909	350
NWSFC9L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	90	161
NWSFM7A	-	-	-	-	-	-	-	-	-	-	62	-	-	-	-	-	3,612	52
NWSFM7L	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	430	90
NWSFM8A	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	3,301	435
NWSFM8L	-	-	-	-	-	-	-	-	-	-	33	-	-	-	-	-	332	267
NWSFM9A	-	-	-	-	-	-	-	-	-	-	851	-	89	-	-	311	11,397	2,690
NWSFM9L	-	-	-	-	-	-	-	-	-	-	-	-	65	-	-	-	441	277
NWWLDF7A	-	-	-	-	-	-	-	-	-	-	1,424	-	342	-	-	857	4,874	702
NWWLDF7L	-	-	-	-	-	-	-	-	-	-	19	-	-	-	-	103	892	752

Stratum	Acres by Unit																	
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN
NWWLDF8A	-	-	-	-	-	-	-	-	-	-	1,620	-	546	-	-	731	5,879	3,794
NWWLDF8L	-	-	-	-	-	-	-	-	-	-	30	-	36	-	-	-	439	211
NWWLDF9A	-	-	-	-	-	-	-	-	-	-	13,557	-	4,538	-	-	11,103	19,969	9,822
NWWLDF9L	-	-	-	-	-	-	-	-	-	-	1,958	-	261	-	-	2,621	4,849	4,296
SWGFRC7A	155	-	-	37	-	-	-	241	-	-	-	-	-	-	347	-	-	-
SWGFRC7L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41	-	-	-
SWGFRC8A	13	-	-	272	-	-	-	-	-	-	-	-	-	-	271	-	-	-
SWGFRC8L	128	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SWGFRC9A	188	-	-	1,364	-	-	-	16	-	-	-	-	-	-	558	-	-	-
SWGFRC9L	-	-	-	161	-	-	-	-	-	-	-	-	-	-	420	-	-	-
SWLP7A	904	-	-	577	-	-	-	2,204	-	-	-	-	-	-	1,167	-	-	-
SWLP7L	291	-	-	841	-	-	-	198	-	-	-	-	-	-	39	-	-	-
SWLP8A	729	-	-	1,705	-	-	-	587	-	-	-	-	-	-	1,135	-	-	-
SWLP8L	359	-	-	129	-	-	-	7	-	-	-	-	-	-	32	-	-	-
SWLP9A	358	-	-	406	-	-	-	12	-	-	-	-	-	-	497	-	-	-
SWLP9L	30	-	-	-	-	-	-	-	-	-	-	-	-	-	191	-	-	-
SWNS6N	1,030	-	-	511	-	-	-	3,213	-	-	-	-	-	-	3,176	-	-	-
SWOGW1	1,366	-	-	1,428	-	-	-	284	-	-	-	-	-	-	511	-	-	-
SWOGW4	26	-	-	684	-	-	-	-	-	-	-	-	-	-	771	-	-	-
SWOGW6	112	-	-	171	-	-	-	26	-	-	-	-	-	-	92	-	-	-
SWPPDF7A	300	-	-	847	-	-	-	2,887	-	-	-	-	-	-	3,754	-	-	-
SWPPDF7L	362	-	-	383	-	-	-	782	-	-	-	-	-	-	1,989	-	-	-
SWPPDF8A	555	-	-	4,312	-	-	-	150	-	-	-	-	-	-	7,174	-	-	-
SWPPDF8L	112	-	-	624	-	-	-	18	-	-	-	-	-	-	1,460	-	-	-
SWPPDF9A	14,997	-	-	32,277	-	-	-	8,657	-	-	-	-	-	-	34,831	-	-	-
SWPPDF9L	2,233	-	-	6,654	-	-	-	3,104	-	-	-	-	-	-	8,585	-	-	-
SWSFC7A	-	-	-	38	-	-	-	-	-	-	-	-	-	-	11	-	-	-
SWSFC8A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	55	-	-	-
SWSFC9A	10	-	-	74	-	-	-	-	-	-	-	-	-	-	142	-	-	-
SWSFC9L	-	-	-	71	-	-	-	61	-	-	-	-	-	-	60	-	-	-

Stratum	Acres by Unit																	
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN
SWSFM7A	55	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-
SWSFM7L	47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SWSFM8A	25	-	-	46	-	-	-	-	-	-	-	-	-	-	178	-	-	-
SWSFM8L	27	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SWSFM9A	116	-	-	350	-	-	-	-	-	-	-	-	-	-	214	-	-	-
SWSFM9L	-	-	-	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SWWLDF7A	20	-	-	284	-	-	-	-	-	-	-	-	-	-	878	-	-	-
SWWLDF7L	22	-	-	314	-	-	-	-	-	-	-	-	-	-	133	-	-	-
SWWLDF8A	77	-	-	1,685	-	-	-	-	-	-	-	-	-	-	1,518	-	-	-
SWWLDF8L	69	-	-	185	-	-	-	-	-	-	-	-	-	-	39	-	-	-
SWWLDF9A	727	-	-	7,955	-	-	-	160	-	-	-	-	-	-	9,841	-	-	-
SWWLDF9L	454	-	-	2,014	-	-	-	53	-	-	-	-	-	-	1,549	-	-	-
Total:	25,895	52,720	19,107	66,453	4,692	28,407	4,741	22,662	4,402	54,289	50,103	30,239	29,979	47,916	81,670	49,688	122,930	50,389

Stocking	Acres by Unit																	
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN
A (adequate)	19,228	20,755	12,565	52,229	2,593	20,933	2,300	14,915	2,239	35,851	42,172	19,525	24,105	20,113	62,582	39,074	93,274	31,977
L (low)	4,133	21,871	4,556	11,431	291	6,350	2,354	4,224	2,155	14,480	5,009	10,364	2,055	17,364	14,538	9,138	11,381	11,102
N (non-stock)	1,030	10,094	1,986	511	1,808	1,124	87	3,213	8	3,958	711	350	1,226	10,439	3,176	985	2,496	471
W1	1,366	-	-	1,428	-	-	-	284	-	-	597	-	798	-	511	33	876	17
W4	26	-	-	684	-	-	-	-	-	-	1,614	-	1,774	-	771	328	10,998	7,660
W6	112	-	-	171	-	-	-	26	-	-	-	-	21	-	92	129	3,906	161
Total:	25,895	52,720	19,107	66,453	4,692	28,407	4,741	22,662	4,402	54,289	50,103	30,239	29,979	47,916	81,670	49,688	122,930	51,389

Deferred Acres	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN	Total
Out (N)	21,114	47,170	9,919	63,801	1,084	24,287	-	22,459	3,096	33,369	47,030	24,877	29,494	47,287	77,058	42,079	110,940	50,163	655,228
Lease Lots, Policy, Law	6	886	330	155	0	79	0	0	0	201	361	207	13	132	86	168	213	6	2,844
Low Value - High Dev. Costs	2,144	1,292	2,289	143	3,195	2,252	4,741	0	523	11,025	125	1,844	174	78	2,218	732	4,765	0	37,542
No Legal Access	1,231	11	4,732	162	0	1,305	0	0	585	7,809	672	1,704	0	351	655	5,308	991	67	25,583
Timber Cons. License / Lease	0	5	0	67	0	0	0	0	0	0	0	0	0	0	75	31	0	0	179
Topography (steep, rocky, etc.)	981	1,718	1,229	96	133	259	0	157	198	1,349	907	1,606	130	42	1,497	950	4,564	617	16,431
Wet Areas	419	1,639	608	2,029	279	225	0	46	0	536	1,009	0	168	24	81	422	1,456	535	9,476
In (Y)	4,782	5,550	9,188	2,652	3,607	4,120	4,741	203	1,306	20,920	3,073	5,362	485	628	4,612	7,609	11,990	1,226	92,055
	25,895	52,720	19,107	66,453	4,692	28,407	4,741	22,662	4,402	54,289	50,103	30,239	29,979	47,916	81,670	49,688	122,930	51,389	747,283

Sensitive Watershed	Acres by Unit																		Total
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN	
Out (N)	25,895	52,720	19,107	66,453	4,692	28,407	4,741	22,662	4,402	54,289	48,917	30,239	29,979	47,916	81,670	49,688	64,390	281	636,449
In (Y)	-	-	-	-	-	-	-	-	-	-	1,185	-	-	-	-	-	58,540	51,109	110,834
Total:	25,895	52,720	19,107	66,453	4,692	28,407	4,741	22,662	4,402	54,289	50,103	30,239	29,979	47,916	81,670	49,688	122,930	51,389	747,283

UMZ	Acres by Unit																		Total
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN	
Out (N)	25,895	52,720	19,107	66,453	4,692	28,407	4,741	22,662	4,402	54,289	50,103	30,239	29,979	47,916	81,670	49,688	121,621	51,271	745,855
In (Y)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,309	119	1,428
Total:	**25,895**	**52,720**	**19,107**	**66,453**	**4,692**	**28,407**	**4,741**	**22,662**	**4,402**	**54,289**	**50,103**	**30,239**	**29,979**	**47,916**	**81,670**	**49,688**	**122,930**	**51,389**	**747,283**

Helicopter Logging	Acres by Unit																		Total
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN	
Out (N)	25,321	52,613	18,659	65,883	4,692	28,407	4,741	22,506	4,402	54,289	49,441	30,239	29,298	47,916	81,670	49,552	113,868	50,712	734,208
In (Y)	575	107	448	571	-	-	-	157	-	-	661	-	681	-	-	137	9,061	677	13,075
Total:	**25,895**	**52,720**	**19,107**	**66,453**	**4,692**	**28,407**	**4,741**	**22,662**	**4,402**	**54,289**	**50,103**	**30,239**	**29,979**	**47,916**	**81,670**	**49,688**	**122,930**	**51,389**	**747,283**

RMZ	Acres by Unit																		Total
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN	
Out (N)	24,842	50,955	18,344	64,186	4,550	27,472	4,645	21,491	4,242	52,392	48,530	29,169	28,950	46,565	79,261	48,070	114,823	48,510	716,997
In (Y)	1,054	1,765	764	2,268	141	936	96	1,171	160	1,897	1,572	1,070	1,028	1,350	2,409	1,618	8,107	2,880	30,286
Total:	**25,895**	**52,720**	**19,107**	**66,453**	**4,692**	**28,407**	**4,741**	**22,662**	**4,402**	**54,289**	**50,103**	**30,239**	**29,979**	**47,916**	**81,670**	**49,688**	**122,930**	**51,389**	**747,283**

GZB Vis.	Acres by Unit																		Total
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN	
Out (N)	25,895	52,720	19,107	66,143	4,657	28,407	4,741	22,662	4,402	54,260	49,783	30,239	29,529	47,916	81,670	49,374	120,435	50,365	742,305
In (Y)	-	-	-	311	35	-	-	-	-	29	320	-	450	-	-	315	2,495	1,025	4,978
Total:	**25,895**	**52,720**	**19,107**	**66,453**	**4,692**	**28,407**	**4,741**	**22,662**	**4,402**	**54,289**	**50,103**	**30,239**	**29,979**	**47,916**	**81,670**	**49,688**	**122,930**	**51,389**	**747,283**

GZB Sec. Zone.	Acres by Unit																		Total
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN	
Out (N)	25,895	52,720	19,107	66,453	4,692	28,407	4,741	22,662	4,402	54,289	50,103	30,239	29,979	47,916	81,670	49,688	102,560	51,389	726,913
In (Y)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20,370	-	20,370
Total:	**25,895**	**52,720**	**19,107**	**66,453**	**4,692**	**28,407**	**4,741**	**22,662**	**4,402**	**54,289**	**50,103**	**30,239**	**29,979**	**47,916**	**81,670**	**49,688**	**122,930**	**51,389**	**747,283**

Current OG	Acres by Unit																		Total
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN	
Out (N)	24,391	52,720	19,107	64,171	4,692	28,407	4,741	22,352	4,402	54,289	47,892	30,239	27,386	47,916	80,296	49,197	107,150	43,550	712,900
In (Y)	1,505	-	-	2,282	-	-	-	310	-	-	2,211	-	2,592	-	1,374	491	15,780	7,839	34,383
Total:	**25,895**	**52,720**	**19,107**	**66,453**	**4,692**	**28,407**	**4,741**	**22,662**	**4,402**	**54,289**	**50,103**	**30,239**	**29,979**	**47,916**	**81,670**	**49,688**	**122,930**	**51,389**	**747,283**

LMA	Acres by Unit																		Total
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN	
CC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14,343	-	14,343
GA	-	-	-	7,432	-	-	-	-	-	-	-	-	-	-	1,232	-	-	-	8,664
Out (N)	25,895	52,720	19,107	47,133	4,692	28,407	4,741	22,662	4,402	54,289	50,103	30,239	29,979	47,916	80,438	49,688	25,755	284	578,450
SE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36,884	-	36,884
SLA	-	-	-	11,889	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11,889
SS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8,720	-	8,720
SW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	37,228	-	37,228
Swan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	51,106	51,106
Total:	**25,895**	**52,720**	**19,107**	**66,453**	**4,692**	**28,407**	**4,741**	**22,662**	**4,402**	**54,289**	**50,103**	**30,239**	**29,979**	**47,916**	**81,670**	**49,688**	**122,930**	**51,389**	**747,283**

Potential Lynx Hab.	Acres by Unit																		Total
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN	
Out (N)	20,038	48,939	4,629	46,523	3,690	6,865	4,741	21,094	4,402	40,643	27,083	28,200	20,446	47,916	62,017	28,247	10,663	2,961	429,098
In (Y)	5,858	3,782	14,478	19,930	1,001	21,543	-	1,568	-	13,647	23,019	2,038	9,532	-	19,653	21,441	112,267	48,428	318,186
Total:	**25,895**	**52,720**	**19,107**	**66,453**	**4,692**	**28,407**	**4,741**	**22,662**	**4,402**	**54,289**	**50,103**	**30,239**	**29,979**	**47,916**	**81,670**	**49,688**	**122,930**	**51,389**	**747,283**

Bald Eagle Habitat	Acres by Unit																		Total
	ANA	BIL	BOZ	CLW	CON	DIL	GLA	HAM	HAV	HEL	KAL	LEW	LIB	MIL	MSO	PLN	STW	SWN	
Out (N)	25,878	52,560	19,107	65,644	4,692	28,339	4,741	22,457	4,402	54,182	49,804	30,239	29,387	47,916	80,203	49,330	120,555	51,173	740,608
In (Y)	18	160	-	809	-	68	-	206	-	108	298	-	591	-	1,467	358	2,375	216	6,675
Total:	**25,895**	**52,720**	**19,107**	**66,453**	**4,692**	**28,407**	**4,741**	**22,662**	**4,402**	**54,289**	**50,103**	**30,239**	**29,979**	**47,916**	**81,670**	**49,688**	**122,930**	**51,389**	**747,283**

11 Appendix D: Management Pathways

The following tables show the combinations of land office, species and productivity class that were eligible for each management pathway (Rx). These tables also show the types of silvicultural treatments that each pathway was eligible for. These treatments can be classified as either pre-commercial thinning (PCT), commercial thinning (CT), or selection harvest (Sel. or uneven-aged). PCT treatments were defined in terms of age of treatment and after-harvest trees per acre (TPA). CT treatments were defined in terms of earliest age of treatment and after-harvest trees per acre (TPA). The selection harvest for the uneven-aged pathways (UERX) were defined in terms of earliest age of treatment, residual TPA target and re-entry period, while the old-growth selection harvests (OGRX) were defined in terms of after-harvest BA, TPA larger than a threshold diameter at breast height (DBH), and re-entry period. The even-aged pathways (EARX) were also defined in terms of the number of leave trees associated with each harvest intensity type (CC, ST, or SW).

Each of the management pathways were labelled with a unique 8-digit Rx code, with each digit describing a different aspect of the pathway. This allowed each pathway to be labeled with a unique code that could be used as a reference for the silvicultural treatments within the pathway. The following table describes the composition of the Rx codes in further detail:

Table 24: Key to the Rx Codes

Digits	Group	Code	Definition
1	Strata Type	E	Existing Strata
		N	Future (Regeneration) Strata
2	PCT	+	No PCT
		2	PCT at Age 20
3 to 4	CT and Sel. Harvest	++	No CT or Selection Harvest
		1T	One CT to a TPA Target
		MB	Multiple Selection Harvests to a BA Target
5	Fertilization	+	No Fertilization
6 to 7	Rx Type	CC	EARX with Clear-Cut Regeneration Harvest
		ST	EARX with Seed-Tree Regeneration Harvest
		SW	EARX with Shelter-Wood Regeneration Harvest
		UD	UERX on Dry Site
		UM	UERX on Moist Site
		W1	OGRX on W1
		W4	OGRX on W4
		W6	OGRX on W6
8	Overstory Removal	N	No Overstory Removal Harvest
		X	Overstory Removal Harvest Option Not Available
		Y	Overstory Removal Harvest

Table 25: Even-Aged Management Prescriptions for Existing Strata (EARX)

Rx	OSR	Land Office	Species	Size Class	Productivity Class	PCT Age	PCT TPA	CT Age	CT TPA	Residual TPA	OSR Timing	# Leave Trees after OSR
E++++CC	X	NW, SW	LP, SFC, W6,	All	All	n/a	n/a	n/a	n/a	4	n/a	n/a
E++++CC	X	CE, EA	LP, SF	All	All	n/a	n/a	n/a	n/a	4	n/a	n/a
E2+++CC	X	All	LP, SFC	7	H	20	300	n/a	n/a	4	n/a	n/a
E++++ST	N/Y	NW, SW	All except LP	All	All	n/a	n/a	n/a	n/a	8	20 years	4
E++++ST	N/Y	CE, EA	DPMC, NS	All	All	n/a	n/a	n/a	n/a	8	30 years	4
E+1T+ST	N/Y	NW, SW	All except LP	8	H, M	n/a	n/a	60	100	8	20 years	4
E2+++ST	N/Y	NW, SW	All except LP	7	H	20	200	n/a	n/a	8	20 years	4
E21T+ST	N/Y	NW, SW	All except LP	7	H	20	200	50	100	8	20 years	4
E++++SW	N/Y	NW, SW	All except LP, SFC, W6	All	All	n/a	n/a	n/a	n/a	25	20 years	4
E++++SW	N/Y	CE, EA	DPMC, NS	All	All	n/a	n/a	n/a	n/a	25	30 years	4
E+1T+SW	N/Y	NW, SW	All except LP, SFC, W6	8	H, M	n/a	n/a	60	100	25	20 years	4
E2+++SW	N/Y	NW, SW	All except LP, SFC, W6	7	H	20	200	n/a	n/a	25	20 years	4
E21T+SW	N/Y	NW, SW	All except LP, SFC, W6	7	H	20	200	50	100	25	20 years	4

Table 26: Uneven Aged Management Prescriptions (UERX)

Rx	Land Office	Forest Type (Species)	Productivity Class	Sel. Res. TPA	Diameter range allowable	Legacy Trees (> up. diam)	Sel. Re-Entry
E+MB+UD	All	DPMC, PPDF, WLDF	All	226	6" – 22"	2	40
E+MB+UM	NW, SW	GFRC, SFM	All	226	6" – 22"	4	30

Table 27: Old-Growth Management Prescriptions (OGRX)

Rx	Land Office	Forest Type (Species)	Productivity Class	Sel. Res. BA	Sel. TPA Large Trees	Sel. Large Tree DBH	Sel. Re-Entry
E+MB+W1	NW, SW	OGW1	All	60	10	21	30
E+MB+W4	NW, SW	OGW4	All	100	12	21	50
E+MB+W6	NW, SW	OGW6	All	80	12	13	50

Table 28: Even-Aged Management Prescriptions for Future Strata (EARX)

Rx	OSR	Land Office	Species	Productivity Class	PCT Age	PCT TPA	CT Age	CT TPA	Residual TPA	OSR Timing	# Leave Trees after OSR
E++++CC	X	All	LP, SFC, SF	All	n/a	n/a	n/a	n/a	4	n/a	n/a
E2+++CC	X	All	LP, SFC, SF	H	20	300	n/a	n/a	4	n/a	n/a
E++++ST	N/Y	NW, SW	All except LP	All	n/a	n/a	n/a	n/a	8	20 years	4
E++++ST	N/Y	CE, EA	DPMC	All	n/a	n/a	n/a	n/a	8	30 years	4
E+1T+ST	N/Y	NW, SW	All except LP	H, M	n/a	n/a	60	100	8	20 years	4
E2+++ST	N/Y	NW, SW	All except LP	H	20	200	n/a	n/a	8	20 years	4
E21T+ST	N/Y	NW, SW	All except LP	H	20	200	50	100	8	20 years	4
E++++SW	N/Y	NW, SW	All except LP, SFC	All	n/a	n/a	n/a	n/a	25	20 years	4
E++++SW	N/Y	CE, EA	DPMC	All	n/a	n/a	n/a	n/a	25	30 years	4
E+1T+SW	N/Y	NW, SW	All except LP, SFC	H, M	n/a	n/a	60	100	25	20 years	4
E2+++SW	N/Y	NW, SW	All except LP, SFC	H	20	200	n/a	n/a	25	20 years	4
E21T+SW	N/Y	NW, SW	All except LP, SFC	H	20	200	50	100	25	20 years	4

12 Appendix E: Selection Harvest Reversed J-Curves

The reversed J-Curves for UERX were developed through a series of trials. Initially only three curves were defined, one each for dry, moist and wet sites. Each of these curves had a Q-factor, a DBH range from zero to 24, a DBH class size of 4”, and retained 2 TPA larger than 24”. All of them also used a 30-year re-entry period. Implementation of these curves showed unacceptably large BA reductions following selection harvests, often resulting in tree lists that were well below their BA target and unsustainable with regards to volume. The solution was to follow a tiered approach, which incrementally decreased the BA target until the desired level was reached (Don’t try to get to future desired condition in one step). This approach worked well for moist, resulting in two tiers each. For moist sites the first tier targeted 115 BA with a Q-factor of 1.8, while the second tier targeted 80 BA with a Q-factor of 1.4. For dry sites more trials were needed. A three-tier approach with a 40-year re-entry period was investigated, which worked well for NW and SW strata. For these strata the first tier targeted 85 BA with a Q-factor of 1.7, the second tier targeted 65 BA with a Q-factor of 1.5, and the third tier targeted 45 BA with a Q-factor of 1.2. The CE and EA strata however still showed residual BA falling well below the target. Following more trials, a two-tier approach was adopted for these strata using a DBH range between zero and 20”, and 1 TPA larger than 20”. For these strata the first tier targeted 80 BA with a Q-factor of 2.8, while the second tier targeted 50 BA with a Q-factor of 2.2.

Table 29: Reversed J-Curve Definitions

Rx	Land Office	Tier	BA Target	Q-Factor	DBH From	DBH To	TPA
UD	CE, EA	1	80	2.8	0	4	335
UD	CE, EA	1	80	2.8	4	8	120
UD	CE, EA	1	80	2.8	8	12	43
UD	CE, EA	1	80	2.8	12	16	15
UD	CE, EA	1	80	2.8	16	20	5
UD	CE, EA	1	80	2.8	20	99	1
UD	CE, EA	2	50	2.2	0	4	125
UD	CE, EA	2	50	2.2	4	8	57
UD	CE, EA	2	50	2.2	8	12	26
UD	CE, EA	2	50	2.2	12	16	12
UD	CE, EA	2	50	2.2	16	20	5
UD	CE, EA	2	50	2.2	20	99	1

Rx	Land Office	Tier	BA Target	Q-Factor	DBH From	DBH To	TPA
UD	NW, SW	1	85	1.7	0	4	90
UD	NW, SW	1	85	1.7	4	8	53
UD	NW, SW	1	85	1.7	8	12	31
UD	NW, SW	1	85	1.7	12	16	18
UD	NW, SW	1	85	1.7	16	20	11
UD	NW, SW	1	85	1.7	20	24	6
UD	NW, SW	1	85	1.7	24	99	2
UD	NW, SW	2	65	1.5	0	4	46
UD	NW, SW	2	65	1.5	4	8	31
UD	NW, SW	2	65	1.5	8	12	21
UD	NW, SW	2	65	1.5	12	16	14
UD	NW, SW	2	65	1.5	16	20	9
UD	NW, SW	2	65	1.5	20	24	6
UD	NW, SW	2	65	1.5	24	99	2
UD	NW, SW	3	45	1.2	0	4	15
UD	NW, SW	3	45	1.2	4	8	12
UD	NW, SW	3	45	1.2	8	12	10
UD	NW, SW	3	45	1.2	12	16	8
UD	NW, SW	3	45	1.2	16	20	7
UD	NW, SW	3	45	1.2	20	24	6
UD	NW, SW	3	45	1.2	24	99	2
UM	All	1	115	1.8	0	4	146
UM	All	1	115	1.8	4	8	81
UM	All	1	115	1.8	8	12	45
UM	All	1	115	1.8	12	16	25
UM	All	1	115	1.8	16	20	14
UM	All	1	115	1.8	20	24	8
UM	All	1	115	1.8	24	99	2
UM	All	2	80	1.4	0	4	45
UM	All	2	80	1.4	4	8	32
UM	All	2	80	1.4	8	12	23
UM	All	2	80	1.4	12	16	16
UM	All	2	80	1.4	16	20	12
UM	All	2	80	1.4	20	24	8
UM	All	2	80	1.4	24	99	2

13 Appendix F: Summary of SYC Law from Montana Code Annotated

77-5-221. Definition. As used in 77-5-222, 77-5-223, and this section, "annual sustainable yield" means the quantity of timber that can be harvested from forested state lands each year in accordance with all applicable state and federal laws, including but not limited to the laws pertaining to wildlife, recreation, and maintenance of watersheds, and in compliance with water quality standards that protect fisheries and aquatic life and that are adopted under the provisions of Title 75, chapter 5, taking into account the ability of state forests to generate replacement tree growth.

History: En. Sec. 1, Ch. 517, L. 1995.

77-5-222. Determination of annual sustainable yield. (1) (a) On July 1, 2013, the department, under the direction of the board, shall commission a new study by a qualified independent third party to determine, using scientific principles, the annual sustainable yield on forested state lands. The department shall direct the qualified independent third party to determine the yield pursuant to, but not exceeding, all state and federal laws.

(b) A new study may be commissioned by the department, under the direction of the board, at any time during the 10-year period provided for in subsection (2).
(2) A determination of annual sustainable yield under subsection (1) must be reviewed and re-determined by the department, under the direction of the board, at least once every 10 years.

History: En. Sec. 2, Ch. 517, L. 1995; amd. Sec. 1, Ch. 440, L. 2003; amd. Sec. 1, Ch. 288, L. 2013.

77-5-223. Annual sustainable yield as timber sale requirement -- review. The annual sustainable yield constitutes the annual timber sale requirement for the state timber sale program administered by the department. This annual requirement may be reduced proportionately by the amount of sustained income to the beneficiaries generated by site-specific alternate land uses approved by the board based on a determination under 77-5-222.

History: En. Sec. 3, Ch. 517, L. 1995 ; amd. Sec. 2, Ch. 288, L. 2013.

14 Appendix G: List of Contributors

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15 Appendix H: SYC Internal and Public Involvement Process

- March 11, 2020 – Met with Montana Wood Products Association members to present preliminary SYC results and answer questions.
- April 1, 2020 – Briefed Southwestern Land Office field staff on SYC results and answered questions.
- April 2, 2020 – Briefed Northwestern Land Office field staff on SYC results and answered questions.
- April 9, 2020 – Briefed all DNRC Forest Management Program staff on preliminary SYC Draft Report and answered questions.
- May 5, 2020 – Completion of the SYC Draft Report.
- May 8, 2020 – Scoping notice sent via email to interested members of the public and the DNRC statewide scoping list announcing the availability of the SYC Draft Report. The notice included an executive summary, instructions for requesting a public meeting and copy of the report, links to the website, an update on the process, instructions for submitting comments, and contact information. Published the Draft Report on the DNRC website, along with an executive summary, FAQ, and a copy of the scoping notice.
- May 11, 2020 to June 11, 2020 – Official 30-day public review period of SYC Draft.
- June 11, 2020 – End of public review period.
- June 23, 2020 – Presented SYC results to Montana Wood Products Association Resource Committee and answered questions.
- July 8, 2020 – DNRC completed written responses to public comments.
- July 8, 2020 – Completion of the SYC Final Report.
- July 8, 2020 – Presented SYC results to Land Board Staffers and answered questions.
- July 20, 2020 – SYC Final Report presented to the Land Board.

16 Appendix I: DNRC Responses to Public Comments

Forest Management Bureau Sustainable Yield Calculation Technical Team

July 8, 2020

DNRC received written comments on the 2020 SYC Draft Report from six respondents identified below. Since many respondents offered similar comments on certain topics, comments are presented as a statement paraphrasing the topic of the comment, followed by the identifying numbers of the respondents who submitted the comment and DNRC's response.

1. F.H. Stoltze Land & Lumber (Stoltze)
2. Friends of the Wild Swan (FOWS)
3. Idaho Forest Group (IFG)
4. Pyramid Mountain Lumber (Pyramid)
5. Sun Mountain Lumber (Sun Mtn)
6. Weyerhaeuser (Weyco)

Topic: Climate Change

Comment 1: DNRC did not consider impacts of climate change when calculating the sustainable yield and should not rely on past conditions to predict future growth and forest conditions.
Specific Comments:
(FOWS) - The most glaring omission from the SYC is not factoring climate change into the calculation. There is abundant scientific data that climate change is and will impact tree growth and forested ecosystems in Montana, yet climate change is not even mentioned in the SYC. It is unrealistic for DNRC to paint a rosy picture of growth and yield while increasing the timber target without accounting for a warmer, drier climate in Montana, decreasing tree growth and tree species conversion. Past conditions will not predict the future in the wake of climate change.

(FOWS)—DNRC must not rely on the past to predict the future when it comes to calculating sustained yield. Climate change must be factored in to determine where trees will regrow, what trees will regrow, and whether trees will regrow.

Response 1: *We agree that evidence of widespread climate change has been well-documented and reported and is an important consideration today (Intergovernmental Panel on Climate Change 2013). In Montana, effects of climate change will be related to changes in temperature and moisture availability, and the response of individual tree species, forests and habitats will be complex and variable depending local site and stand conditions. Changes in temperature and moisture availability may affect the ability of some tree species to establish and regenerate on some sites. Forest productivity may increase in some areas due to longer growing seasons associated with increased temperature where moisture is not limited, but may decrease in other areas where increasing temperature results in decreased water availability (Wade et al. 2017).*

Drought severity is expected to increase, leading to increases in forest and tree mortality. Changing climate may also lead to changes in the range of some species, resulting in changes in forest composition and distribution (Wade et al. 2017).

Changing climate is also expected to alter natural disturbance regimes, such as fire and insects, with the resulting effects expected to have greater impact on Montana's forests than changes in temperature and moisture availability that directly affect individual trees and species (Wade et al. 2017).

Climate change related factors and influences are considered and incorporated in a number of ways in the SYC. These include current growth data, regeneration success and stocking, tree species composition, standing inventory, and actual constraints themselves that address currently important habitat parameters, such as those for bull trout, Canada lynx and grizzly bears. By using the most current constraints and forest data available, the calculation integrates and considers numerous variables potentially influenced by, and sensitive to, changes in climate in deriving sustainable harvest estimates. Thus, this type of modeling provides one of the best available assurances for any forest management program that key variables potentially influenced by climate factors are considered and incorporated each time a sustainable harvest level is calculated. Three of the most important elements that DNRC will continue to incorporate, and believes are critical to obtaining accurate calculation estimates are: current and accurate stand data, ample sample size and sample distribution to address the appropriate land base, and continued calculations every 10 years as required under (MCA 77-5-222) that continue to incorporate and track changing local forest conditions over time.

References:
Intergovernmental Panel on Climate Change (IPCC). 2013. Fifth Assessment Report for the Intergovernmental Panel on Climate Change. Available online at http://www.ipcc.ch/report/ar5/index.shtml (accessed 6 July 2018).

Wade, A.A, A.P. Ballantyne, A.J. Larson, W.M. Jolly. 2017. Forests and climate change in Montana. In: Whitlock, C., W. Cross, B. Maxwell. N. Silvervman, A.A. Wade. 2017 Montana Climate Assessment. Bozeman and Missoula, MT: Montana State University and University of Montana, Montana Institute on Ecosystems. Available online at http://montanaclimate.org/chapter/forests (accessed 6 August 2018).

Topic: Growth and Yield Calibration

Comment 2: DNRC's growth and yield calibration fails to account for situations where forest is converted to nonforest, and their use of FVS variants does not provide an accurate picture of conditions of DNRC forest land.

Specific Comments:

(FOWS) The SYC states: "DNRC updated its growth and yield model calibration using western root disease model calibrations developed by the U.S. Forest Service for the IE (Inland Empire) variant of FVS (Forest Vegetation Simulator), and used a calibration developed for the Custer-Gallatin National Forest by MB&G for the EM (Eastern Montana) variant. DNRC also opted to use the IE variant of FVS for the CLO (Central Land Office) as opposed to the EM variant that was used in 2015; the EM variant is now used only in the EA (Eastern Land Offices) area. These calibrations resulted in increased growth rates across all Land Offices compared to 2015 and that are in line with published growth rates for Montana as well as anecdotal growth rates from industrial private forest landowners in Montana." However, it fails to acknowledge that the Forest Service has voluntarily reported on two other case histories of conversion to non-forest, one in the Ashland district of the Custer-Gallatin, another in the Big Belts of the Helena-L&C.

(Weyco)-- The reliance on FVS variants developed for other applications to represent the specific conditions on DNRC Trust Lands lends the appearance of a temporary rather than a permanent solution.

(IFG)—While we appreciate the improvements made in the 2020 methodology including additional data collection, we feel that the use of regional variants introduces an assumption that limits further understanding and inhibits decision making particularly at the Land Office scale.

Response 2: *Case studies of conversion from one forest type to another (non)forest type are not appropriate sources for estimating forest growth and yield; instead DNRC relied on calibrations developed by third-party sources that are based on permanent plot data. If DNRC were to observe conversion of forested land to nonforest, that change in condition would be reflected in Stand Level Inventory updates and in future sustainable yield calculations. DNRC selected the Forest Vegetation Simulator (FVS) as the growth and yield model for this calculation for several reasons, including that it is a nationally-recognized and supported model that is widely used by both private and public forest landowners. FVS relies on regional variants to estimate forest growth in geographic areas throughout the U.S., and the two variants that were used for this calculation, the Inland Empire (IE) and Eastern Montana (EM) variants, are specifically applicable to Montana forests. As such, we feel that the estimates of growth and yield produces by those variants is appropriate for estimating growth and yield on forested State trust lands.*

Topic: Inventory Data

Comment 3: A stand-level inventory based on “walkthrough” data is subjective and does not provide an adequate level of detail to reliably estimate forest conditions or model sustainable yield. DNRC should transition to a stand-level inventory that is based on field-sampled data.
Specific Comments:
(Weyco)-- we feel that the basis for the entire process relies on subjective data produced by the Stand Level Inventory (SLI) walkthrough system. Inventory and growth and yield programs are only as good as the data that feeds them and the reliance upon a walkthrough inventory data set does not provide adequate data to base a growth and drain program upon. Even with the modifications and restratification of the SLI doesn’t change the fact that it does not use measurable data; furthermore the workload and cost required to augment a system that doesn’t adequately represent the conditions on the ground is questionable. The reliance on FVS variants developed for other applications to represent the specific conditions on DNRC Trust Lands lends the appearance of a temporary rather than a permanent solution. We agree with the MBG suggestions under the “Recommendations for Future Calculations” heading that the DNRC implement an annual inventory collection program focusing on under-represented Strata, assigning standard habitat typing to the SLI so FVS can more accurately represent growth models and ultimately transition to a stand based

inventory using field sampled data. Some suggestions for achieving this include exploring new technology such as Lidar or utilizing timber cruises already performed during timber sale preparation and associating that cruise data with stand polygons; depletions can be based on timber volume removed from the timber sale. DNRC foresters are already collecting cruise data as a part of timber sale preparation, it seems as if that data should be put to use on the land base and a programmatic plan to ultimately transition to practices used throughout the forest industry is advisable.

(IFG)-- We'd like to encourage the DNRC to continue its investment in a full stand-based inventory in order to continue to enhance the level of detail and information available regarding existing conditions and the State's ability to fine-tune growth and yield calculations.

(Sun Mtn)--Continuing the Stand Level Inventory and increasing the data to describe forest conditions are important investments and will significantly aid the success of future SYC projects.

(Stoltze)—The 2020 SYC is a step ahead of the 2015 project. We were pleased to see the DNRC acting on the recommendations of MB&G from 2015 and encourage continued improvement along those lines. We support the DNRC continuing to build a Stand Level Inventory, utilizing current processes and new technology to incrementally build a SLI. We think the return over time would be significant in high level planning as well as project level analysis, not to mention budgeting.

(Stoltze)—Similarly, investment in some permanent growth plots will help better inform the SYC process as well as aid in management decision prioritization. Focus your efforts on those lands that are sufficiently productive to produce a return on investment faster.

Response 3: *DNRC's stand level data (SLI) is currently based upon "walk-through" data collection. DNRC recognizes that "walk-through" is subjective and has a lower degree of accuracy compared to measured plot data collection at the stand level. Due to budget and personnel limitations, the "walk-through" data collection system was chosen by the DNRC many years ago in order to inventory the most acres for the least amount of costs. We are considering several alternative methods of data collection to update the SLI that would result in a more accurate and robust forest inventory, including using timber sale cruise data (as recommended by one of the commenters), expanding use of remote sensing and LiDAR methods, and installation of permanent plots to inform and improve growth and yield data.*

Topic: Deferred Acres and Constraints

Comment 4: Deferred acres and other management constraints account for a substantial reduction in sustainable yield and therefore return to the Trust beneficiaries. DNRC should review deferred acres and other constraints and work to bring those acres into management in order to increase revenues to the trust beneficiaries.

Specific Comments:

(Stoltze)—It continues to be surprising to see the scale of deferred acres within the program. Having 163,851acres under No Management, over 21% of total forested acres, still seems high. While an improvement over the last calculation, we encourage continued review of this number. Ensuring there is consistent direction given regarding criteria required to designate acres deferred is important. Specific criteria for what constitute "*Low Value – High Development Cost*" and "*Topography*" must be consistently applied. We question if "*No Legal Access"* should be a deferral criterion as that is a limitation that could be remedied. We would encourage the DNRC to continue to review how commercial forestlands are categorized as "deferred" especially as new harvest techniques and other remedies may become available.

(Weyco)—The SYC report indicates a certain portion is related to parcels with no legal access and we suggest the DNRC have a system to address parcels without legal access by focusing on obtaining either permanent or temporary access, land trades, or ultimately divesture of the parcel. A parcel without access or a plan to obtain access is not contributing to the trust and it is incumbent upon the DNRC to maximize returns to the school trusts while divesting of underperforming assets.

(IFG)—It has been widely discussed and noted by others that the Sustainable Yield Calculation (SYC) is heavily constrained by many years and layers of forest management regulations. We would like our comments to reflect that these decisions have incremental, but very significant impacts on the beneficiaries return from Trust Lands. Combined these restrictions reduce the yield by over 25% from a biological capacity of 91.5 MMBF to a constrained 68.3 MMBF on 750,000 acres of commercial forestland. Approximately 18% of that reduction is just in leave trees and deferred acres. We would encourage the DNRC to continue to review how commercial forestlands are categorized as "deferred" especially as new harvest techniques and other remedies may become available.

(Stoltze)—As we have seen in previous SYC work, it is continually surprising the impact and scale of deferred acres and constraints on the model. Going from a biological capacity of over 90mmbf/yr to an operational capacity of 68.3mmbf/yr is huge. Using a conservative, unweighted average stumpage value of $125/mbf, this equates to roughly $2.7 million dollars in forgone annual stumpage payments to the Trusts. Certainly, some of that is due to physical constraint, but much can be attributed to management constraints that have either been imposed upon or agreed to by the agency. That is a significant cost of constraint that needs to be kept in mind as future management, access and land ownership decisions are considered.

Response 4: *The DNRC recognizes that there are a significant amount of acres deferred from management in our commercial timber base. The DNRC will be taking a closer look at these deferred acres and explore ways to move those acres out of Trust ownership when careful evaluation determines it is beneficial to the Trust Beneficiaries to divest of these parcels. Some of the parcels are generating revenue from other land uses and this must be a consideration during the evaluation.*

Constraints applied in this 2020 calculation are consistent with those applied in prior DNRC calculations. The constraints account for programmatic requirements contained in the SFLMP, Forest Management ARMs, and Forest Management HCP. 22,007-acres alone are constrained as deferred lands required as a part of a Federal Court settlement agreement approved in 2015 pertaining to a lawsuit filed against the U.S. Fish and Wildlife Service regarding the HCP. Further, many of the lands recently acquired by DNRC are constrained by conservation easements legally bound to land deeds. DNRC remains diligent in finding and acquiring permanent and temporary *access to all of its forested land base and continues to take advantage of opportunities to put up limited access projects. Constraints applied in this calculation ensure that the volume target will be achievable for the upcoming decade while complying with all applicable laws and agreements, while fostering a credible forest management program that promotes sound forest stewardship and protects the short and long-term interests of Trust beneficiaries.*

While access and markets are highly limiting in eastern Montana, timber production and management is not the primary revenue-generating use on the vast majority of these lands. Most are managed for the purpose of grazing and agriculture.

Topic: RMZ Restrictions

Comment 5: The RMZ constraint specifies no management with RMZs; however, management in RMZ's can be beneficial and should be allowed. Is this restriction for modeling purposes only, or is management allowed in RMZs?

Specific Comments:

(Stoltze)—We were surprised to see the entire RMZ acreage treated as "grow only" management regime. We have been told all along that there would be some management allowed within the expanded RMZ to meet resource objectives. Is that not the case?

(IFG)—Regarding RMZs, it appears that these areas were extended to include adjacent wetlands as well as channel migration zones and modeled as a "grow only" management pathway. This may be a limitation of the model itself, but its our understanding that some management would be allowed within the expanded RMZ definition to meet resource objectives. Further clarification on these constraints would be helpful.

(Weyco)--We find the exclusion of RMZ acres from harvest surprising and question the efficacy of this decision. Management of RMZ's is critical to forest health, LWD recruitment, uneven aged management, and wildlife security. This abrupt change to management is concerning, however it is concerning whether this is a model constraint or an actual management decision. Under this description one could also infer that no management of RMZ's could also qualify as Old Growth (OG) or OG recruitment and those OG specific acres should be removed from elsewhere on the landscape but this does not appear to be the case. Stepping away from RMZ's should be more thoroughly vetted before implementing this strategy.

(Sun Mtn)--The reasons for the restrictions with RMZ classification are not clear. Management activities could occur on these acres versus the 'grow only' constraint in the model.

Response 5: *We apologize for not providing more clarity in the report regarding the RMZ constraint. The HCP and ARMs contain measures to provide habitat connectivity for biodiversity, Canada lynx, and fisher, which are difficult to quantify and account for in a SYC modeling process. Thus, rather than try and develop a subjective separate constraint in an attempt to account for varied patch retention on a subset of projects for this purpose across all land offices, the decision was made by the DNRC SYC working group to account for these requirements through a model constraint "deferral" of the entire RMZ. The working group and third party contractor believed this approach would provide a reasonable estimate of minor additional volume that would typically be constrained* *for this purpose. It is important to note that volume retained to address wildlife habitat connectivity requirements is not permanently deferred. Also in practice, during normal project development, DNRC will continue to consider and harvest volume in RMZs where it is allowable and deemed feasible according to related existing allowances under ARMs and the HCP. We apologize for this confusion.*

Topic: Sensitive Watersheds

Comment 6: What is a sensitive watershed and why are harvests constrained in those areas? DNRC should continue to evaluate management techniques in areas sensitive to potential increases in water yield.

Specific Comments:

(Stoltze)—This is a significant constraint on the Stillwater and Swan units, both highly productive areas. What specifically constitutes a "sensitive watershed"? Is there a regulatory definition? Specific restriction within the SFLMP? Once again, it would be nice to determine if this is a required or voluntary constraint.

(IFG)—However, we would encourage the DNRC to continue to evaluate management techniques in areas that are sensitive to potential increases in water yield. The science available for establishing limitations on non-stocked or younger age class stands for the purposes of sustaining water yields is very site specific and best efforts are easily undone by factors such as wildfire and insect and disease issues that could have far more long-term effects than managed harvest.

Response 6: *Sensitive watersheds are those that have been identified for municipal water uses and/or listed as impaired on Montana's 303(d) list. These watersheds are required by Rule (36.11.423) to be managed with a low to moderate degree of risk when cumulative watershed effects are assessed. The DNRC continually assesses the best available information and adaptively incorporates monitoring data from the forest management program into its management to limit cumulative watershed effects while maintaining maximum management flexibility.*

Topic: Old Growth

Comment 7: How is old growth distributed across the landscape and between managed and unmanaged acres?

Specific Comments:

(Stoltze)—We appreciate the projections of old growth acres by management area and planning period. How are old growth acres distributed between managed acres and deferred acres? It would seem over time that the preponderance of OG acres would naturally occur on the non-managed acres. Does the model prefer grow-only management regimes for allocation of OG stand characteristics?

(IFG)—We appreciate the explanation and establishment of the old growth targets by Land Office. We understand that selection harvest in old growth stands is included in the modeled silvicultural prescriptions; however, its unclear if old growth stand characteristics are required to be distributed across the landscape or if the preponderance of old growth (current and planned) is on deferred acres, RMZs, etc. On lands designated as commercial forestlands, we would expect that most of the old growth stands would occur on unmanaged or otherwise restricted acres.

Response 7: *As described on page 44, each DNRC Administrative Unit is required to maintain a specific percentage of old growth within its area. For Units in the NWLO and SWLO, each Unit is required to maintain, or achieve if it currently does not have, 8% of its acreage as old growth, and Units in the CLO are required to maintain or achieve 4%. There is no specific requirement for where old growth acres should be located within each Unit. Current old growth stands, regardless of their geographic location, can be managed using old growth maintenance or restoration treatments that maintain stands as old growth. In Units that are currently below their intended percentage of old growth acres, currently existing old growth stands must be managed using treatments that maintain those stands as old growth, while Units that currently exceed their intend percentage of old growth may apply treatments that would remove acres from old growth down to the intended percentage. Over time, areas that do not receive management, such as deferred acres, would be expected to develop into old growth; however, if those acres did not provide sufficient acreage to meet a Unit's intended percentage, an appropriate amount of acres would be managed using treatments that would facilitate their development into old growth. Old growth acres that occur in deferred and other unmanaged areas do contributed to the 8 and 4 percent old growth requirements and serve to free up other manageable acres for non-old growth management prescriptions. This would particularly be true and applicable regarding DNRC's recent Swift Creek BPA Land Acquisition on the Stillwater Unit, which is required to be managed in an old growth forest condition.*

The results of this calculation show that 9,500 acres of old growth are under active management, while the number acres contributing to old growth amounts that are not under active management for various reasons including deferral, RMZ, etc. increases from 7,011 acres in period 1 to over 127,000 acres in period 20.

Topic: Grizzly bear, Lynx, UMZ, Sensitive Watershed Constraints

Comment 8: Do wildlife, RUMZ, and sensitive watershed constraints result in more acres assigned to grow-only regimes, and does that result in reduced restrictions on managed acres?
Specific Comments:
(Stoltze)—do the grow only acres bear more of the burden for these future management constraints? And does that reduce the restriction burden on the management acres?

Response 8: *In general, the application of each successive constraint increases the amount of acres assigned to grow-only management regimes; this can be considered the "cost" of applying the management constraint associated. Acres under management are unencumbered by constraints. The constraints that result in the largest amounts of acres assigned to grow-only regimes in terms of the number of acres added to grow-only from the prior constraint are deferred acres (110,032 acres), riparian/unique management zones (23,669 acres), even-aged silviculture (15,974 acres), grizzly bear habitat/security zones (14,312 acres), and lynx habitat constraints (9,406 acres, cumulatively). It is important to note that some acres already assigned to grow only from constraints applied earlier in the model run could also fulfill the requirements of constraints applied* *later in the model run; therefore, these numbers should not be considered the "gross" effect of each constraint in terms of acres assigned to grow only regimes. For example: some acres that would have been assigned to grow only in the GZB constraint may have already been assigned to grow only because of another constraint (egs. deferred acres, riparian/unique management zones, etc.), but because of the order of constraint application, the GZB constraint results in additional 14,312 acres being assigned that were not already deferred through application of a prior constraint.*

Topic: Precommercial Thinning

Comment 9: The amount of PCT treatments seems low; this is a treatment that is very beneficial and should be applied as much as practicable, particularly on highly productive sites.
Specific Comments:
(Stoltze)—It was interesting to see very few acres modeled for PCT. We wonder if that was in response to Lynx habitat restrictions or an economic constraint? It is an interesting question if it is economically driven. Maybe a concentrated study on the economic return of precommercial thinning on State lands would be in order. While generally considered good stand tending, in many of our less productive sites, the economic viability may be questionable. Then you would need to assess if PCT has other benefits, habitat, meeting desired future condition, fuels management. Then the funding source for this may need to be reviewed based upon the beneficiary of the value promoted if not economic.

(Weyco)—The number of acres modeled for Precommercial Thinning (PCT) seems very low and does not appear to be a consideration in future management decisions. We believe the application of PCT in specific stands can greatly influence growth rates and when further coupled with commercial Thinning (CT) can have very favorable results. This benefits of this silvicultural method is particularly evident on the Stillwater Acquisition and we strongly encourage both modeling and implementation of PCT and CT on younger stands particularly in the NWLO where stocking levels and growth rates are higher than other regions.

(Sun Mtn)—The minimal use of pre-commercial thinning is a concern. Applying this treatment on as many acres as possible would seem necessary to maintain the sustained yield and maximize growth potential.

Response 9: *The occurrence of PCT within Lynx Management Areas was not reported correctly in the draft report, and this has been corrected in Figures 33-39 of Appendix J in the Final Report. However, the results presented in Figures 33-39 of Appendix J only show the application of PCT within LMAs, not the entirety of DNRC's ownership. As shown in Appendix D, for modeling purposes PCT treatments were limited to high productivity sites on the NW and SW Land Offices, although in practice some acres in the moderate productivity class receive PCT treatments. Across the entirety of DNRC ownership, 32,118 acres were assigned to management pathways that include PCT.*

Topic: Cable and Helicopter Harvesting

Comment 10: What is the basis for the 18% cable harvest constraint, and is this only a model constraint or is it an operation constraint? New harvesting methods may allow for more harvesting in difficult terrain.
Specific Comments:
(Weyco)—The not to exceed 18% cable harvest during a period is concerning and is not clear whether a period is one year or 20 It is unclear if the not to exceed 18% cable harvest is only a model constraint or an operational decision that will implemented on trust lands. We are concerned that the 18% imposition artificially limits the full capacity of the cable logging workforce; if more cable units are offered, the market will respond and more capacity will come online. Please consider this going forward as we have routinely witnessed agencies deciding what levels of cable logging are appropriate and focusing on ground-based systems instead; this is a short-sighted solution as it defers cable units to a future date. Additionally, this constraint does not consider the advent of new harvest technology such as steep slope and cable assist systems allowing more harvest on steeper ground. The focus should be on accessing difficult areas with appropriate systems instead of deferring these areas to later years.

(Pyramid)—In the current draft calculations, 1.4 MMBF was determined to only be accessible by helicopter logging. We agree helicopter logging in Montana is mostly uneconomical at this time. This may change in the future, time will tell. We encourage the DNRC to continue the use of Exca-line cable logging and look at future technology as it develops. Today, Exca-line logging can be used in many areas where helicopter was the only opportunity in the past. Tethering and new technology may continue to access more of what was considered helicopter only. Exca-line and Tethering are not cheap compared to traditional tractor ground-based harvesting, but much cheaper than helicopter harvest.

Response 10: *The 18% cable harvesting constraint was derived from slope analysis on our commercial acres. We found that 18% of our commercial timber acres has slopes in excess of 40%. This constraint is a modeling constraint per 10-year period and not an operational constraint. We agree that new harvesting technology such as Exca-line and Tethering have the potential to increase the feasibility of harvesting on steeper terrain.*

Topic: Sustainable Yield by Land Office

Comment 11: How will the 60 MMBF of annual harvest (excluding the 8.3 MMBF of "opportunity" volume) be distributed among Land Offices?
Specific Comments:
(Stoltze)—It appears from the report discussion that the SYC was modeled on a land office level, specifically for the NDY constraint. This makes sense on an organizational level due to the extreme variability in productivity and constraints. However, I can't find anywhere in the report where the results are presented on a land office level. This becomes important when the recommendation is 60mmbf target and 8.3mmbf "opportunity" volume that accounts for regional market distinctions.

(Weyco)--While conceptually the annual 8.3 MMBF of "opportunistic" volume makes sense, a specific breakdown of the constraints and associated volumes would be appreciated.

(Weyco)--The report indicates the SYC constraints placed on the 8.3 MMBF "Opportunity" volume is based on market constraints and geographic distribution however the total annual harvest of target of 60 MMBF is presented as a final sum, not broken down by office. A breakdown of annual harvest targets by Region and office would be appreciated as well as a breakdown of where the "Opportunity" volume exists and a plan to address it.

(IFG)— We fully support the concept and process of modeling the SYC at the Land Office level due to wide variation in productivity, operational constraints, and specific markets. That said, its unclear in the report how the recommendation of a 60 MMBF target will be distributed among the Land Offices annually.

Response 11: *We have added a graph to Figure 4 in Appendix J showing the resulting harvest levels by Land Office for the Fully Constrained model run. The harvest levels shown in the graph include the 8.3 MMBF of opportunity volume. The graph also shows the change in harvest levels over the planning horizon for each Land Office. For planning purposes, we expect to increase from our current harvest level of 56.9 MMBF in two phases, with a planning target of 58.4 MMBF in fiscal year 2021, and increasing to 60.0 MMBF in fiscal year 2022. The 60 MMBF target would include the following Land Office sale planning targets, although these may fluctuate slightly from year-to-year depending on the sequence and size of sales offered at each Land Office: NW—39.6 MMBF; SW—15.4 MMBF; CE—3.5 MMBF; EA—1.5 MMBF.*

Topic: Opportunity Volume

Comment 12: How will the opportunity volume be implemented? Is it all ponderosa pine? Opportunity volume should be included in the statewide target as this would ensure consistent supply and create demand if sales are designed/packaged in a desirable manner.
Specific Comments:
(Pyramid)—In your draft, you have calculated 8.3 MMBF in Eastern Montana as "Opportunity Wood" which is currently uneconomical to harvest, haul and make any money for the Trust in today's markets. Is this volume all species or just Ponderosa Pine? If market conditions don't allow economical harvest in the next 5-10 years, does that 8.3 MMBF/year get added onto their sustainably harvest when markets do improve? There are other markets for Douglas fir, Spruce, Lodgepole in Eastern Montana that are not available for Ponderosa Pine.

(IFG)--We'd like to encourage the DNRC to include the opportunity volume in the statewide target in an effort to encourage creation of a market for eastside pine, which would also help the DNRC meet some of its forest health and restoration goals.

(Weyco)--Ponderosa Pine (PP) volume primarily found in the ELO is indicated to be a large contributor to the 8.3 MMBF of annual deferred volume and the report states that future markets could develop and bring that volume online. Perhaps the DNRC could approach ELO PP by offering several sales lumped together in a larger multi-year package rather than and individual, per sale basis with shorter terms. The larger volumes and longer timeframe could encourage bidders/businesses and provide some supply related certainty which a limiting factor for wood products manufacturing.

(Stoltze)—While we understand the rationale behind recommending a target level of 60mmbf and additional “opportunity volume” we question how this will be implemented. While markets in the eastern part of the state may be less developed than the west, not having consistency in supply is one of the primary barriers to market development.

(Stoltze)—One option would be to develop a “wood basket” or portfolio of potential projects in the east that a potential purchaser could then review and possibly purchase from. It is the proverbial chicken and egg situation, but from a trust mandate standpoint, it is the role of the agency to develop value from these lands or to divest and reinvest. We suggest that some level of annual target be allocated to all units with forestland, then direct development of a portfolio of management projects that could be available to a purchaser. Quite honestly, opportunities don’t just show up on your doorstep, you usually need to seek or create them.

(Stoltze)—While we fully understand the scope of the model is not project level, the management intent of the model needs to match that on the ground. Hence the reason for allocating some of the 8.3mmbf opportunity volume as target rather than all “opportunity”.

Response 12: *The 2020 SYC of 68.3 MMBF provides an estimate of annual timber harvest level given the current DNRC forested land base and set of management constraints. Diminished pine markets across the state, specifically in the eastern half of Montana, present the most significant challenge in achieving this target over the next 10 years. To date, DNRC has experienced several ponderosa pine sales that have received no bids and support classifying this predominately eastside ponderosa pine volume as opportunity volume. For this reason, the DNRC is recommending an adjusted annual target of 60.0 MMBF recognizing an additional 8.3 MMBF of unharvested, commercial reserves that could be realized in the program should strategic markets and infrastructure develop in the future. DNRC as an agency, will continue working with interested stakeholders to package this eastside “wood basket,” to test existing markets in new ways and to work towards developing new markets.*

The eastern area offices will have a proposed annual target of 1.5 MMBF. This 1.5 MMBF is part of the proposed 60.0 MMBF annual target. It is important to note that the dispersed nature of our eastside forested parcels, poor market conditions and limited mill availability have only warranted that we maintain 1.1 full time staff split between three eastside DNRC Area Offices. We also note that all eastside opportunity volume parcels produce revenue from other predominant uses in many cases, which include agriculture, grazing, and/or oil and gas leases and therefore are not prime candidates for disposition. These eastside forested acres (opportunity volume) were included in the 2020 SYC because it allows DNRC to account for these assets, albeit as unrealized potential future revenue for the trusts.

Topic: Comments Related to Unclear Information in the Report

Comment 13: (Weyco)—Figure 4 on page 59 indicates that the total standing inventories are increasing but harvest levels exceed growth, this does not seem possible.
Response 13: *We discovered that the growth rate calculation used to generate the numbers shown in Figure 4 of Appendix A in the Draft Report was incorrect. It has been corrected and Figure 4 of Appendix A has been updated in the Final Report. The updated figure shows that growth exceeds*

harvest until the final two periods of the planning horizon, which corresponds with the increase in inventory until the final two periods of the planning horizon.

Comment 14: (Weyco)—Appendix J, Figure 9-Age Class Distribution Chart: It looks like a definition is missing for the large yellow bar beginning period 4. Are we to assume this group of acres is greater than 160 years old? Comparing back to the Acres by Species chart there are very few acres in in the OG categories, why is there a difference? In Period 1 there looks to be ~100K acres of 0-10 year-olds, but in period 2 there are only ~25K acres of 10-20 year-olds, why didn't the 100K acres grow into the 10-20 year old class?
Response 14: *The definition for the 150+ age class was missing from Figure 9 of Appendix J in the Draft Report; this has been corrected in the Final Report. The difference in acres in old growth species groups shown in Figure 5 and the 150+ age class shown in Figure 9 occurs because only existing stands are classified as an old growth species type (W1, W4, or W6) at the onset of the model run; as currently existing non-old growth acres develop into old growth during the progression of the model run they retain their original species classification. Therefore, the acreage of old growth species does not appear to increase as shown in Figure 5. However, the amount of acres in the 150+ age class increases over the planning horizon as shown in Figure 9, and those acres include both existing old growth from the onset of the model run and non-old growth acres that are recruited into old growth. It is important to note that not all stands in the 150+ age class meet the criteria to be classified as old growth; at the conclusion of the model run there are nearly 137,000 acres of old growth, while there are over 400,000 acres in the 150+ age class.*

The issue with recruitment of the 0-10 age class to the 10-20 age class between periods 1 and 2 is due to a difference in the start age of regeneration yields and existing stands, and also because the interval from period 0 to period 1 is only 5 years, while the interval between all other periods is 10 years. While investigating this issue, we discovered an error in the age assignment for regeneration yields that has been corrected in the final report, and Figure 9 of Appendix J has been updated accordingly. In the updated figure, there are 43,672 acres in the 0-10 age class in period 0. Those acres do not advance to the 10-20 age class in period 1 because the interval between period 0 and period 1 is only 5 years. Additionally, there are 78,249 acres that were regenerated from period 0 to period 1 that are now included in the 0-10 age class in period 1, resulting in a total of 121,921 acres in period 1 but creating an apparent gap in the 10-20 age class in period 1. From period 1 to period 2, the 121,921 acres of 0-10 age class now advance into the 10-20 age class as expected.

Comment 15: (Weyco)—Appendix J, Figure 10-Average Annual Growth Rate Chart: Why does the annual growth rate drop so much in periods 6, 9 and 18? Regional growth rates vary a fair bit period to period, why is that? Over a large acreage and in a sustainable yield calculation won't the growth rates remain reasonability constant? Also, a stacked bar chart by Region is very hard to discern. The total growth rates in this chart are also different than the growth rates in Table 35.
Response 15: *As mentioned in the response to Comment #13, we discovered that the growth rate calculation in the Draft Report was incorrect. Figure 10 in Appendix J has been updated to show the correct growth rates, and also re-formatted from a stacked bar chart to a clustered column chart to be able to more easily discern trends by Land Office.*

The variation in growth rates between periods is due to large increases in regenerated acres that achieve merchantable volume in a given period, and also due to the replacement of slower-growing existing types by faster-growing regeneration types in some periods. The regeneration types typically have very low board foot volume growth for the first 2-4 periods before they attain merchantable size containing board-foot volume. For example, there are relatively large regen acreages in periods 1, 4, 10, 11, and 16, each of which is followed by an increase in growth rate 2-4 periods later.

The growth rates in Figure 10 are different than those in Table 35 because they represent growth rates from fully constrained model results, while the growth rates shown in Table 35 compare biological potential (unconstrained managed) and grow only (unmanaged) growth rates.

Comment 16: (Weyco)—According to the Old Growth Acres charts starting with Figure 45, OG recruitment in many of the NWLO office units take dramatic spikes in years 9 and 18, what causes this? Is there an age class chart/table of existing inventory that shows development of this of age group is possible? Looking at the Plains and Stillwater offices for example does there currently exist several thousand acres of 100- year old stands that can be classified as OG in periods 5 & 6?
Response 16: *The large increases in old growth acres is primarily due to existing non-old growth stands that attain sufficient age, along with having the minimum number and size of trees, necessary to be classified as old growth. Age is not the only factor in determining whether a stand is old growth; the stand must also contain a specified number of large trees of a given diameter along with a minimum amount of basal area. Because of this, not all stands that achieve the age threshold will qualify as old growth, nor will stands that meet them minimum requirements for number of large trees and basal area if the stand does not also meet the age requirement. The minimum criteria for each old growth type are shown on Page 44 of the Final Report.*

Topic: General observations and recommendations

Comment17: (FOWS)—We find it disturbing that you are asking the public to comment on the 2020 SYC yet will not change anything in it based on science (climate change) and public input - if you solicit public comments you should incorporate public comments into your final decision.
Response 17: *Accommodation of transparent public review and consideration of public comments for this process is being conducted in a consistent manner with calculations done in the past. Current data, scientific information relevant to the process, and state-of-the-art modeling procedures and technology were all incorporated into this calculation. To foster objectivity and credibility of the calculation, DNRC is required by statute to have a third party to conduct each calculation (MCA 77-5-222). We note that public comment was solicited, received and considered in this process prior to final adoption of the result by the Montana Board of Land Commissioners. See response to comment number 1 regarding more specific information regarding climate change.*

Comment 18: (Stoltze)—We appreciate the cumulative way you presented the constraints effects, allowing us to see what the incremental change to the SYC is of each subsequent constraint. Undoubtedly, many of the constraints overlap so it is hard to independently assess the impact of an individual constraint, none the less, the presentation is appreciated.

Response 18: *Thank you for recognizing our efforts to transparently demonstrate the effects of constraints on volume.*

Comment 19: (Pyramid)—In your draft, you talk about the decrease in FTE available from 55 to 50 to setup, sell and administer the new sustained yield number. In our opinion, the DNRC is the most efficient governmental agency in setting up efficient and profitable timber sales. Roads are constructed or reconstructed to the degree necessary, not adding very expensive bells and whistles. The DNRC looks at the harvest units as what do they want them to look like post-harvest. We encourage the DNRC to utilize end result silviculture, i.e. Designation by Description and Designation by Prescription and other “End-result” prescriptions in lieu of marking timber. Today’s professional loggers are almost as good at selecting leave trees as a forester with a paint gun.
Response 19: *Thank you for the compliments regarding DNRC efficiency and profitability. We are conscientious about keeping our costs down and have already begun to implement many of these suggestions.*

Comment 20: (Stoltze)—Finally, while the model is heavily constrained and, in some estimates, conservative, ultimately the management strategy of the agency needs to reflect the model in intent and application. Case in point is in the Overstory Removal management directive. Oftentimes, the environmental document or even just local preference indicates tree retention into the future that are more restrictive than what is required in the SFLMP. If OSR is part of the management regime, then they need to be included in projects on the ground. Likewise, it is important that buffers and restricted zones are implemented to the letter of the SFLMP and not arbitrarily expanded without specific justification. It is seen all too often, this constraint creep may be unintentional, but has significant and long-standing impacts on the ability of the Trusts to reap returns.
Response 20: *The DNRC agrees that application of on-the-ground management should be similar to the management regimes modeled in the calculation, and to that end refined the management regimes used in the 2015 calculation based on extensive input and review from its foresters. DNRC also recognizes that voluntary implementation of additional restrictions beyond those required will impact its ability not only to achieve management objectives and annual timber sale targets, but also to generate revenue for the Trust beneficiaries. We believe the constraints that were developed and applied in this calculation process accurately and adequately capture the philosophy, intent and sideboards provided by the State Forest Land Management Plan, Forest Management Arms, Forest Management HCP and other applicable rules, laws and agreements. Appropriate application of constraints and measures implemented on DNRC forest management activities support a credible forest management program that promotes sound forest stewardship and protects the short and long-term interests of Trust beneficiaries.*

17 Appendix J: Additional Model Results

The following charts show selected results from the final LP model run with the model fully constrained.

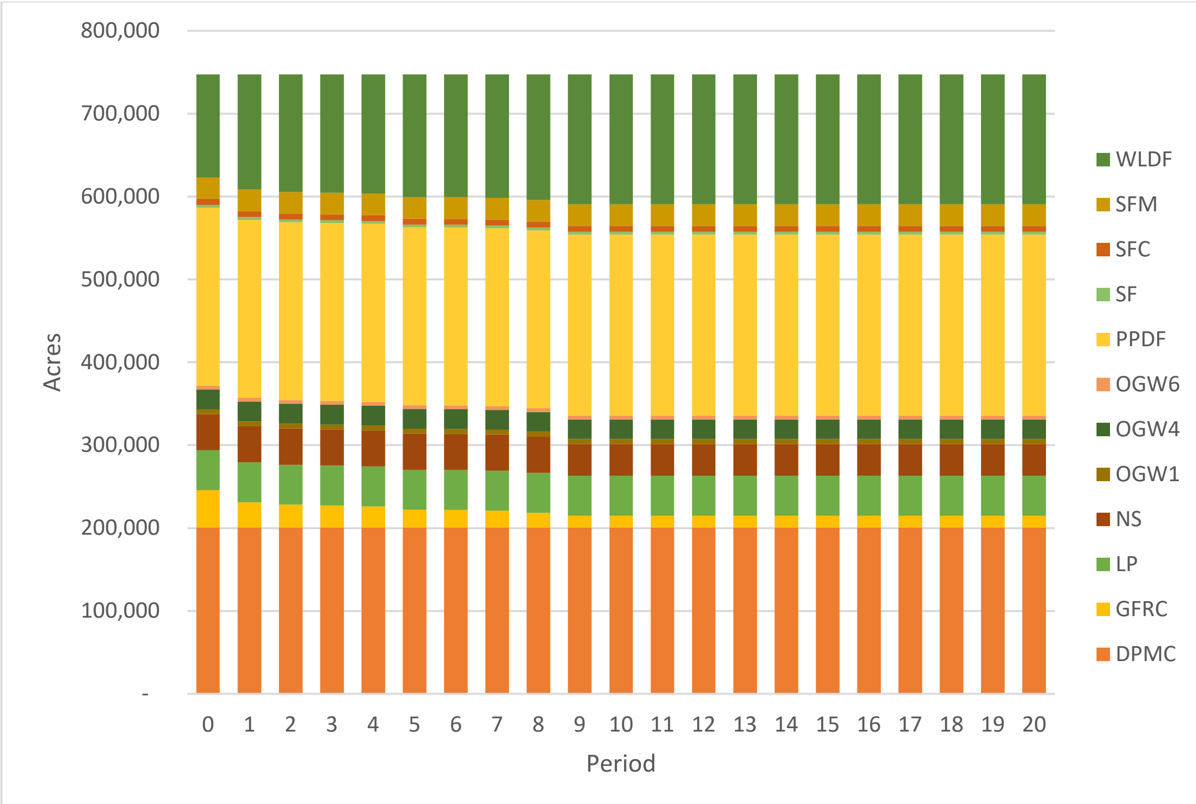

Figure 5: Acres by Species – Fully Constrained Model

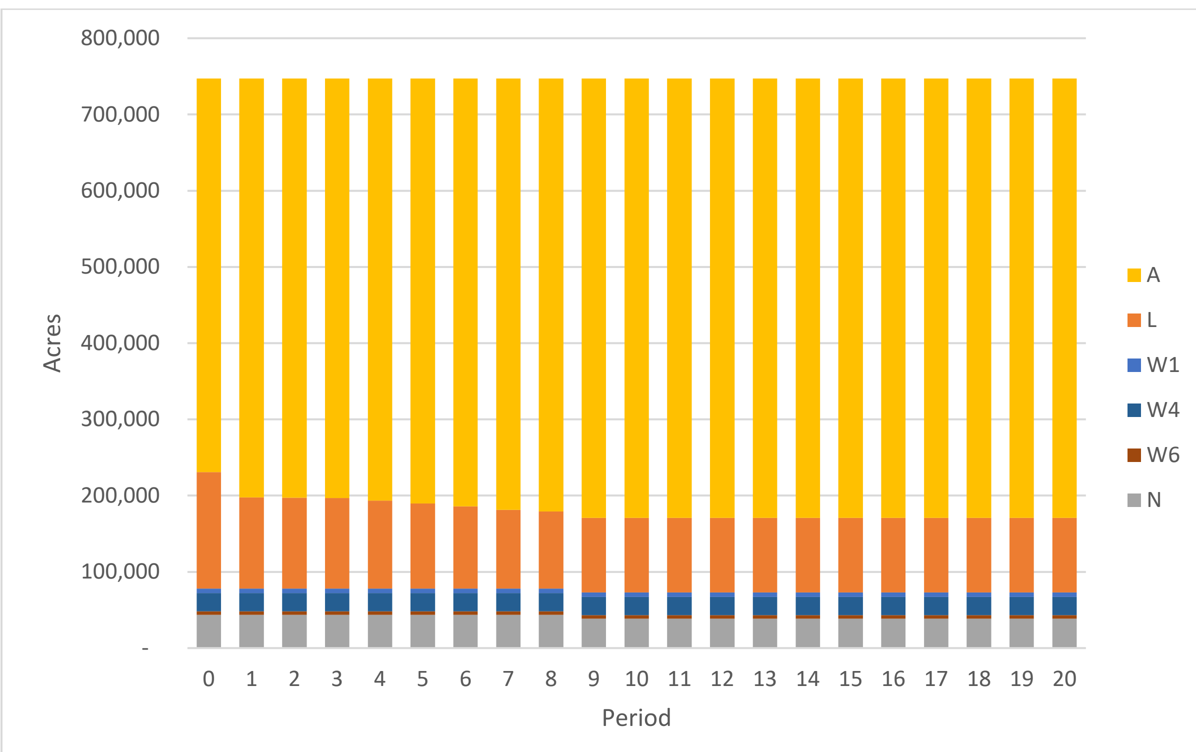

Figure 6: Acres by Stocking – Fully Constrained Model

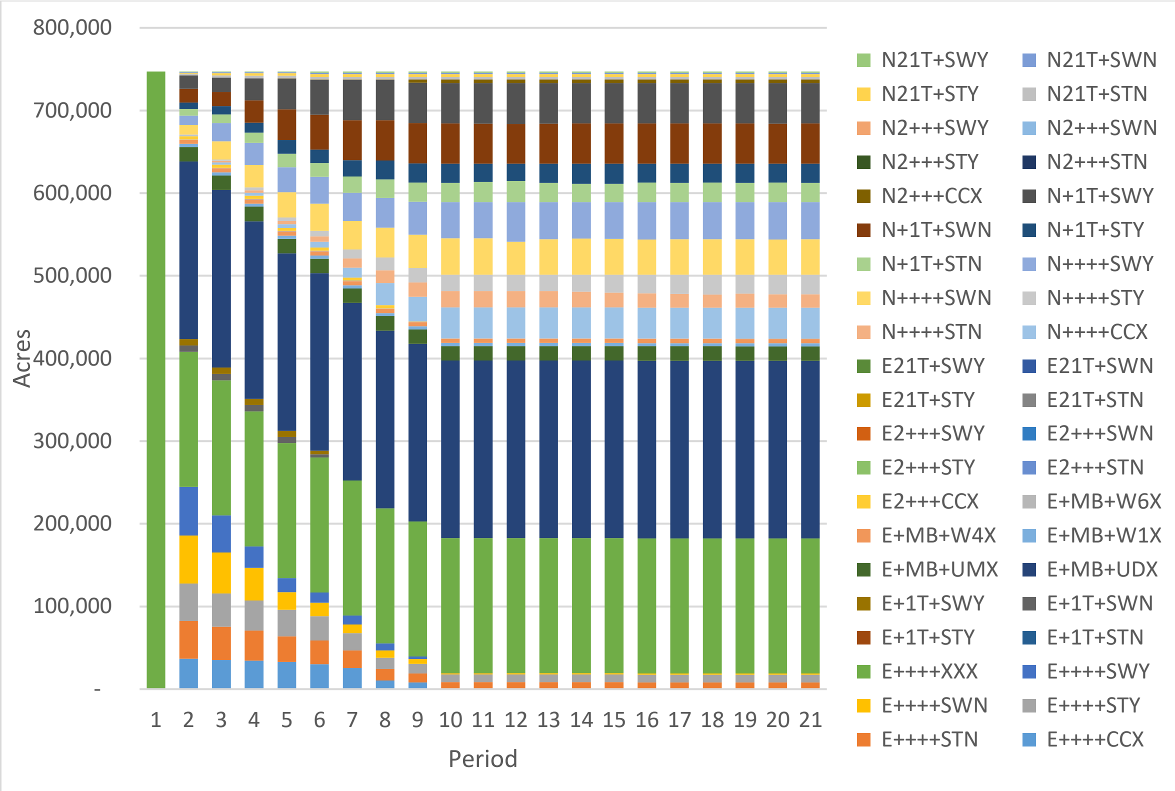

Figure 7: Management Pathway Acres – Fully Constrained Model

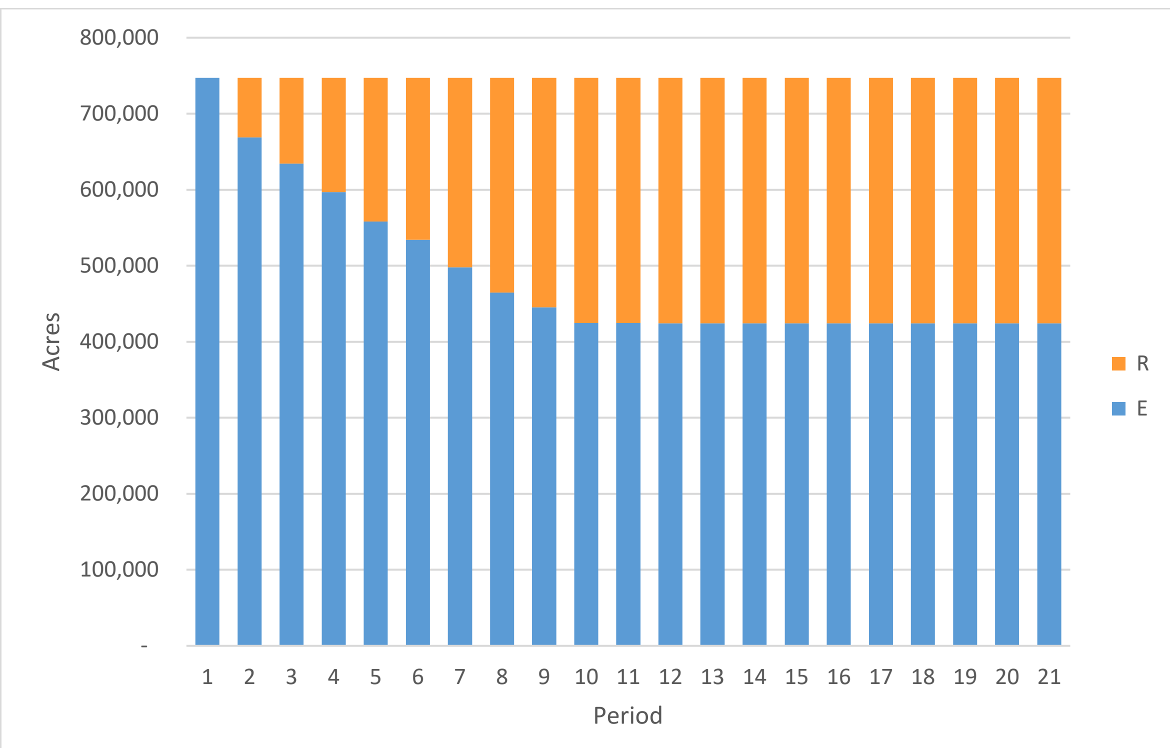

Figure 8: Existing vs. Future Rotation Acres – Fully Constrained Model

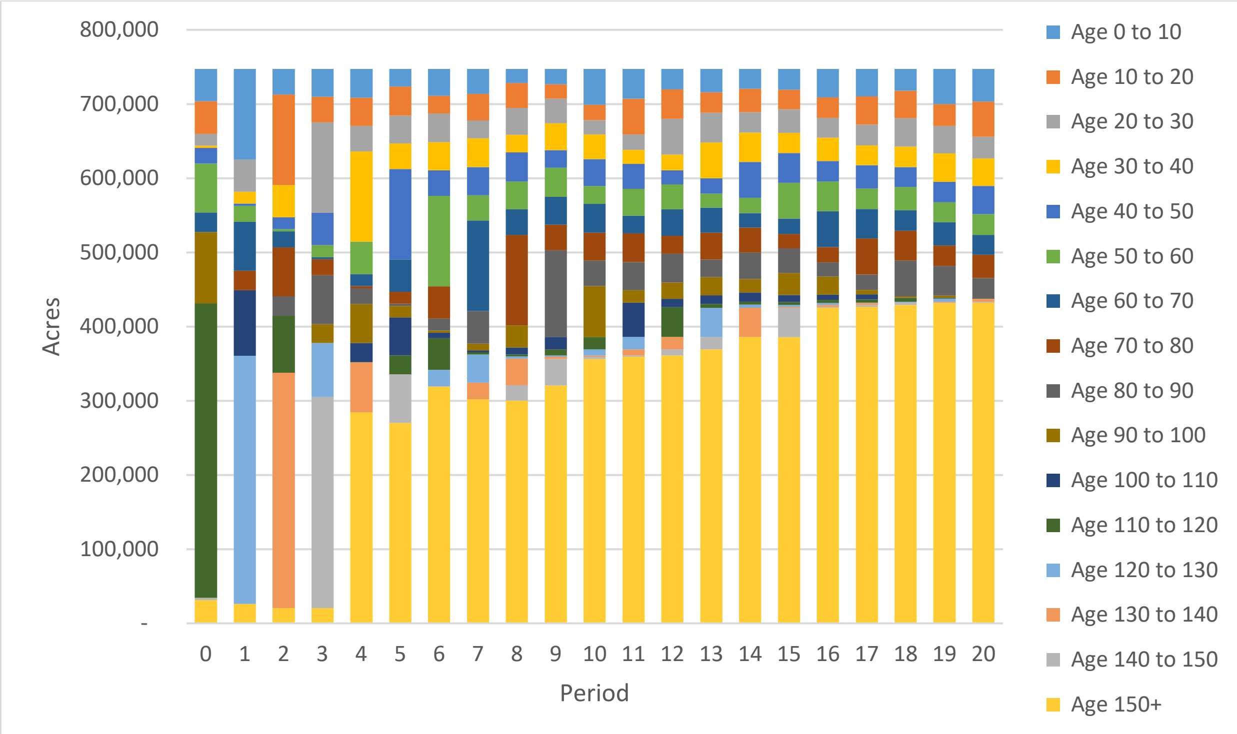

Figure 9: Age Class Distribution – Fully Constrained Model

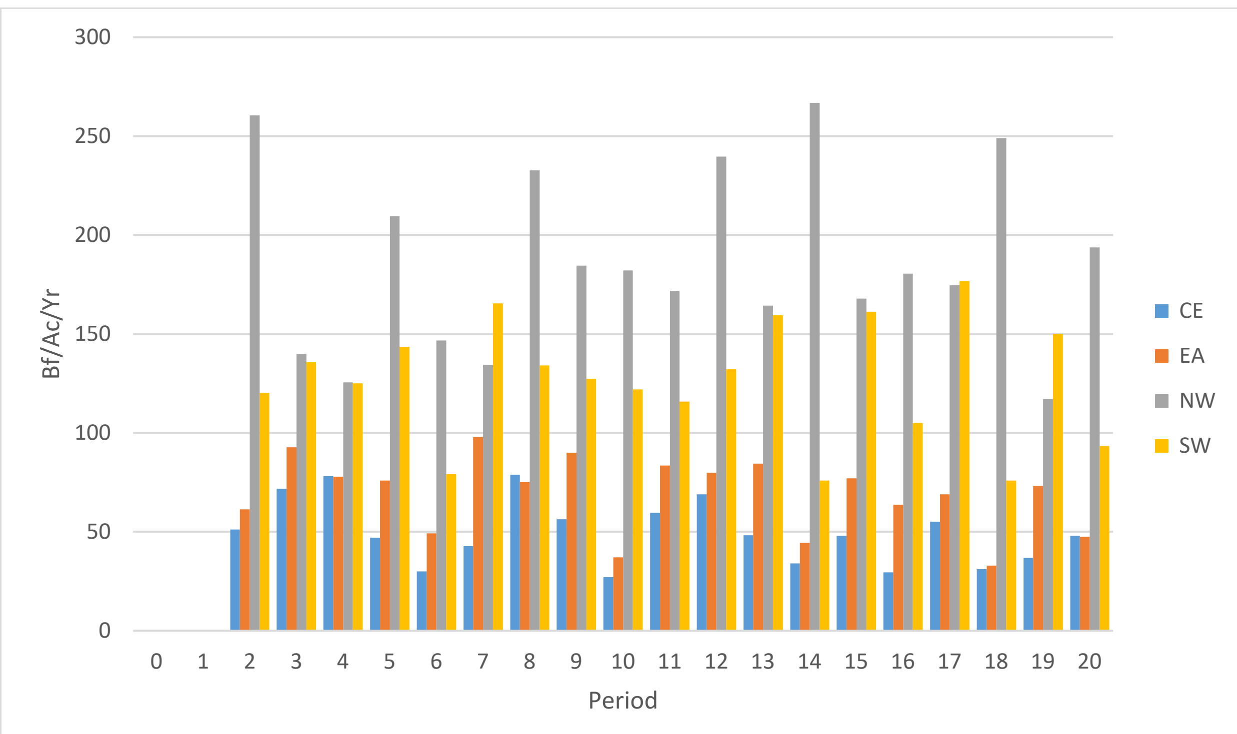

Figure 10: Average Annual Growth Rate – Fully Constrained Model

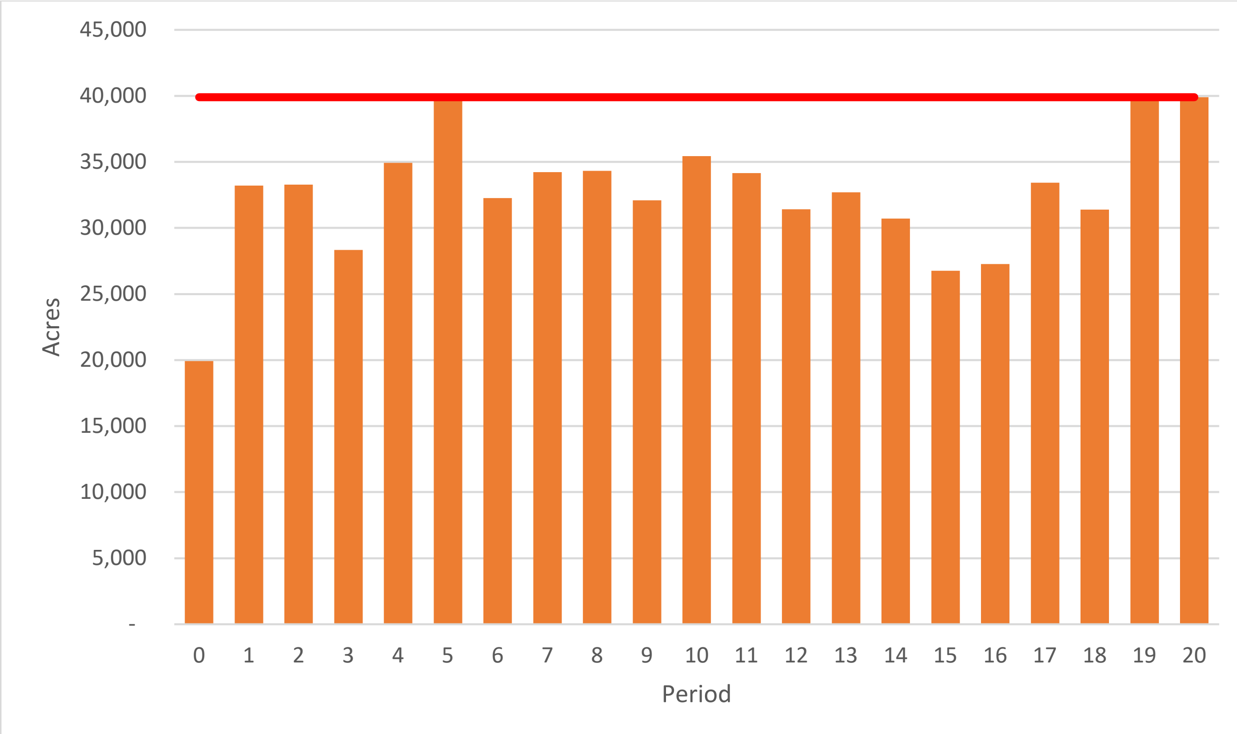

Figure 11: Sensitive Watershed Development – Fully Constrained Model

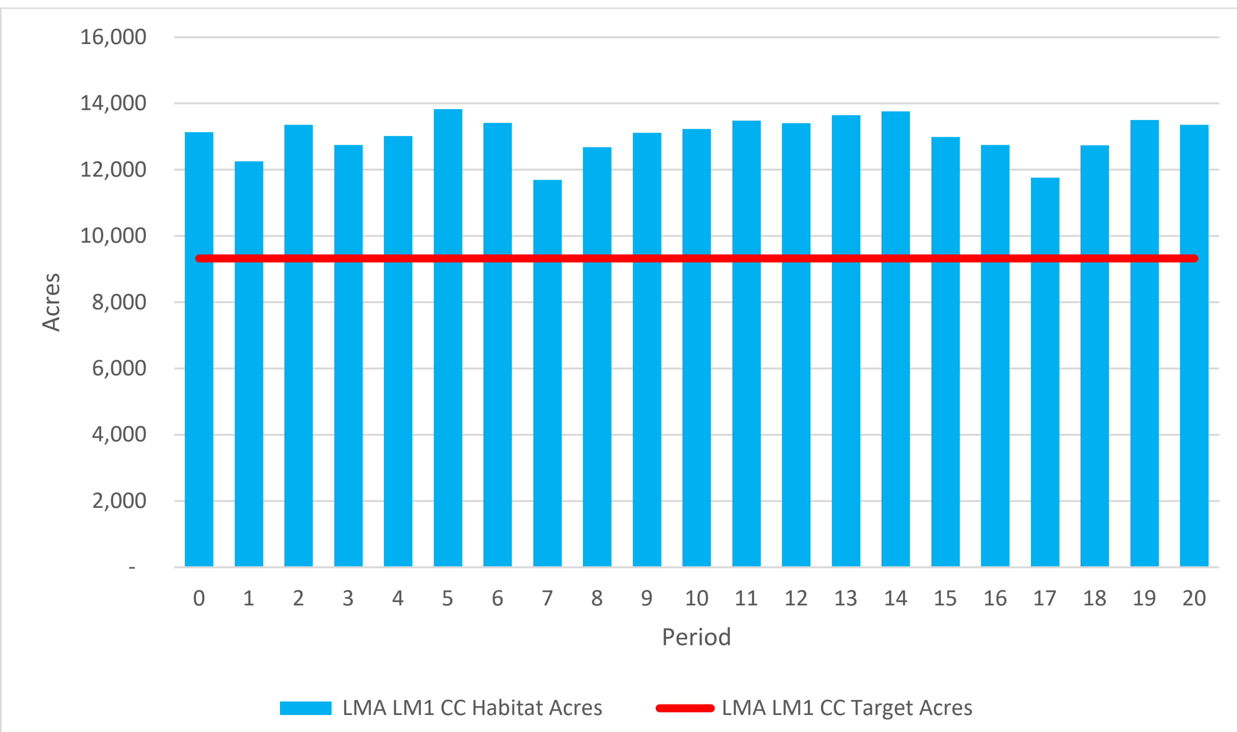

Figure 12: LMA (Coal Creek) Cover Acres – Fully Constrained Model

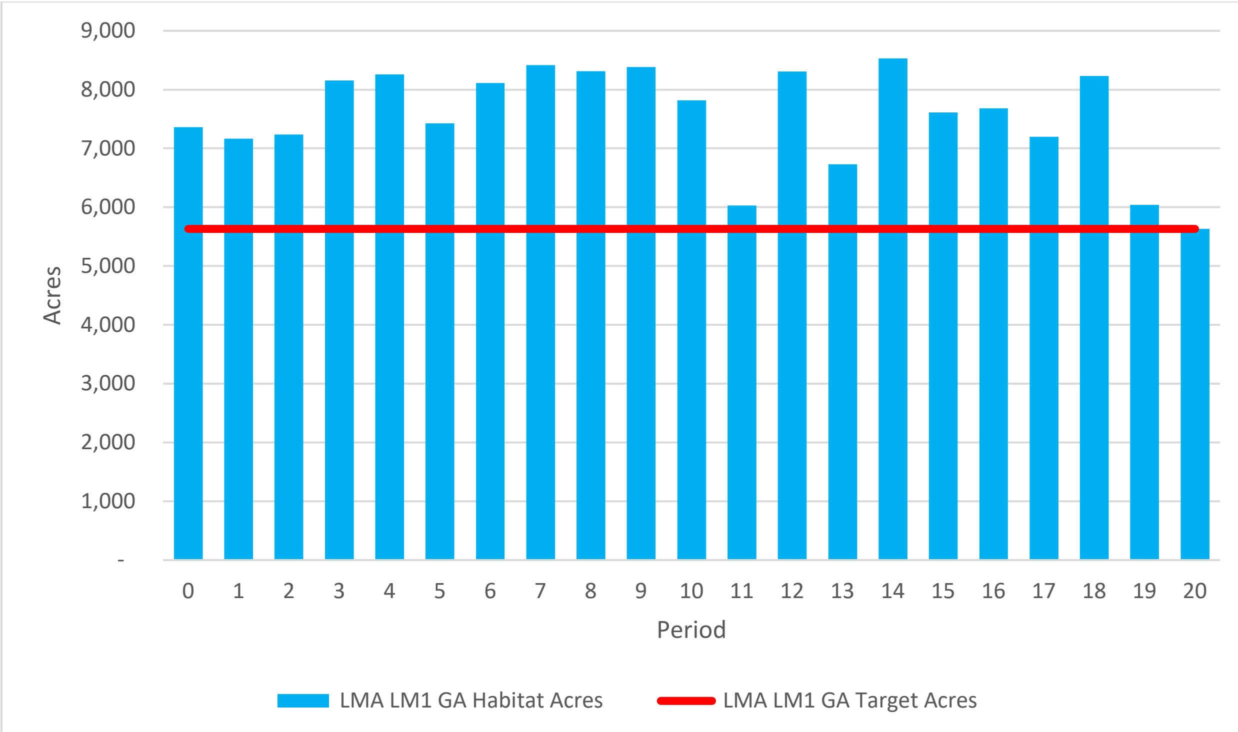

Figure 13: LMA (Garnet) Cover Acres – Fully Constrained Model

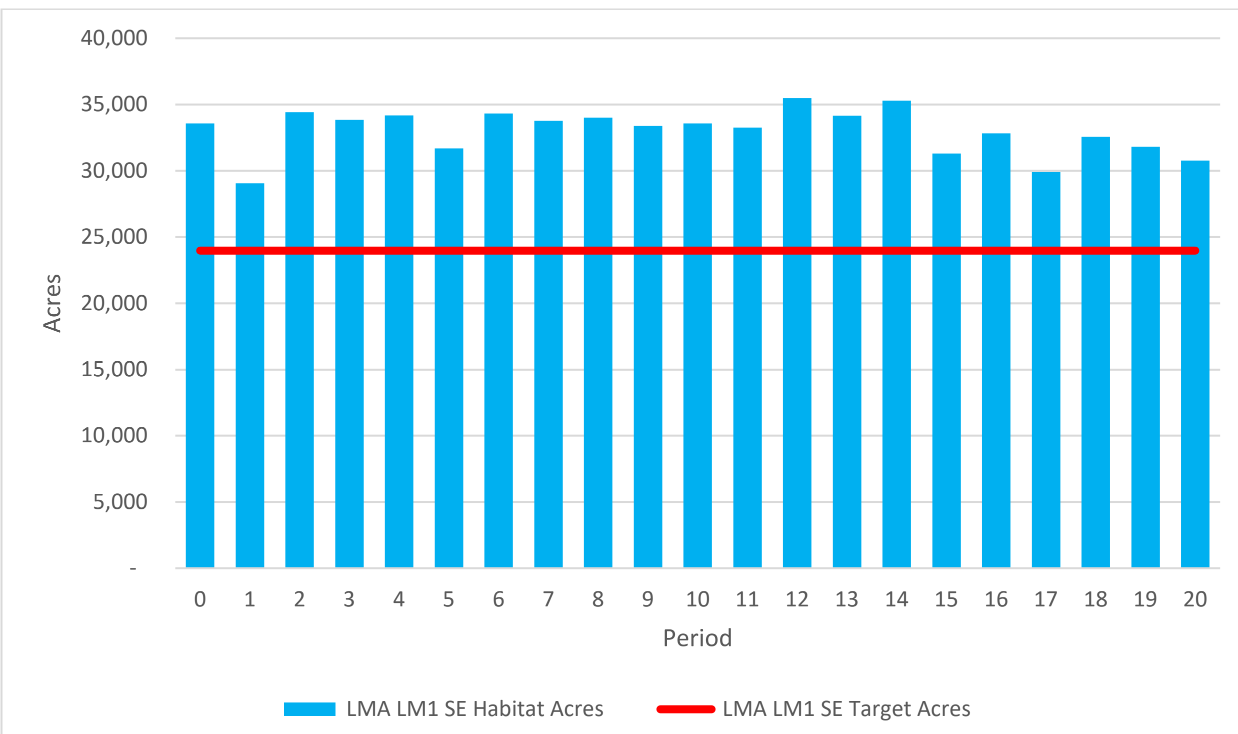

Figure 14: LMA (Stillwater East) Cover Acres – Fully Constrained Model

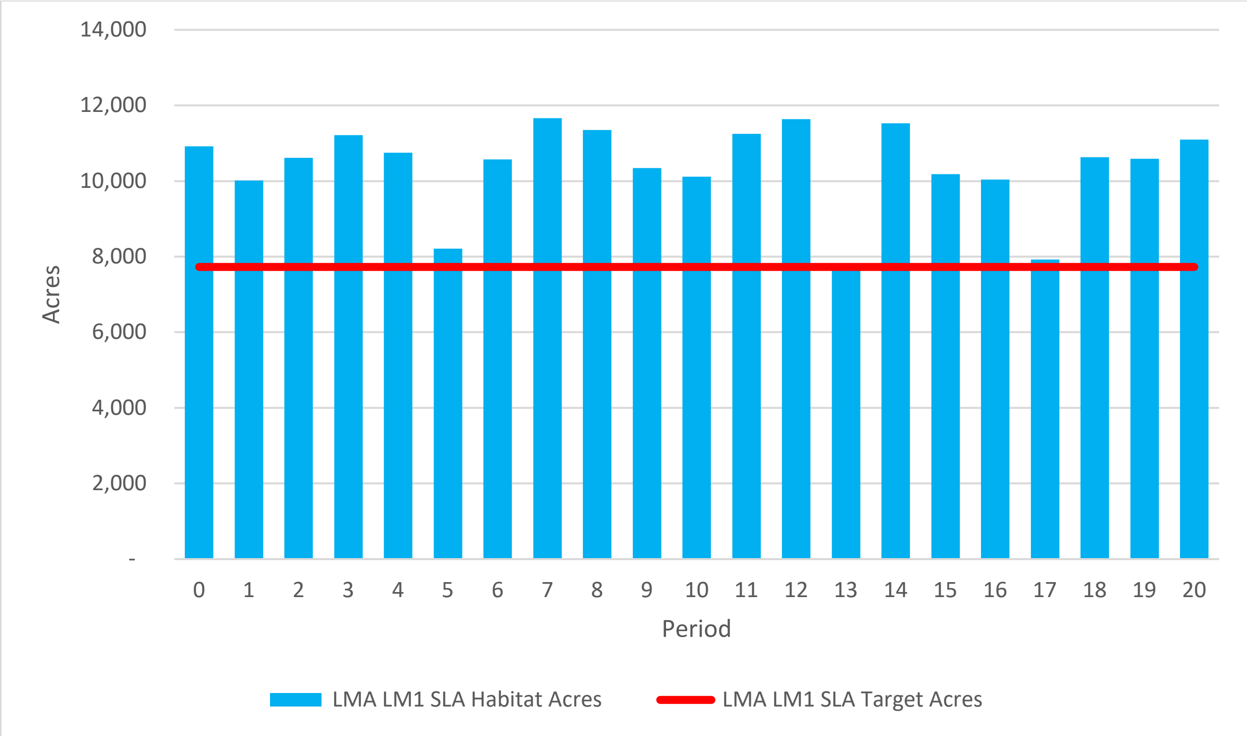

Figure 15: LMA (Seeley Lake) Cover Acres – Fully Constrained Model

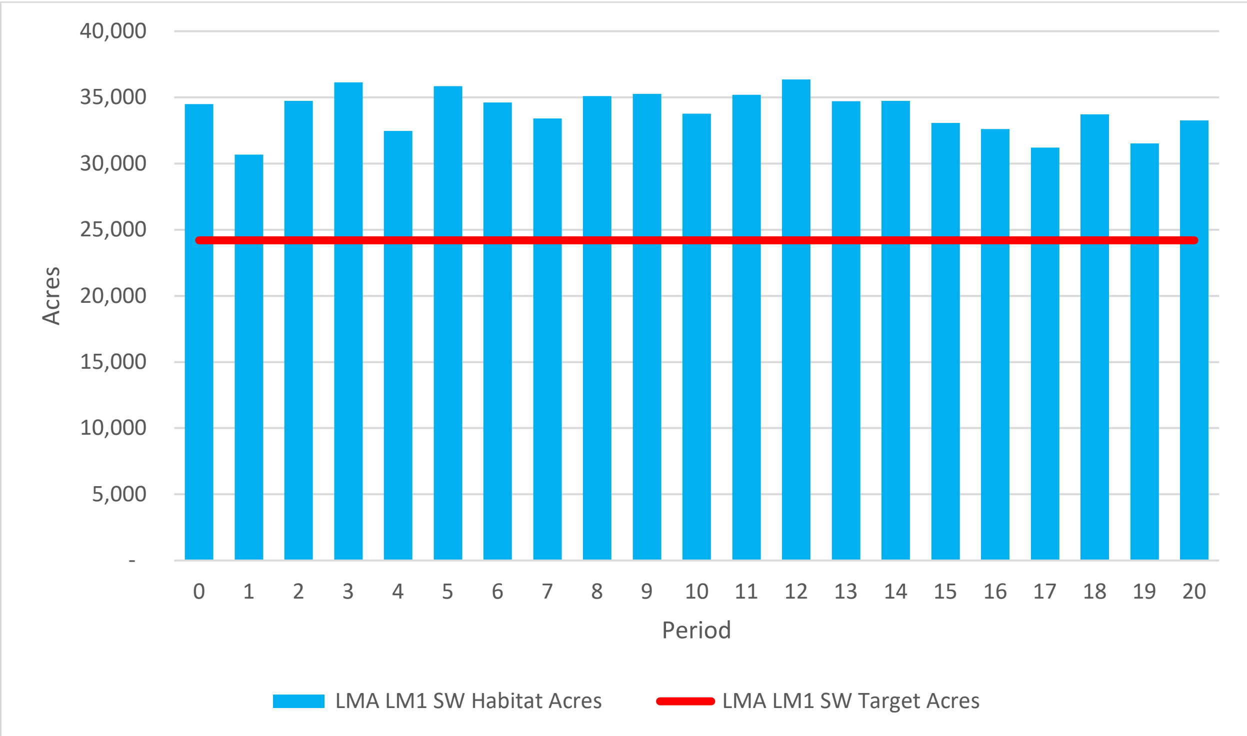

Figure 16: LMA (Stillwater West) Cover Acres – Fully Constrained Model

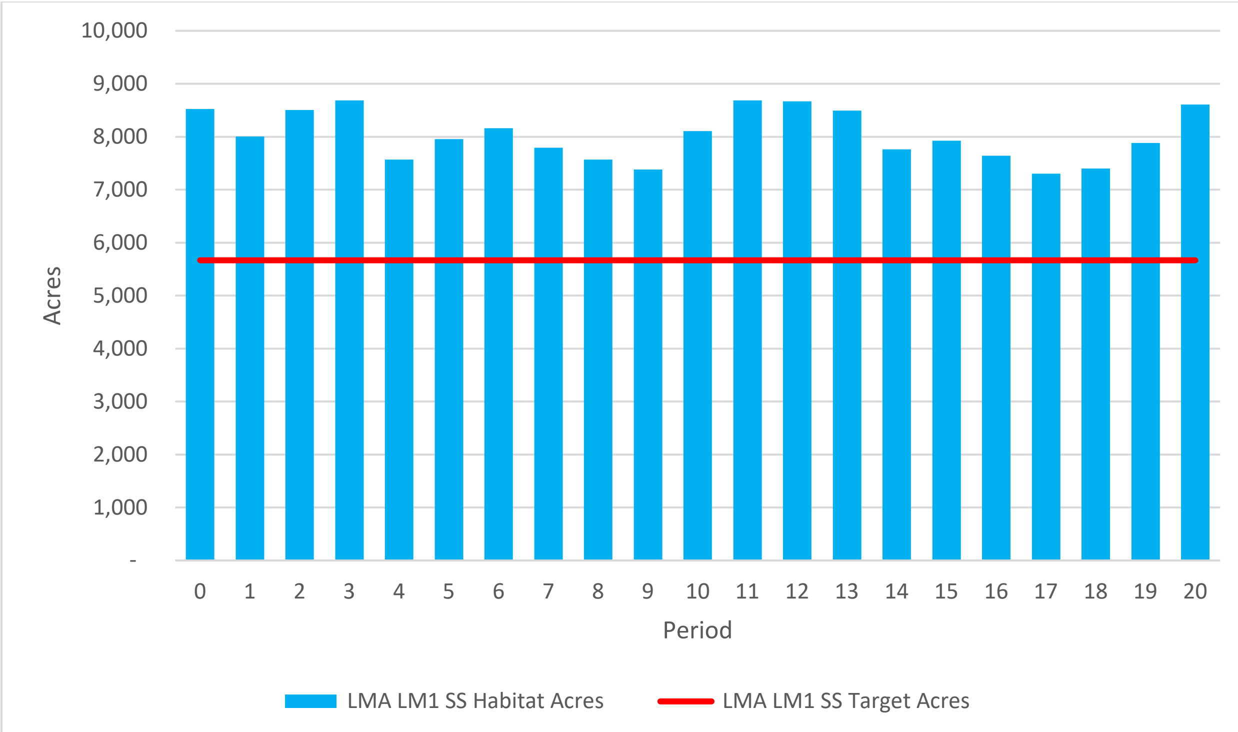

Figure 17: LMA (Stillwater South) Cover Acres – Fully Constrained Model

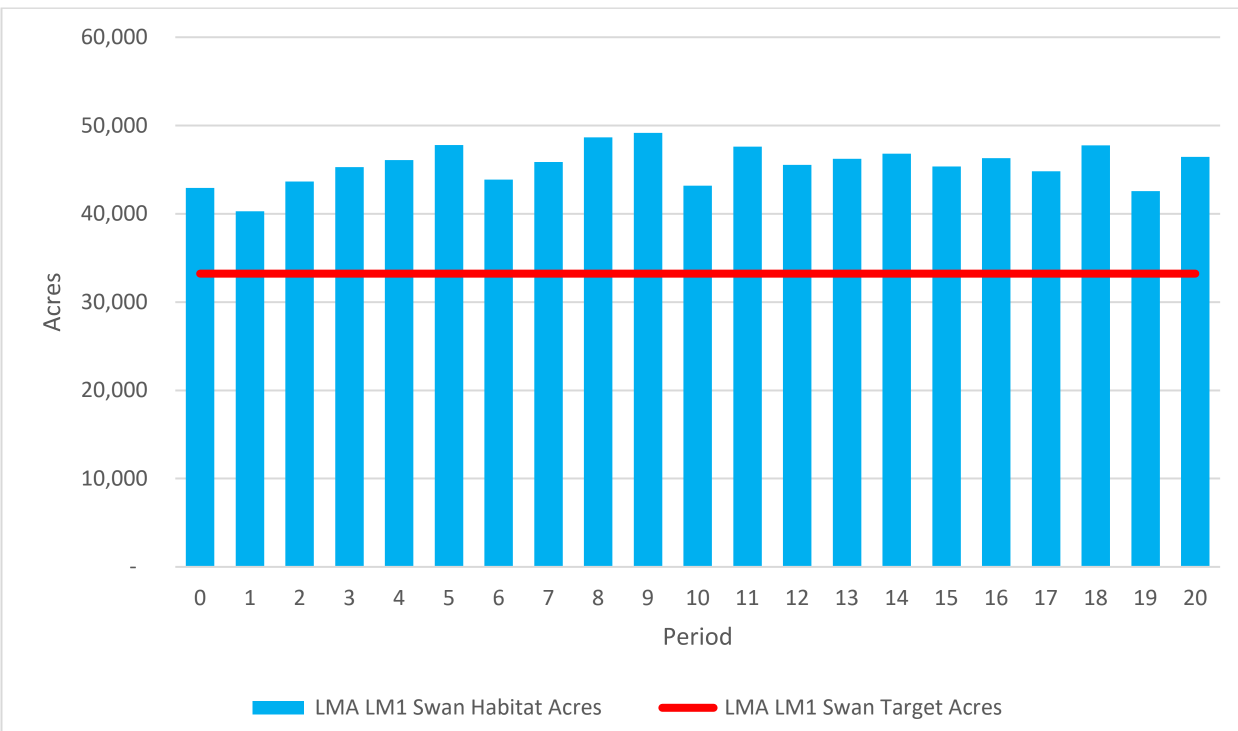

Figure 18: LMA (Swan) Cover Acres – Fully Constrained Model

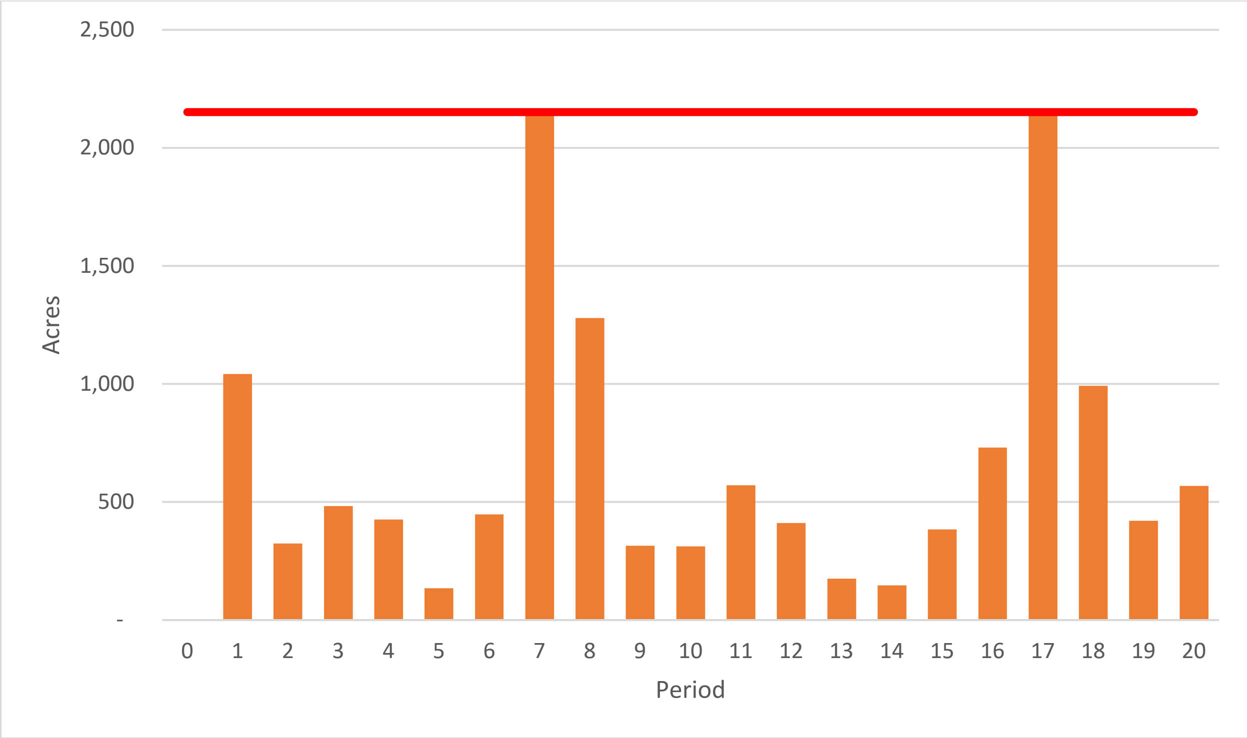

Figure 19: LMA (Coal Creek) EA Harvest Acres – Fully Constrained Model

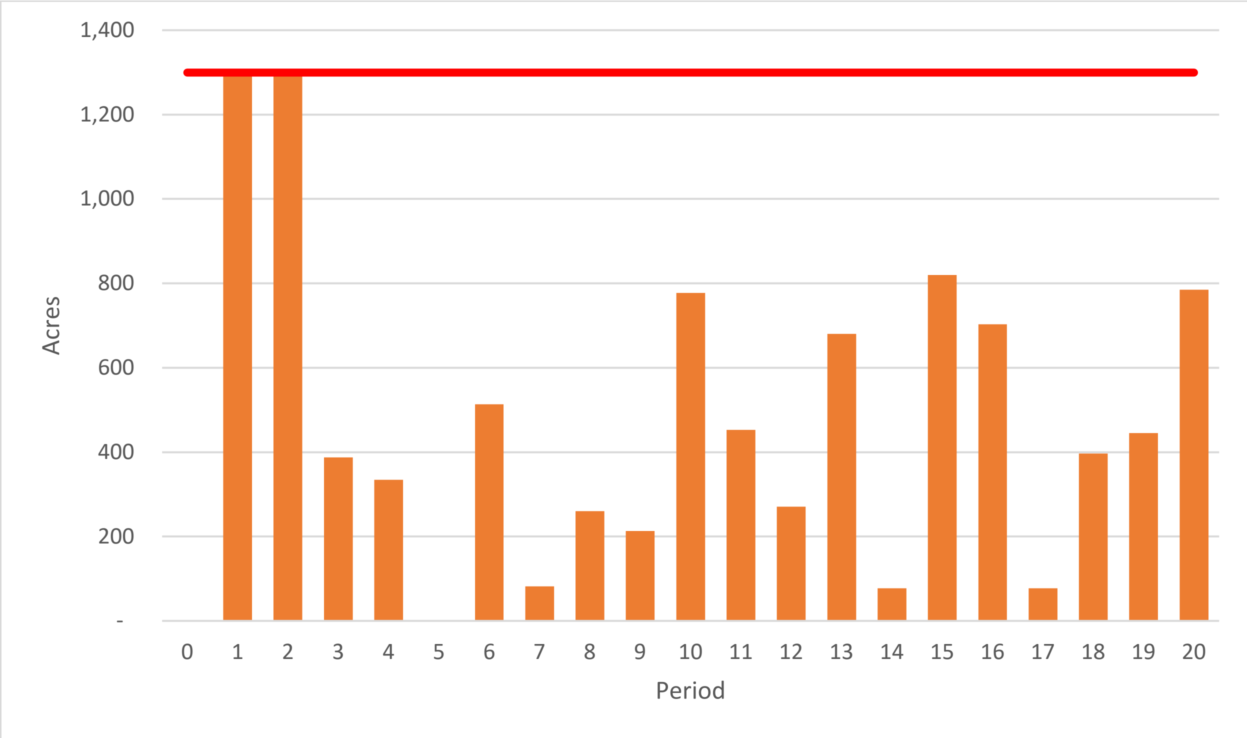

Figure 20: LMA (Garnet) EA Harvest Acres – Fully Constrained Model

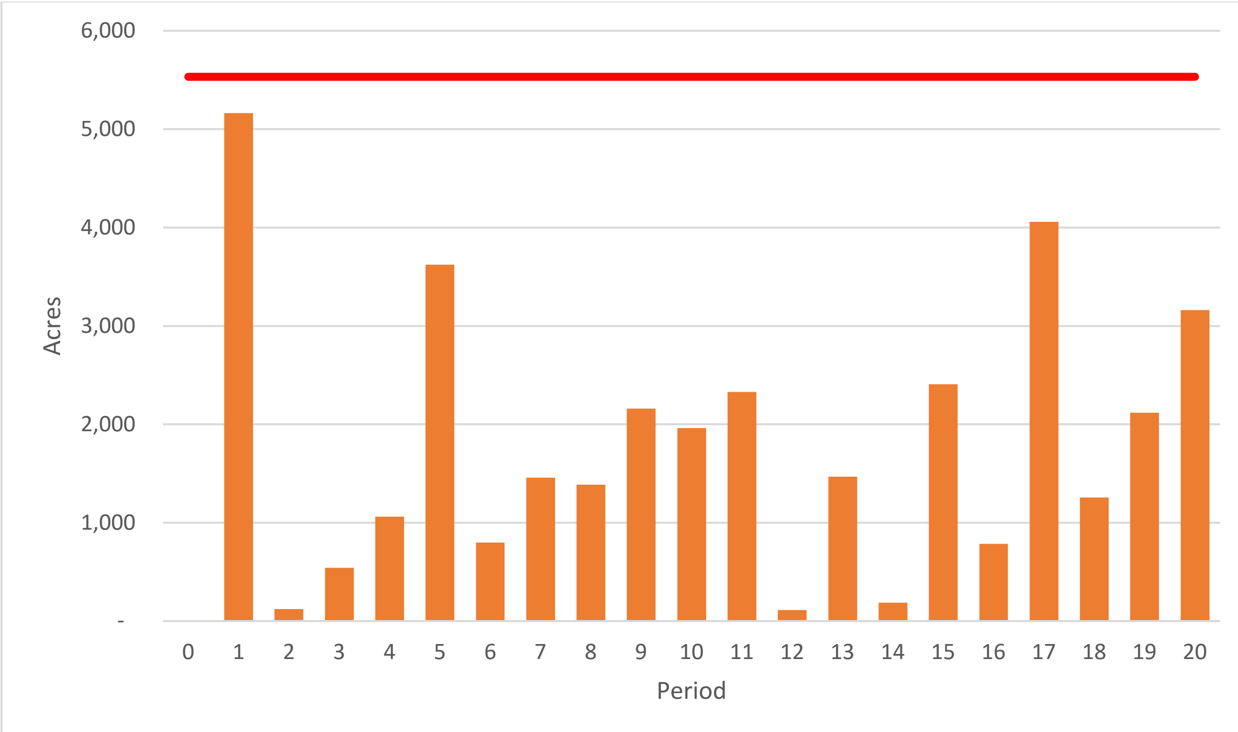

Figure 21: LMA (Stillwater East) EA Harvest Acres – Fully Constrained Model

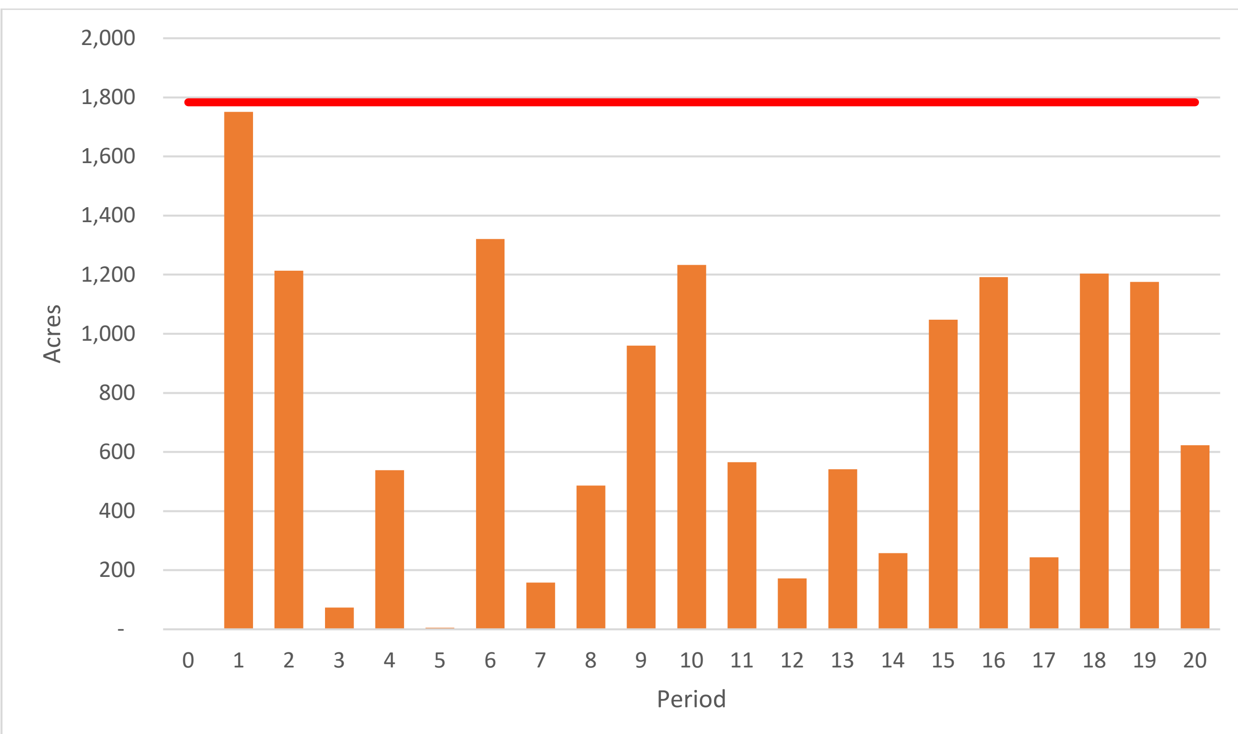

Figure 22: LMA (Seeley Lake) EA Harvest Acres – Fully Constrained Model

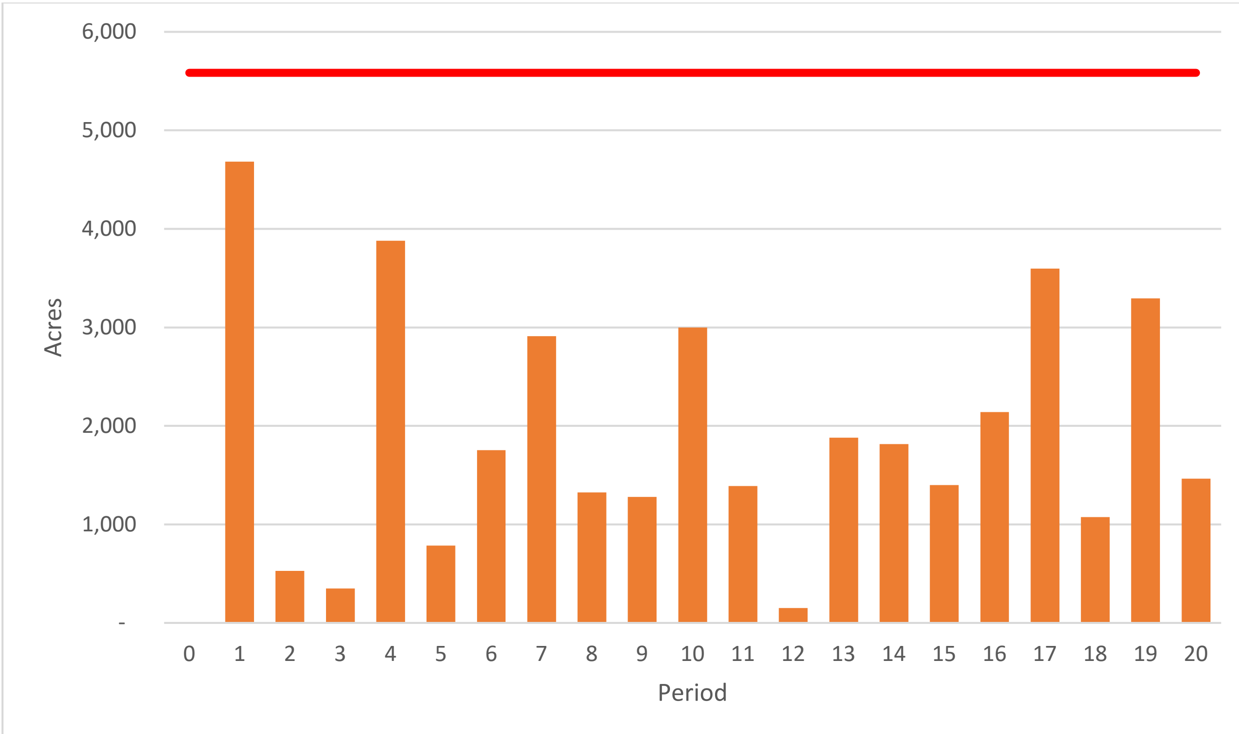

Figure 23: LMA (Stillwater West) EA Harvest Acres – Fully Constrained Model

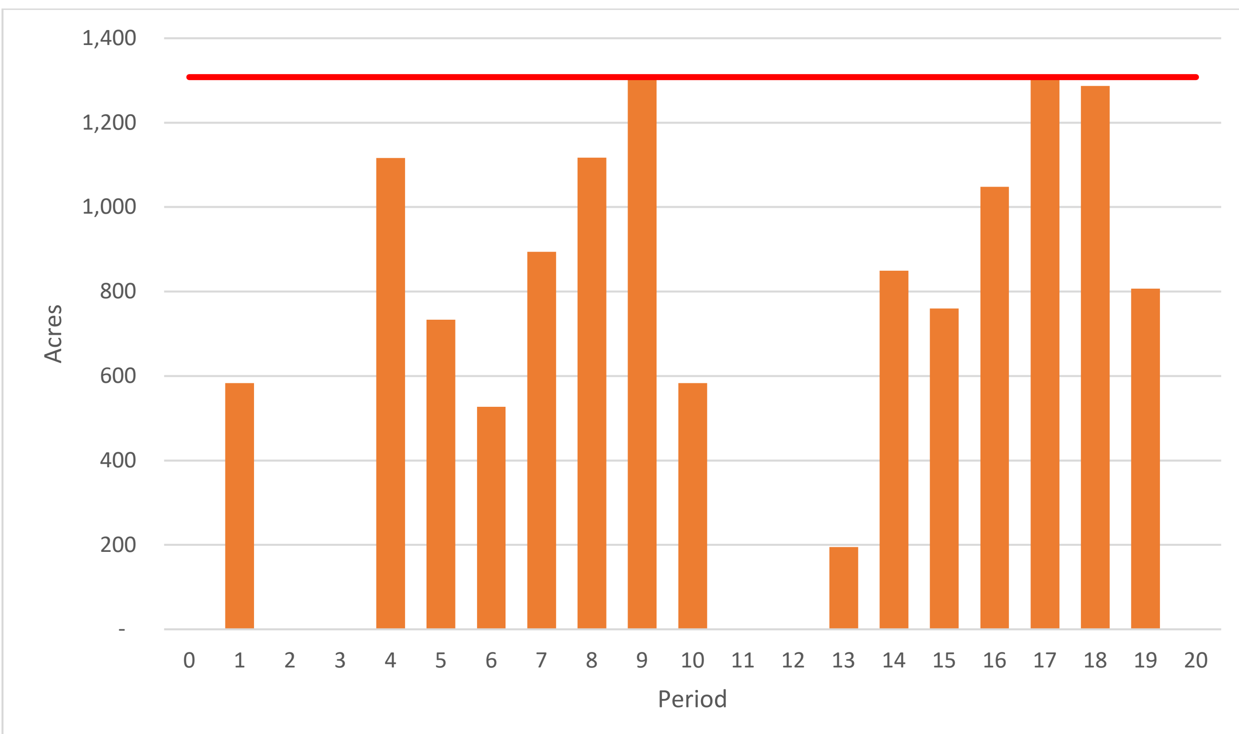

Figure 24: LMA (Stillwater South) EA Harvest Acres – Fully Constrained Model

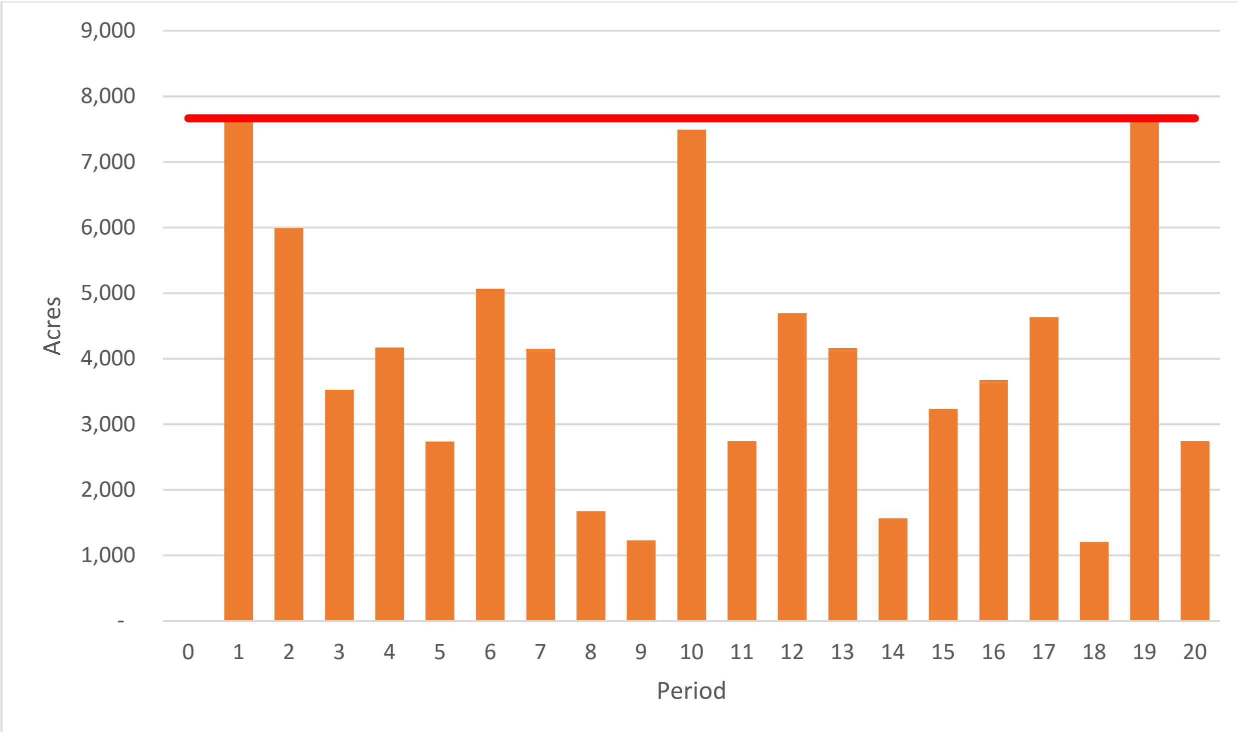

Figure 25: LMA (Swan) EA Harvest Acres – Fully Constrained Model

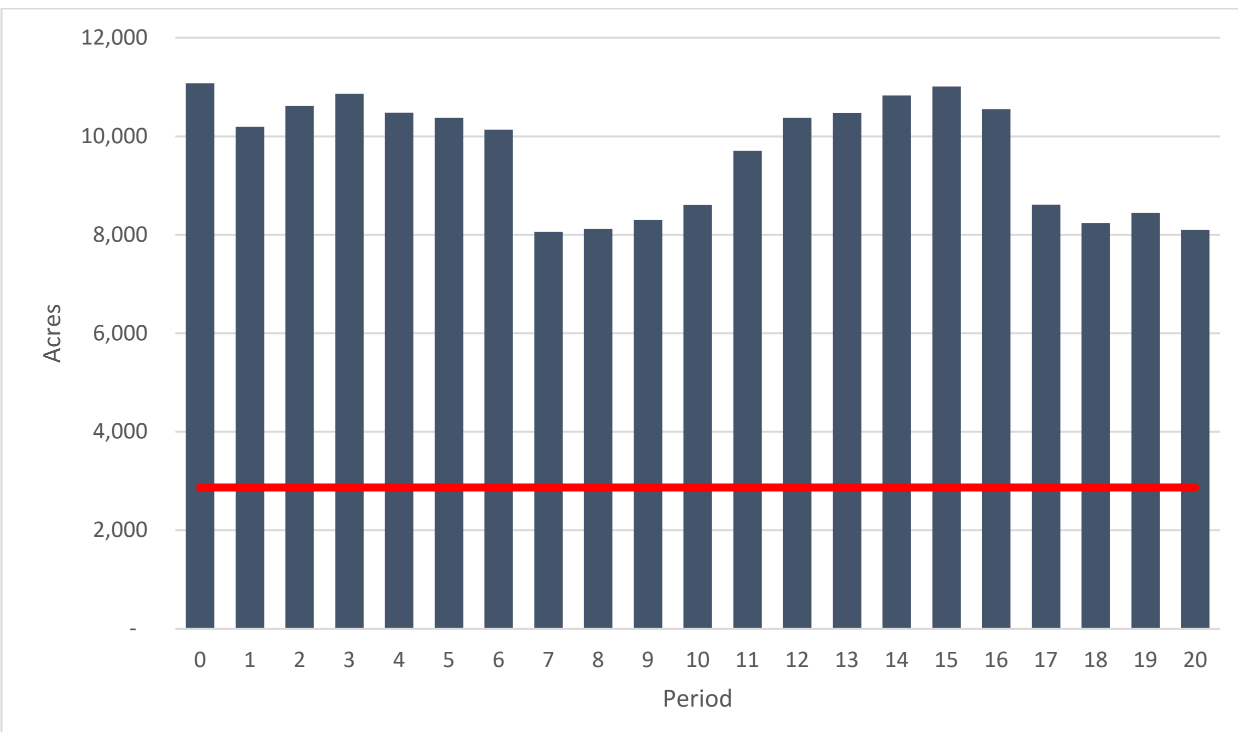

Figure 26: LMA (Coal Creek) Saw-Timber Acres – Fully Constrained Modell

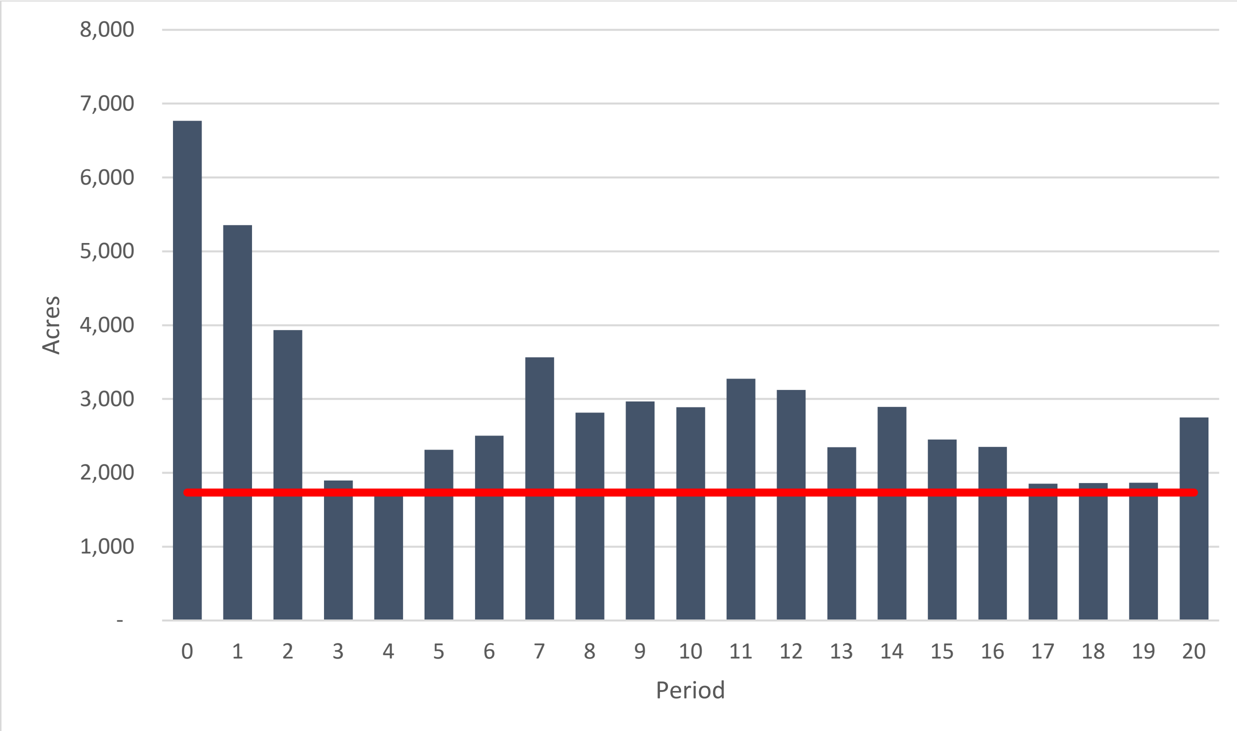

Figure 27: LMA (Garnet) Saw-Timber Acres – Fully Constrained Model

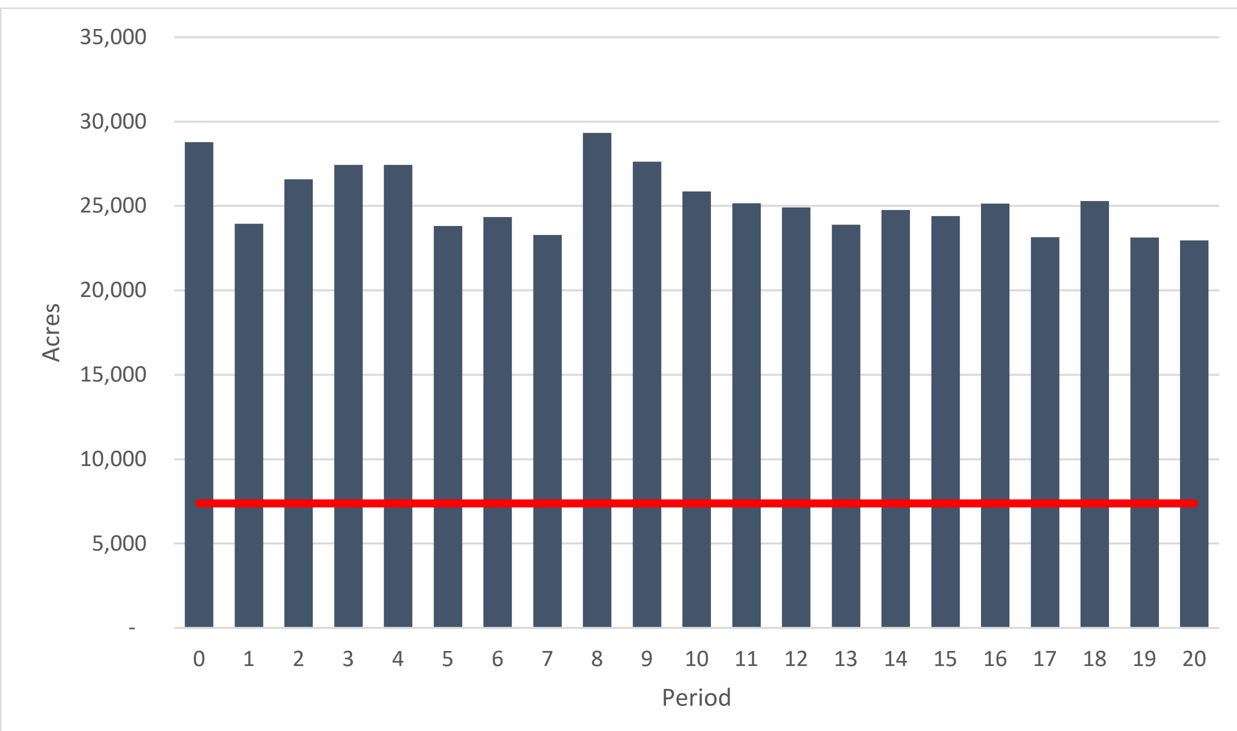

Figure 28: LMA (Stillwater East) Saw-Timber Acres – Fully Constrained Model

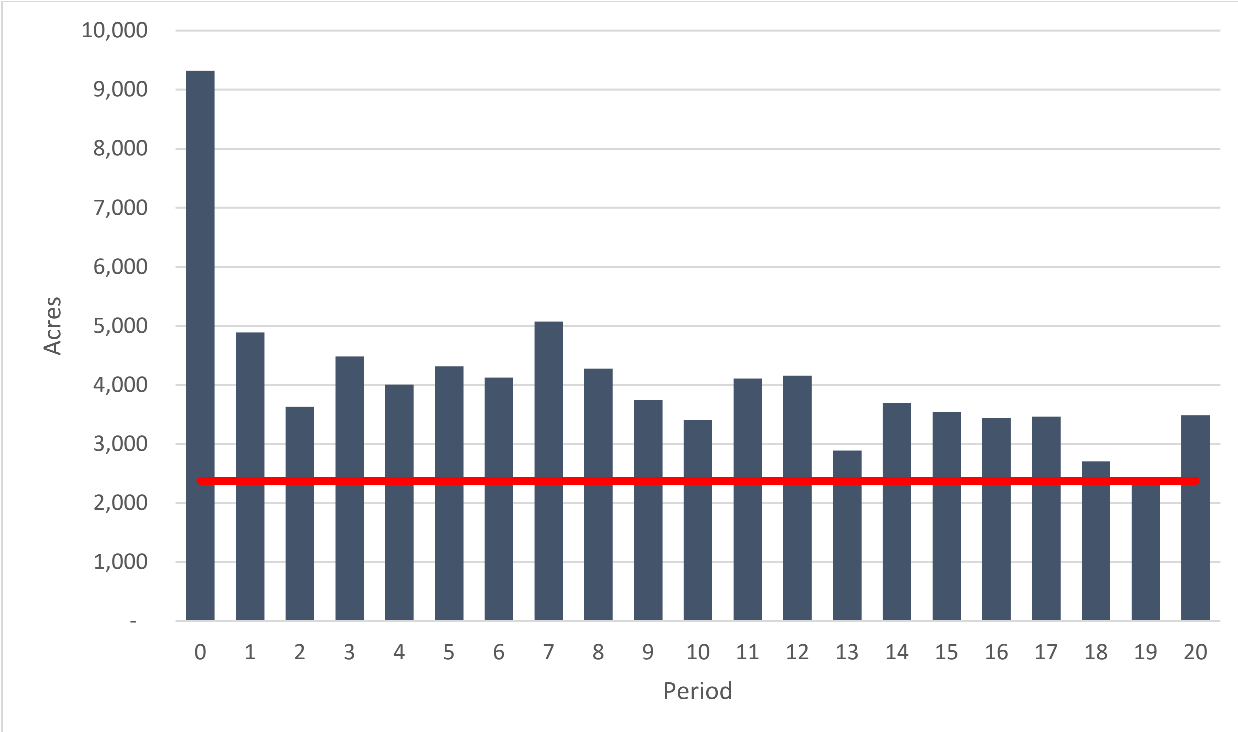

Figure 29: LMA (Seeley Lake) Saw-Timber Acres – Fully Constrained Model

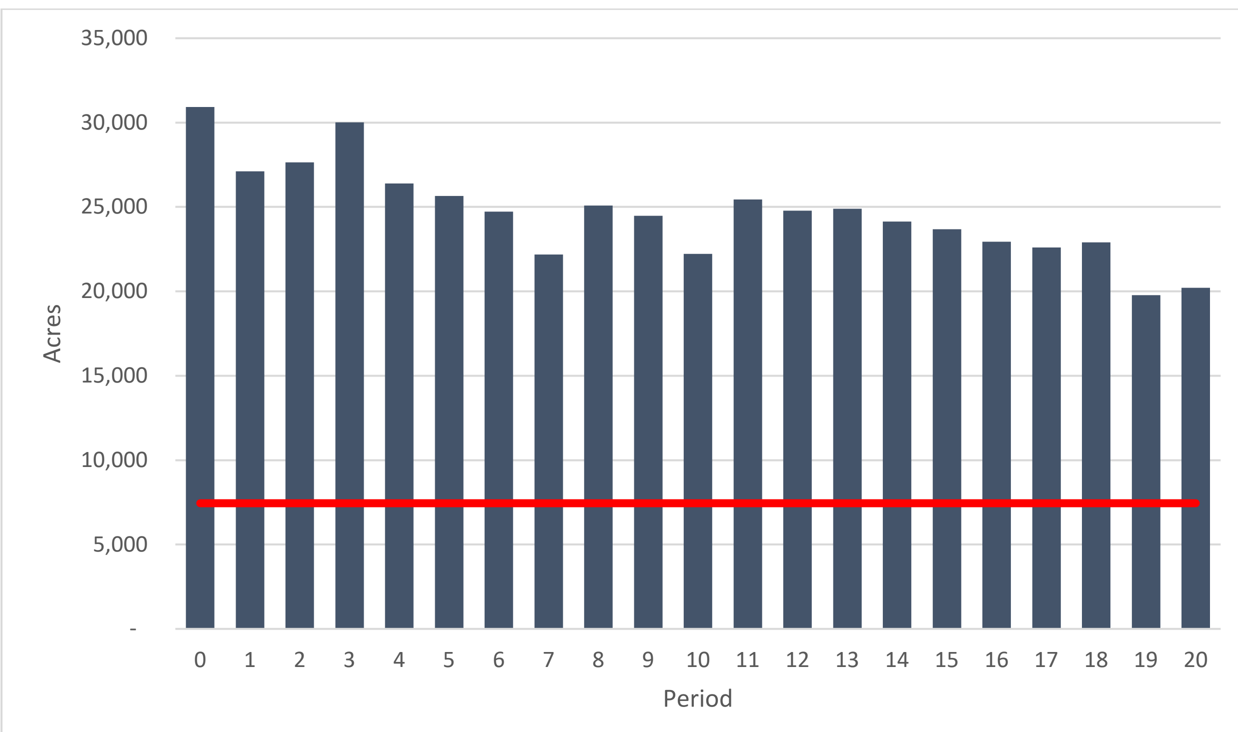

Figure 30: LMA (Stillwater West) Saw-Timber Acres – Fully Constrained Model

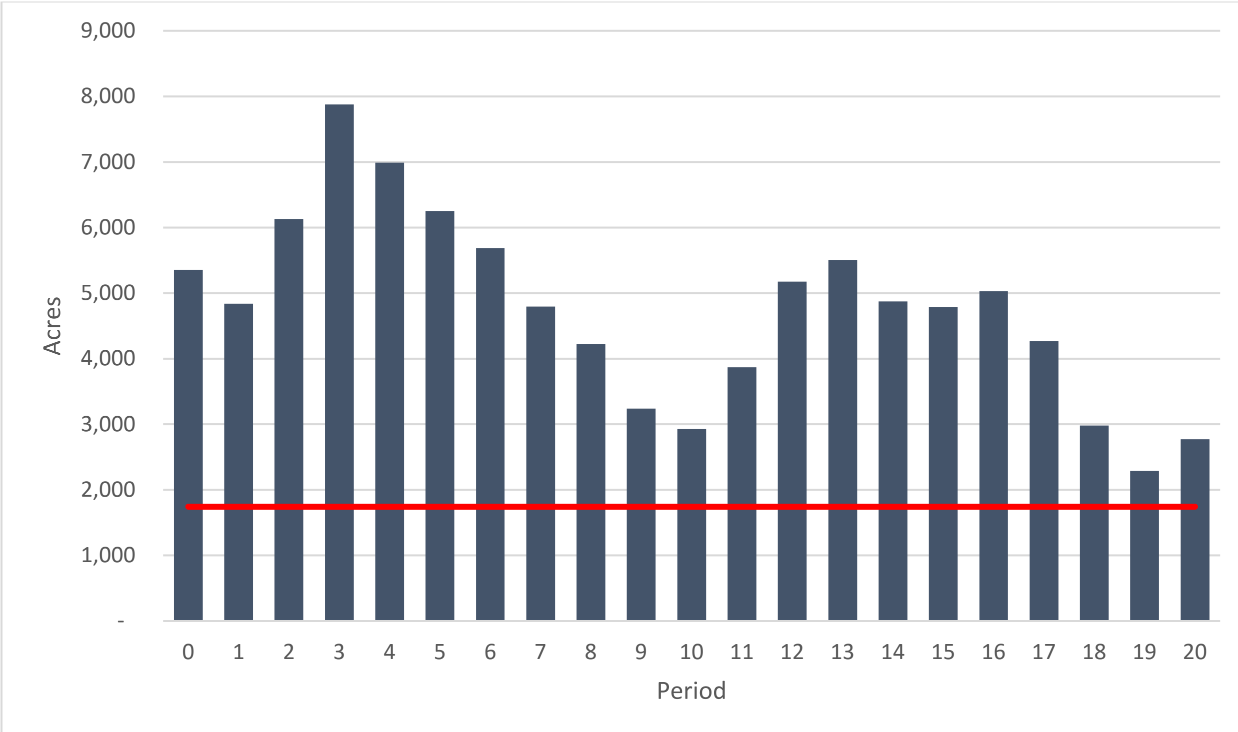

Figure 31: LMA (Stillwater South) Saw-Timber Acres – Fully Constrained Model

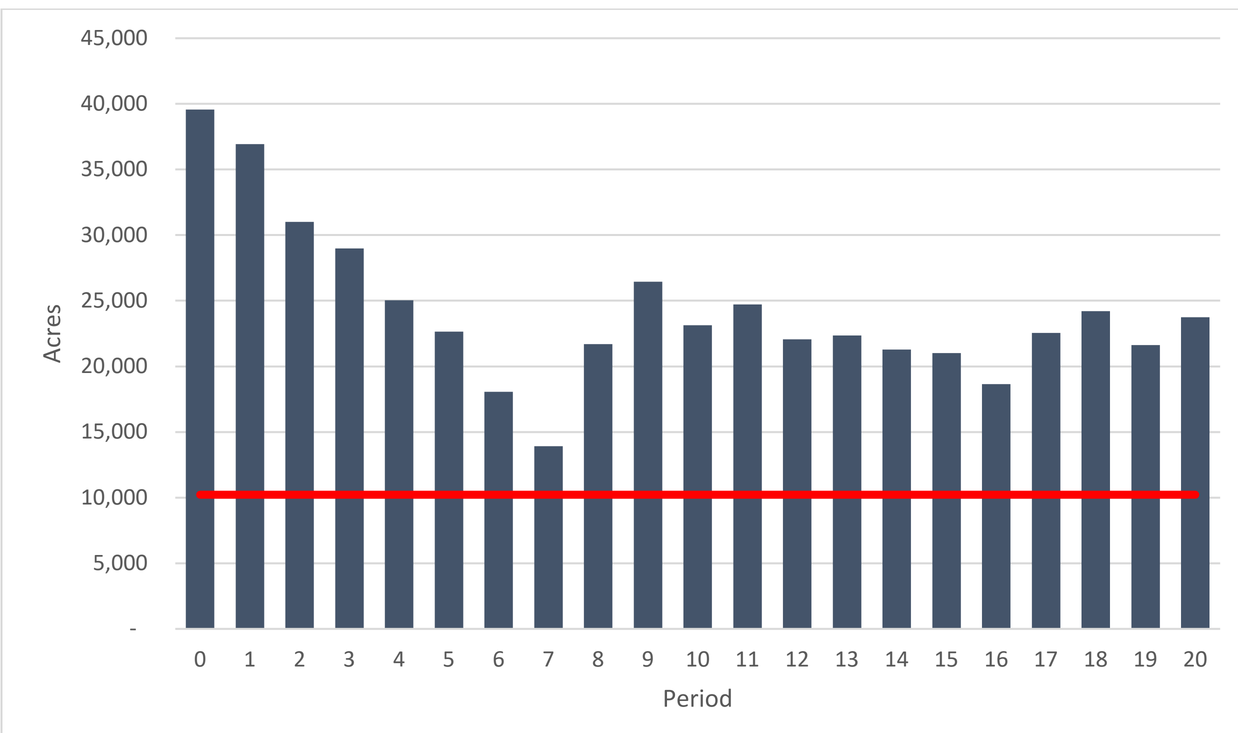

Figure 32: LMA (Swan) Saw-Timber Acres – Fully Constrained Model

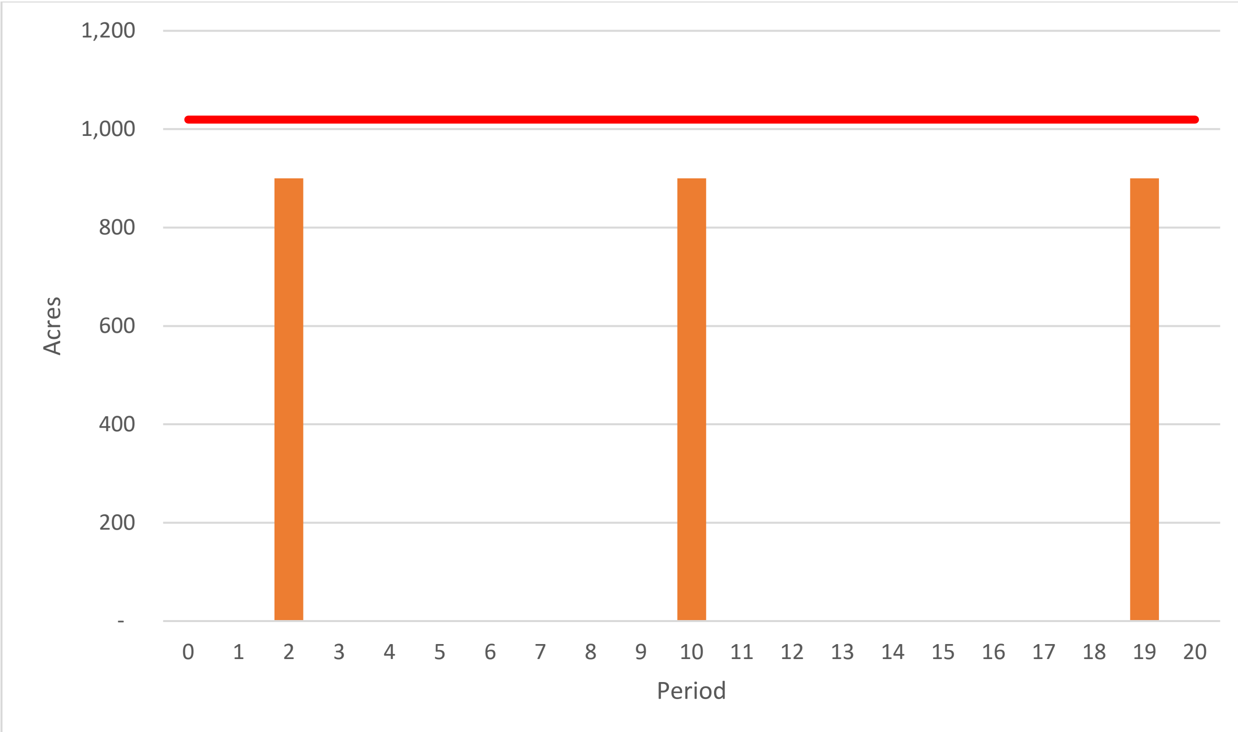

Figure 33: LMA (Coal Creek) PCT Acres – Fully Constrained Model

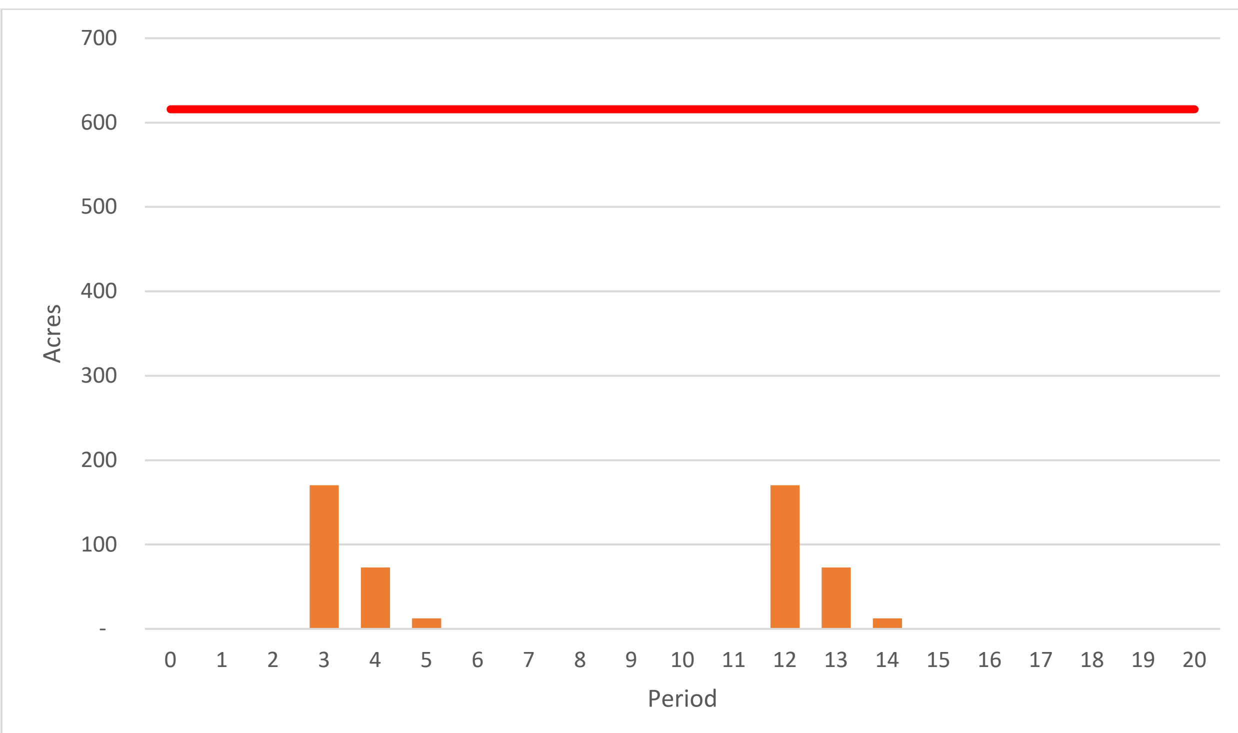

Figure 34: LMA (Garnet) PCT Acres – Fully Constrained Model

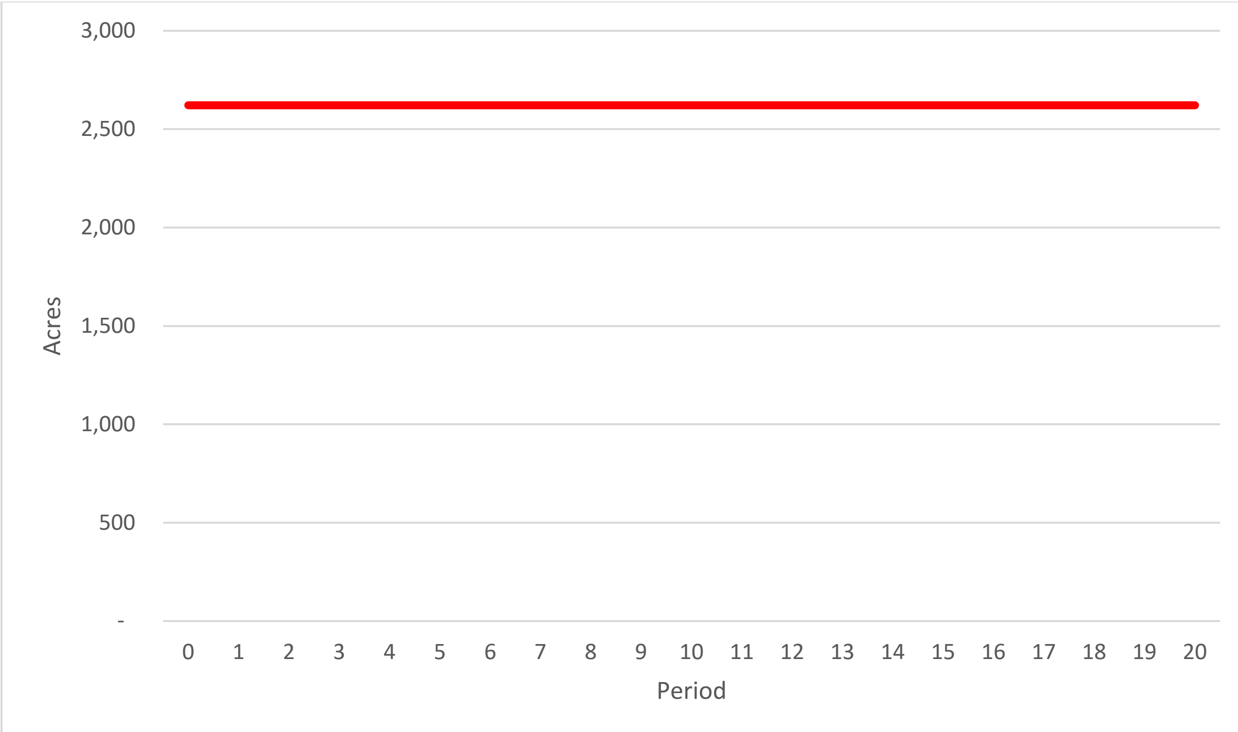

Figure 35: LMA (Stillwater East) PCT Acres – Fully Constrained Model

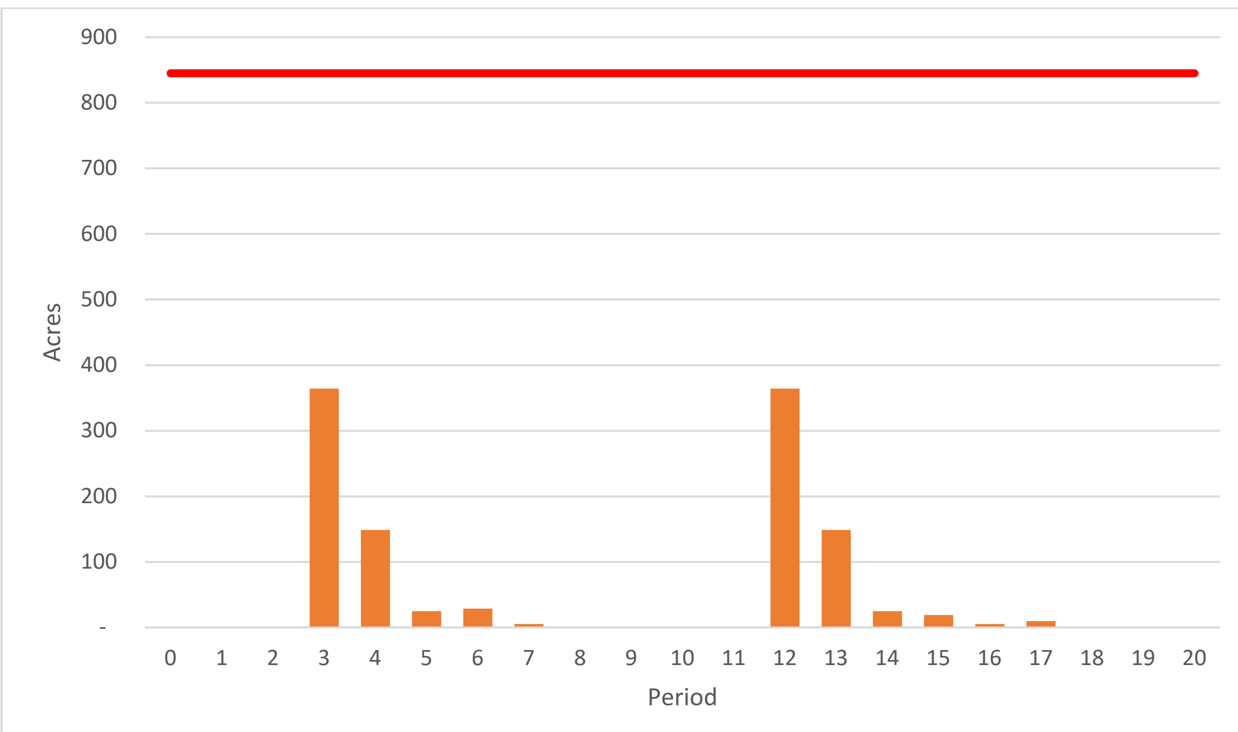

Figure 36: LMA (Seeley Lake) PCT Acres – Fully Constrained Model

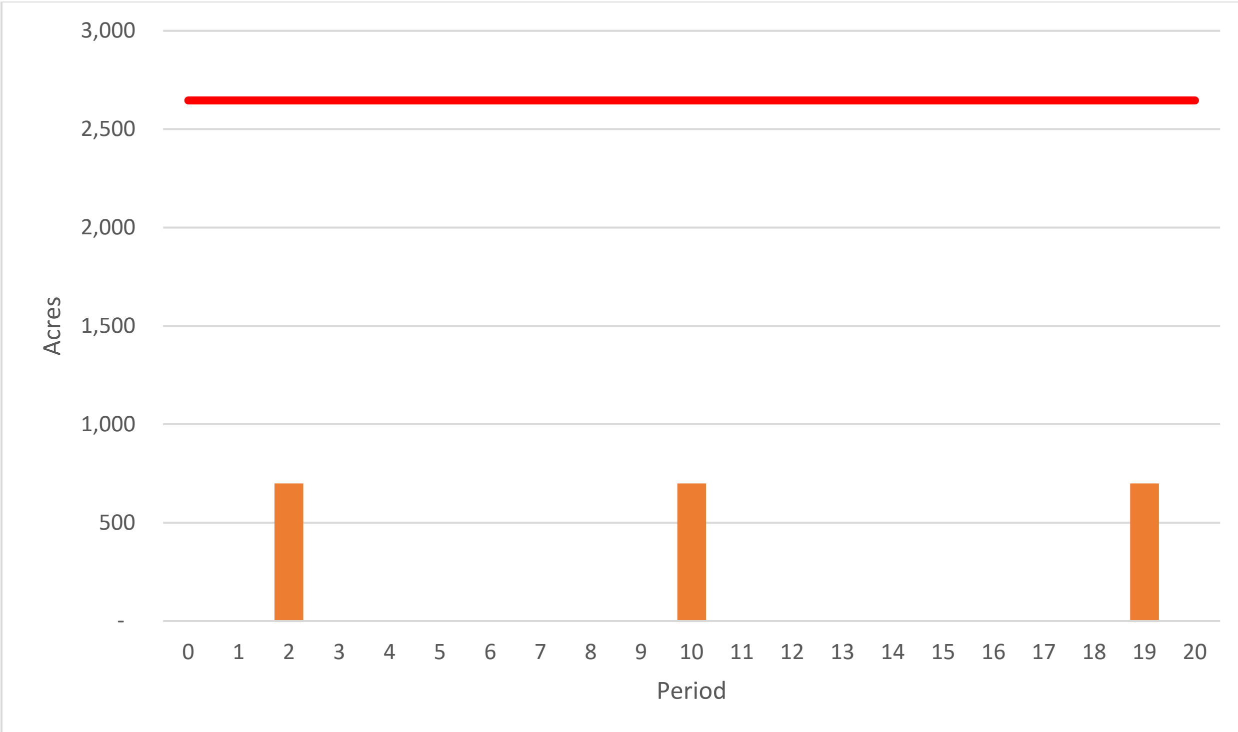

Figure 37: LMA (Stillwater West) PCT Acres – Fully Constrained Model

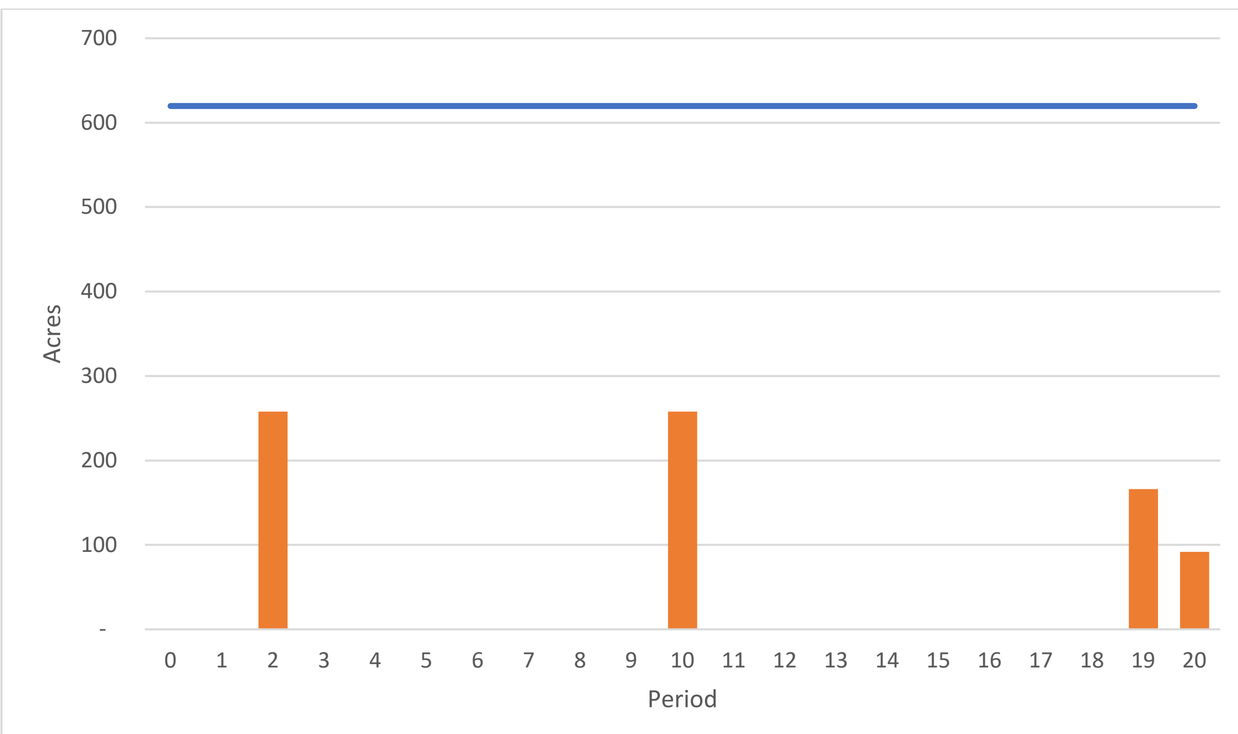

Figure 38: LMA (Stillwater South) PCT Acres – Fully Constrained Model

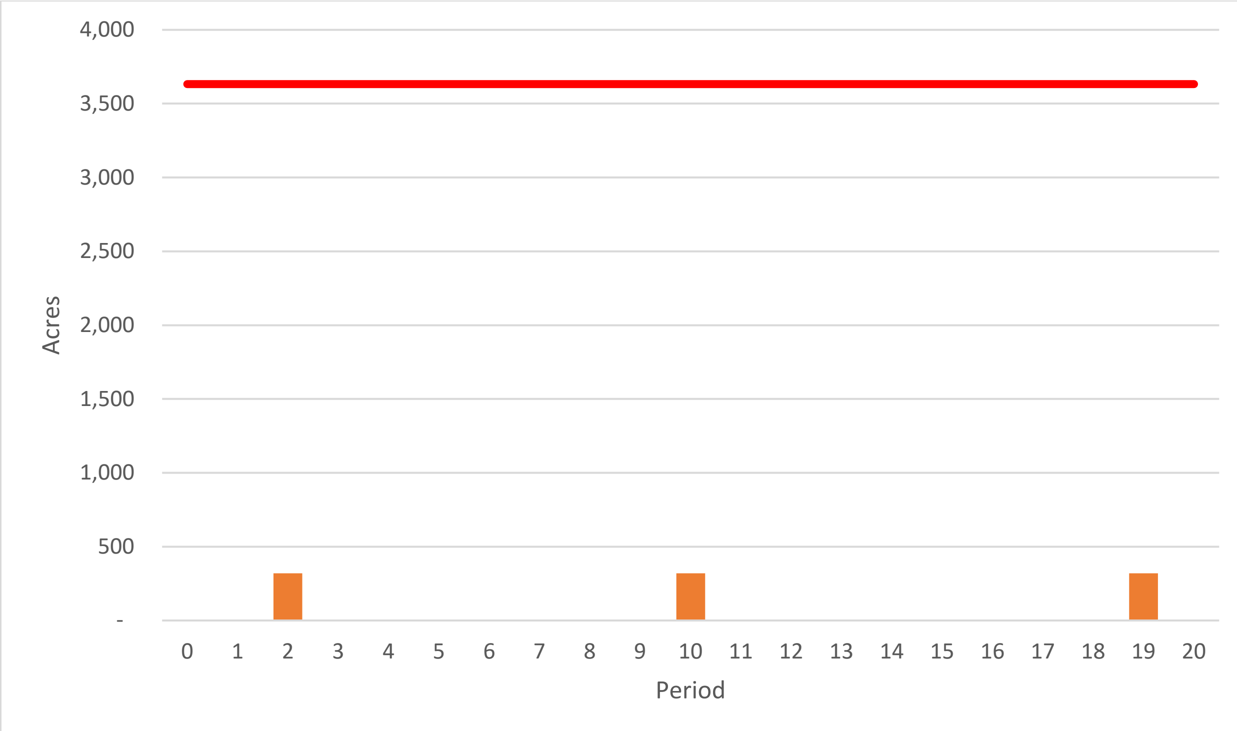

Figure 39: LMA (Swan) PCT Acres – Fully Constrained Model

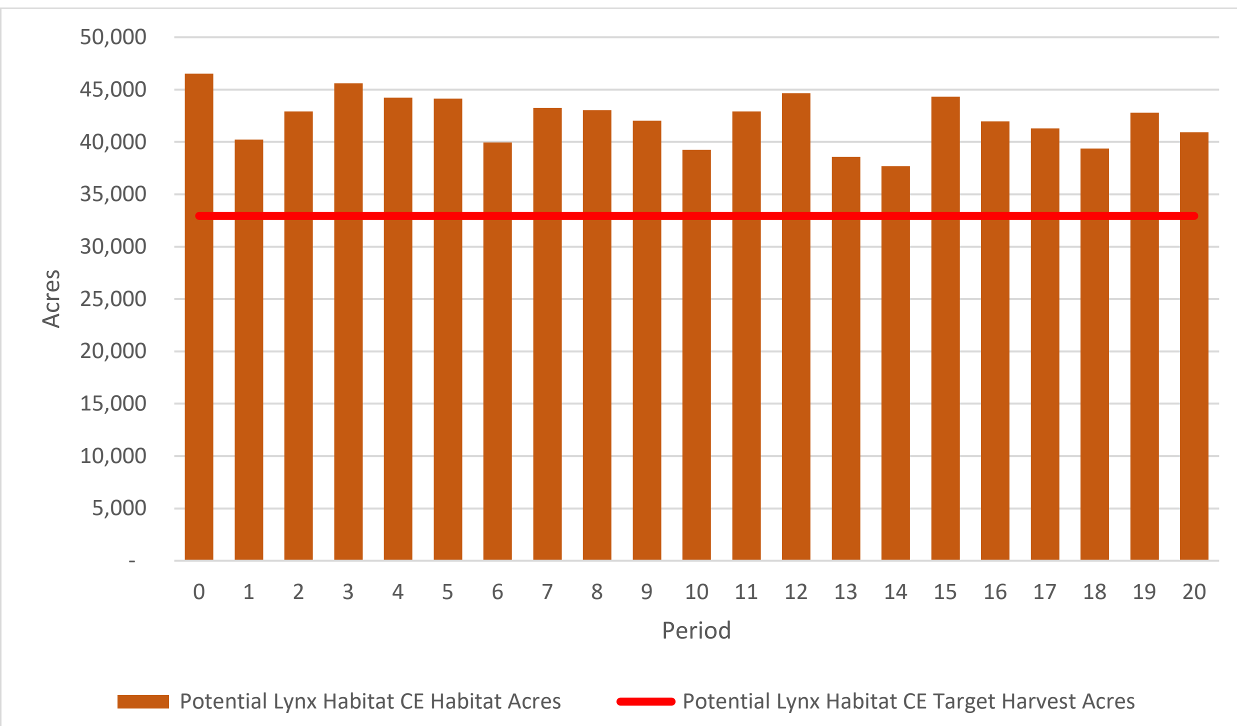

Figure 40: Potential Lynx Habitat Development (CE) – Fully Constrained Model

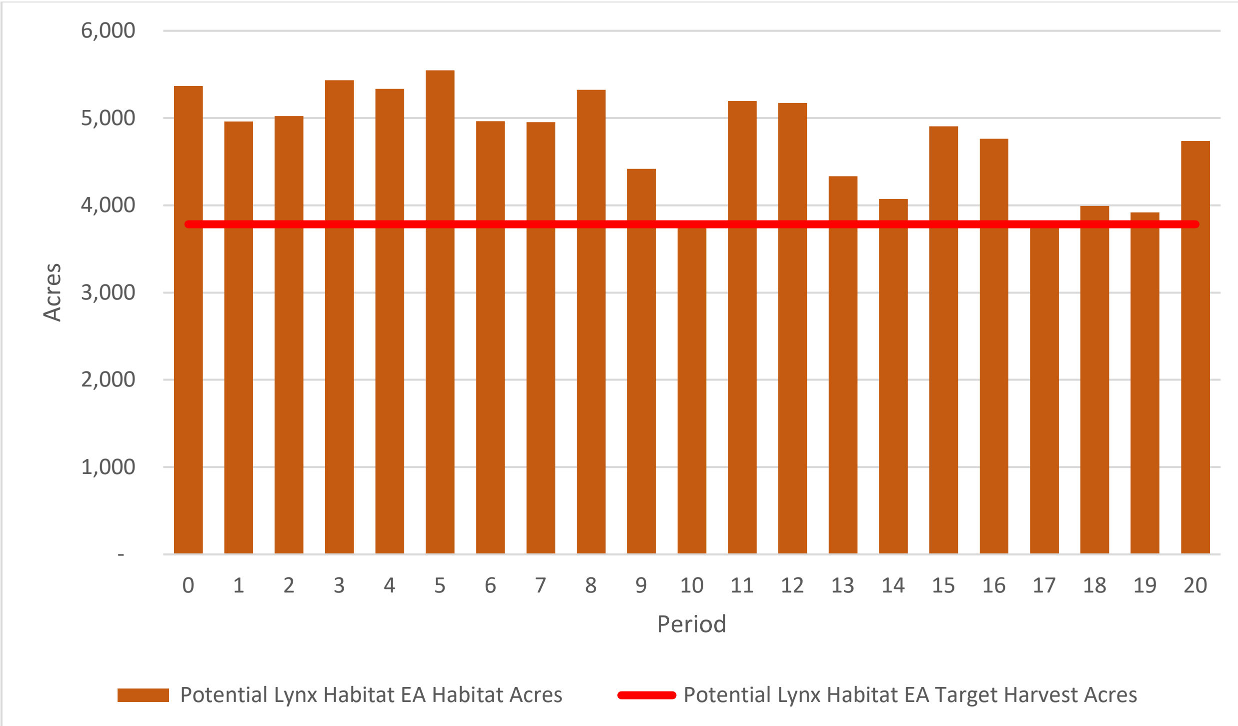

Figure 41: Potential Lynx Habitat Development (EA) – Fully Constrained Model

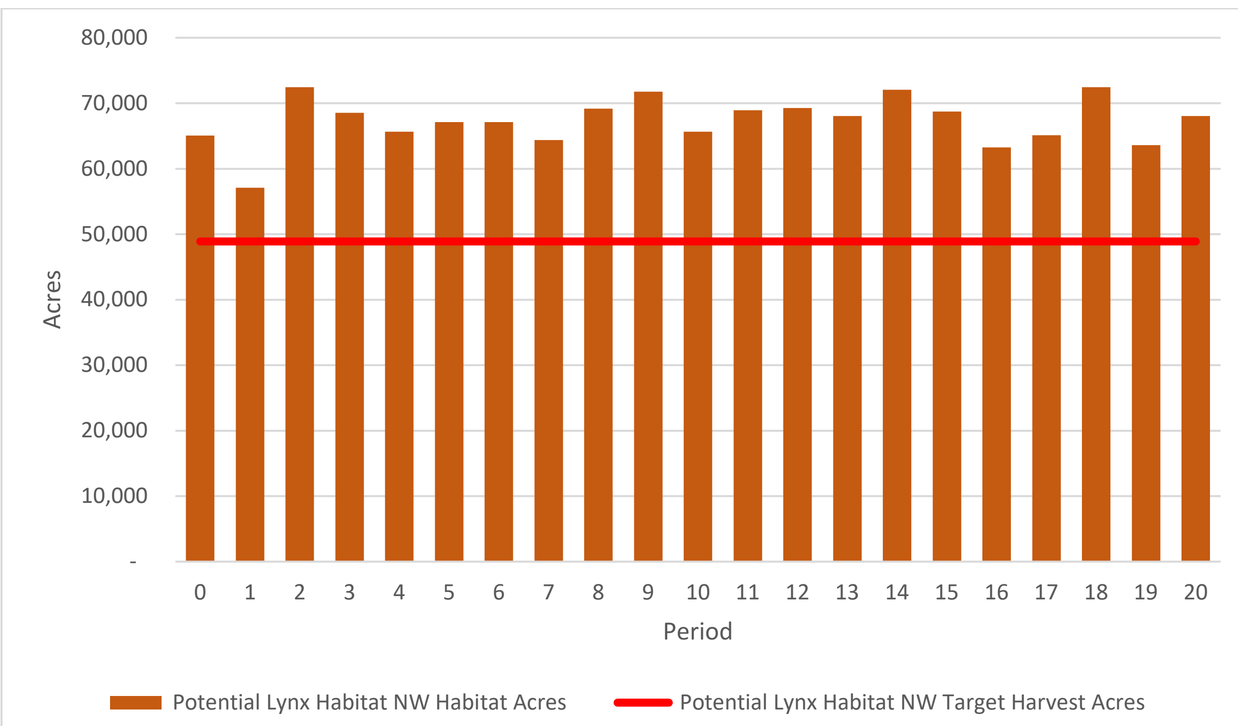

Figure 42: Potential Lynx Habitat Development (NW) – Fully Constrained Model

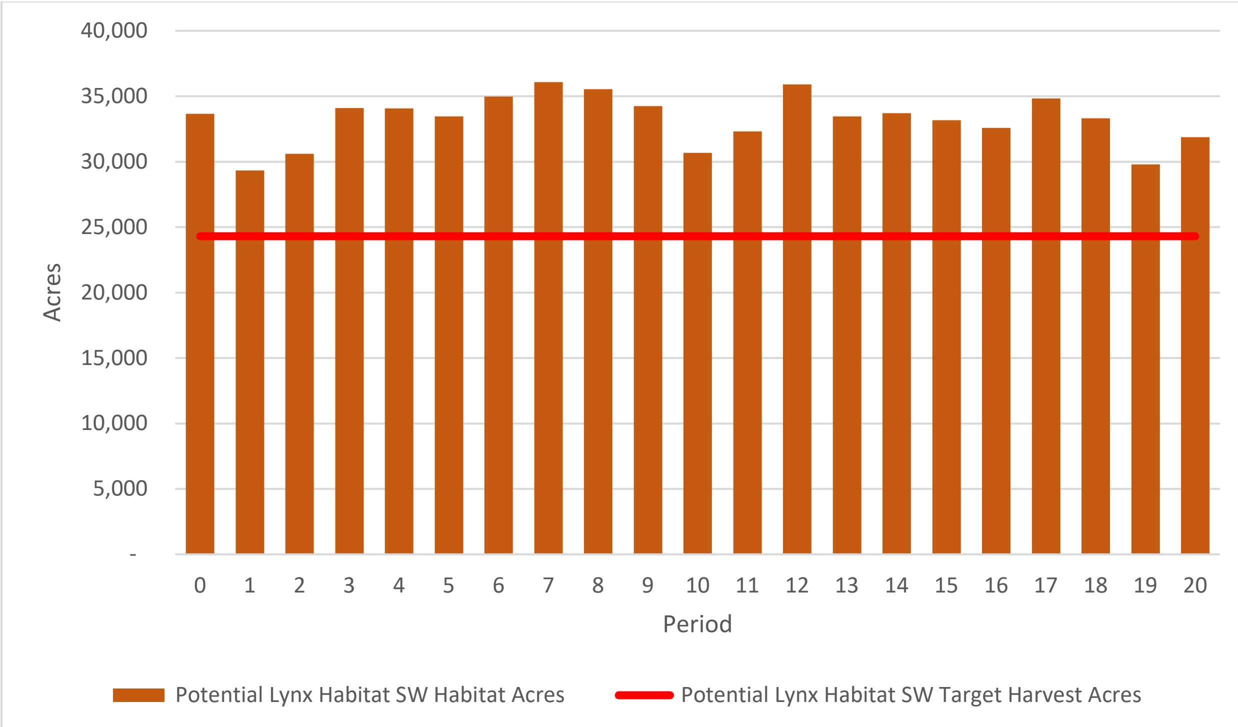

Figure 43: Potential Lynx Habitat Development (SW) – Fully Constrained Model

Figure 44: Bald Eagle Habitat Acres – Fully Constrained Model

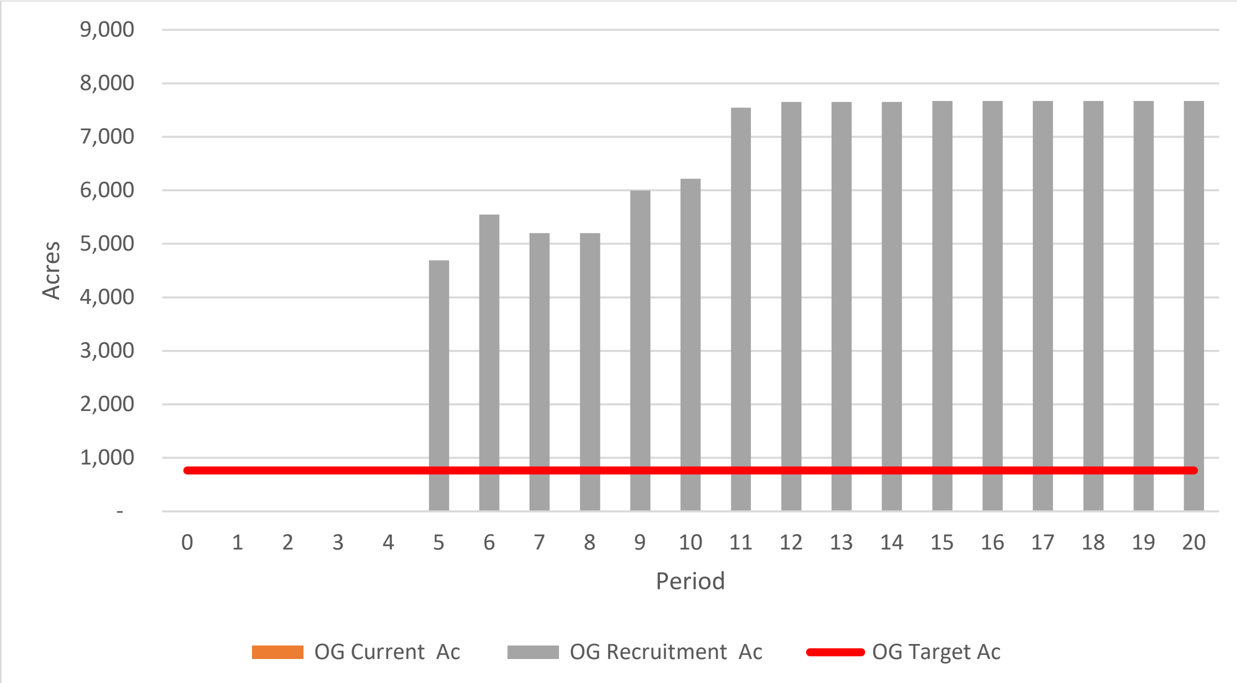

Figure 45: CE Old Growth Acres (Bozeman) – Fully Constrained Model

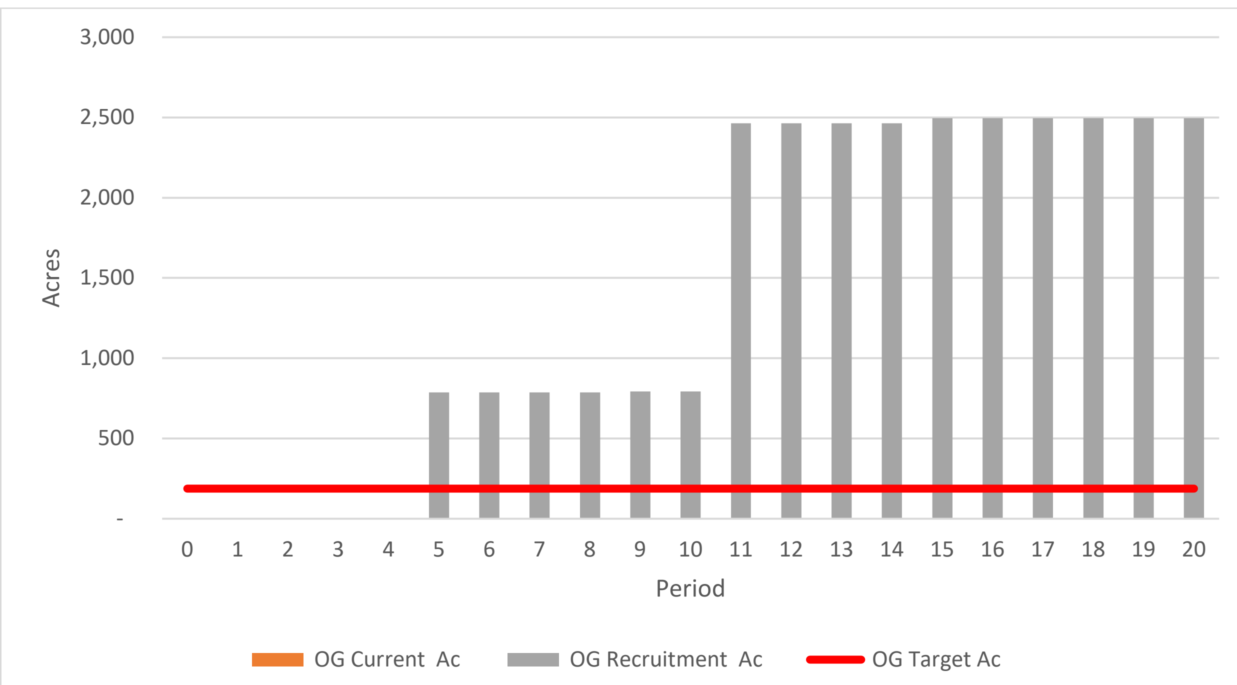

Figure 46: CE Old Growth Acres (Conrad) – Fully Constrained Model

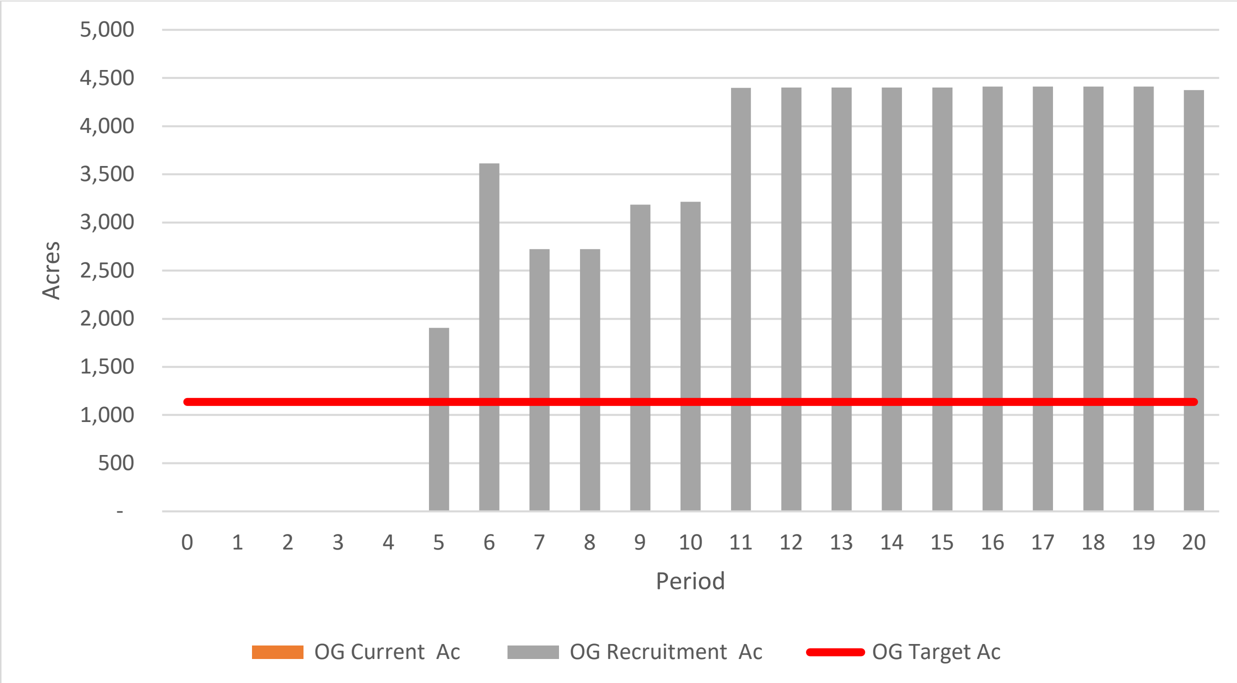

Figure 47: CE Old Growth Acres (Dillon) – Fully Constrained Model

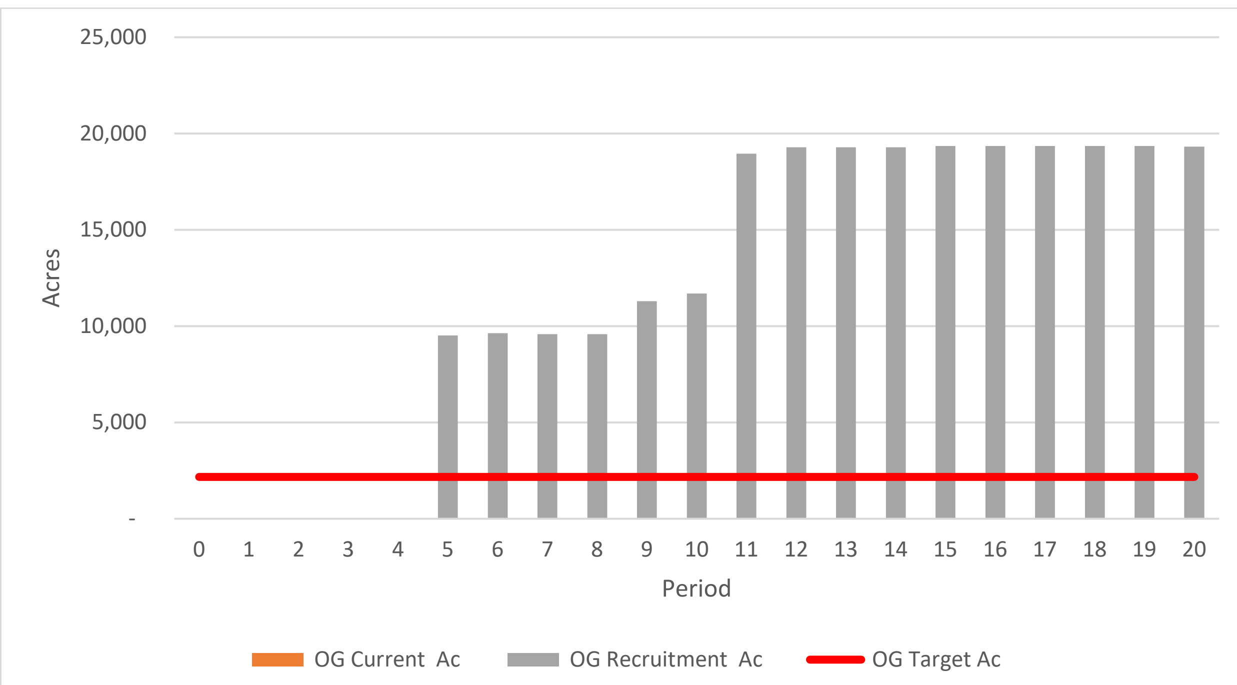

Figure 48: CE Old Growth Acres (Helena) – Fully Constrained Model

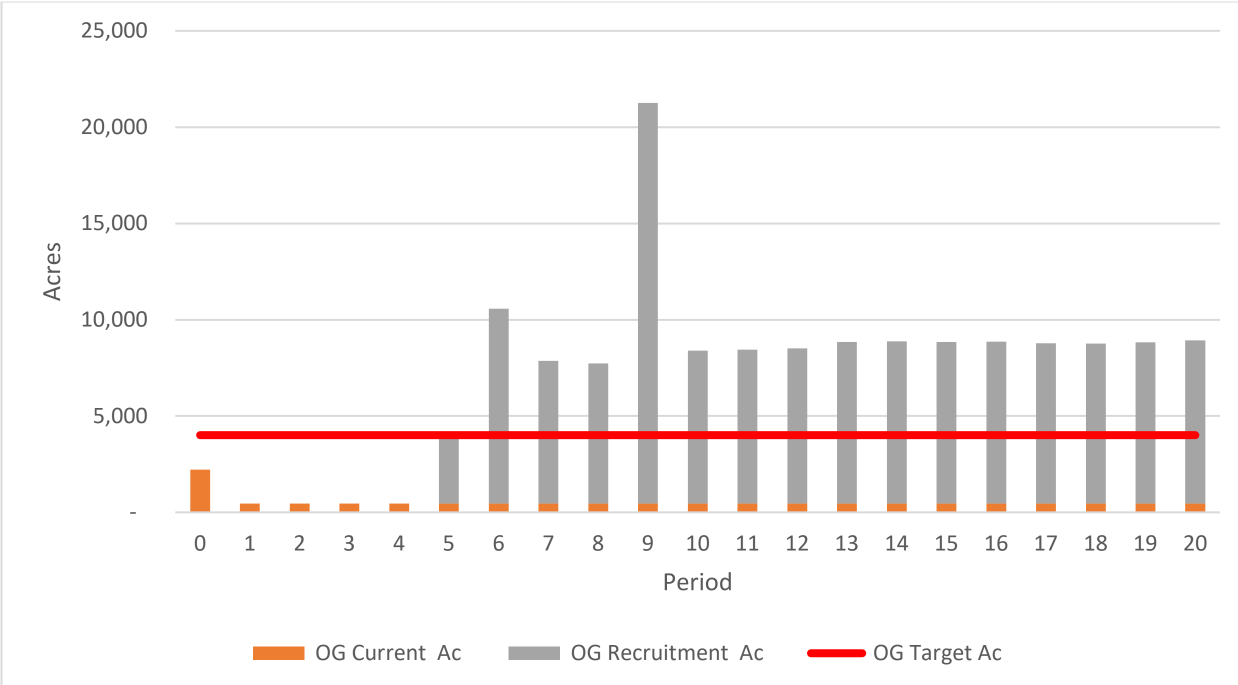

Figure 49: NW Old Growth Acres (Kalispell) – Fully Constrained Model

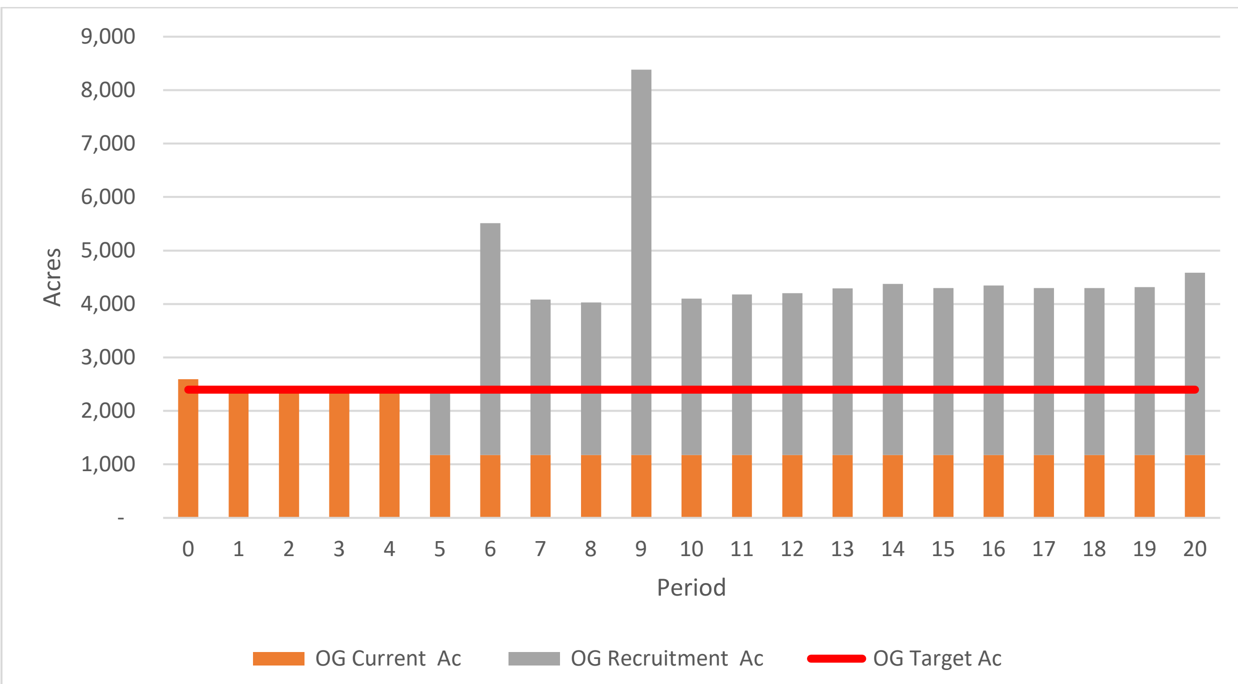

Figure 50: NW Old Growth Acres (Libby) – Fully Constrained Model

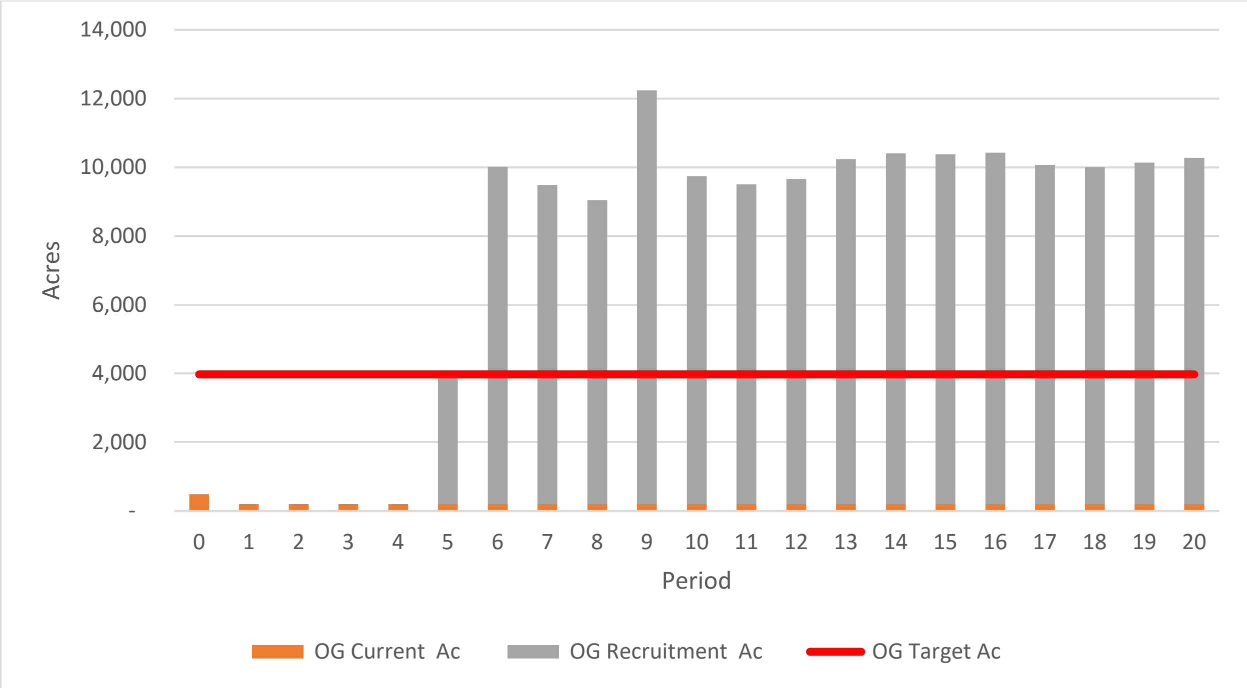

Figure 51: NW Old Growth Acres (Plains) – Fully Constrained Model

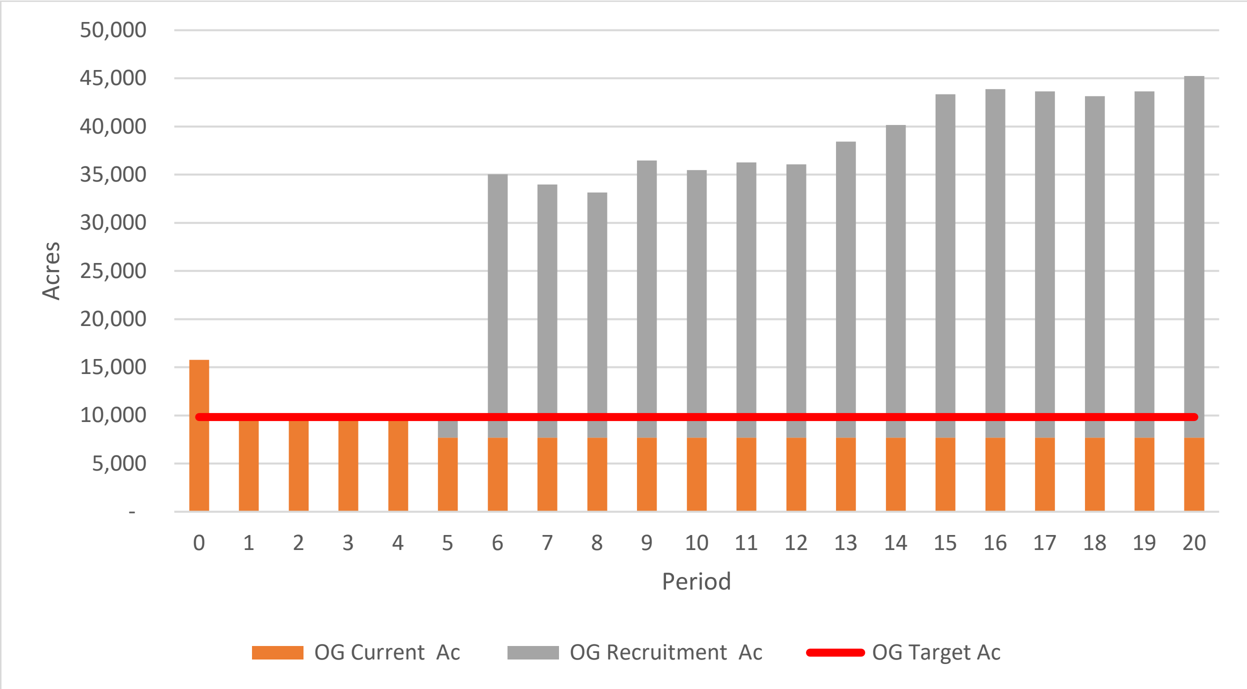

Figure 52: NW Old Growth Acres (Stillwater) – Fully Constrained Model

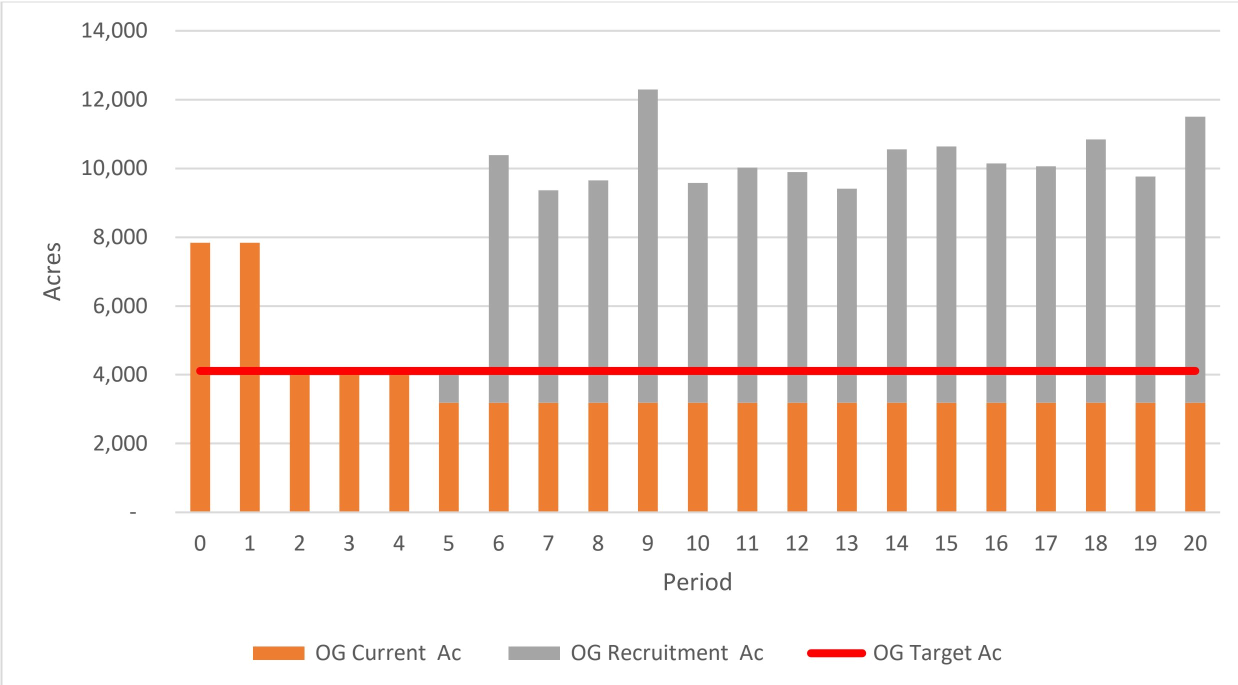

Figure 53: NW Old Growth Acres (Swan) – Fully Constrained Model

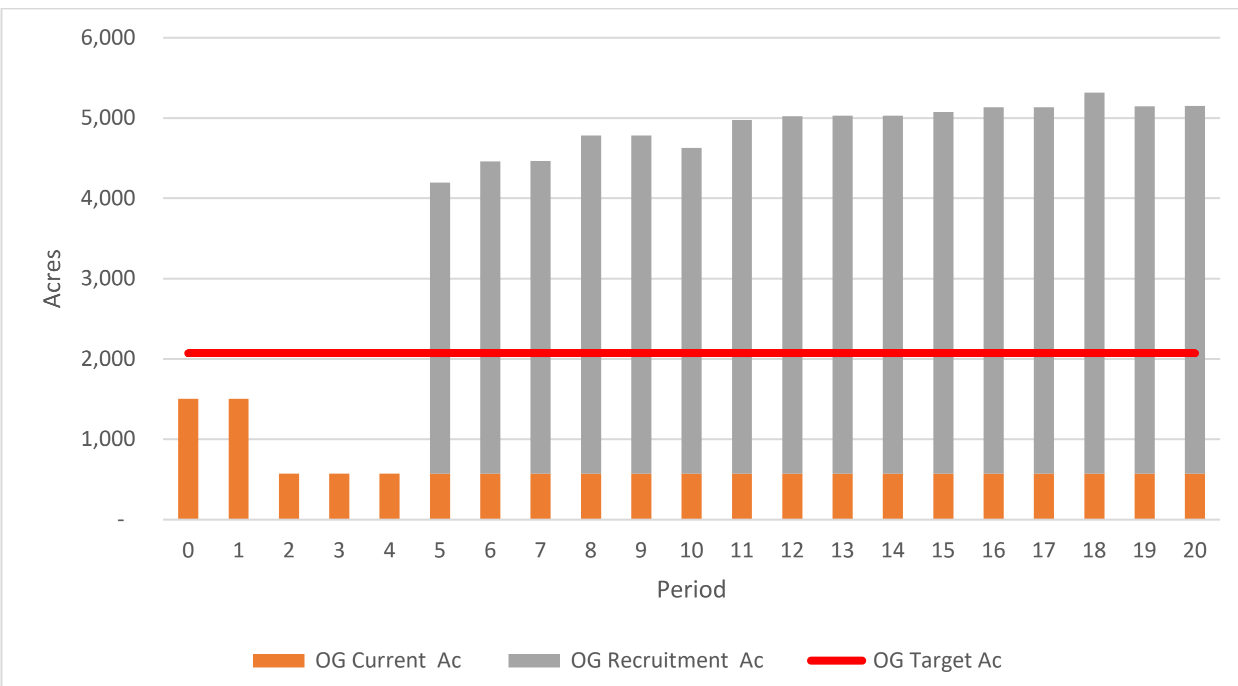

Figure 54: SW Old Growth Acres (Anaconda) – Fully Constrained Model

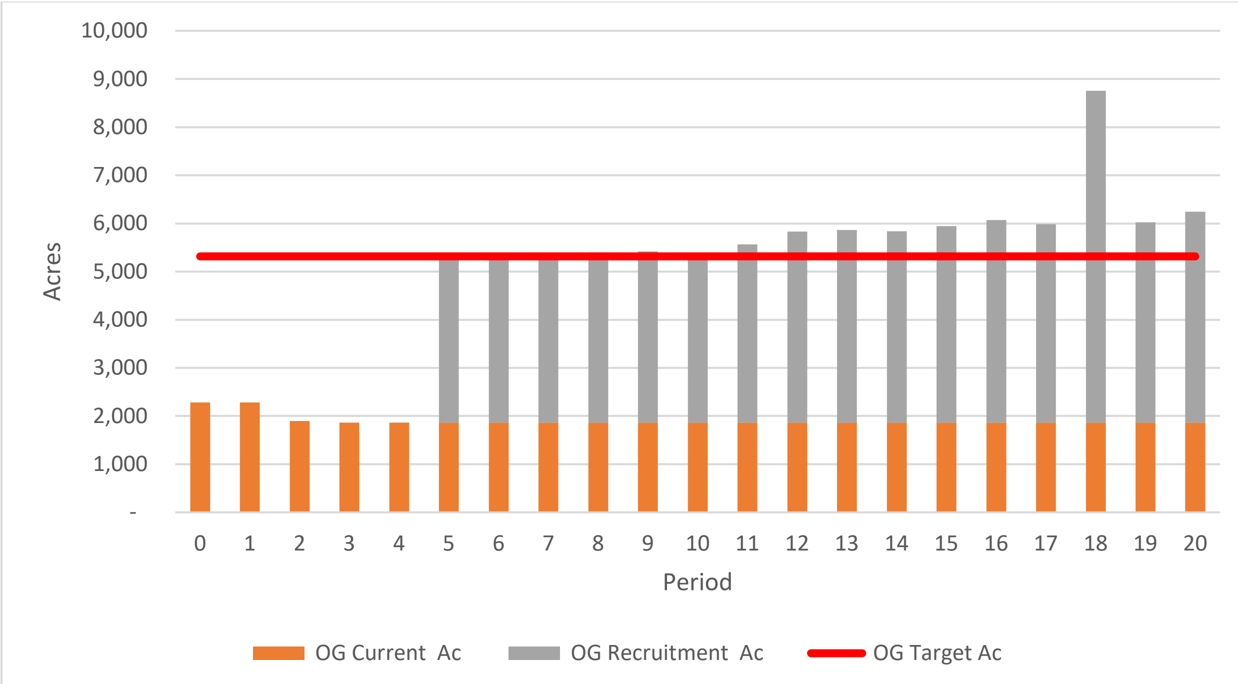

Figure 55: SW Old Growth Acres (Clearwater) – Fully Constrained Model

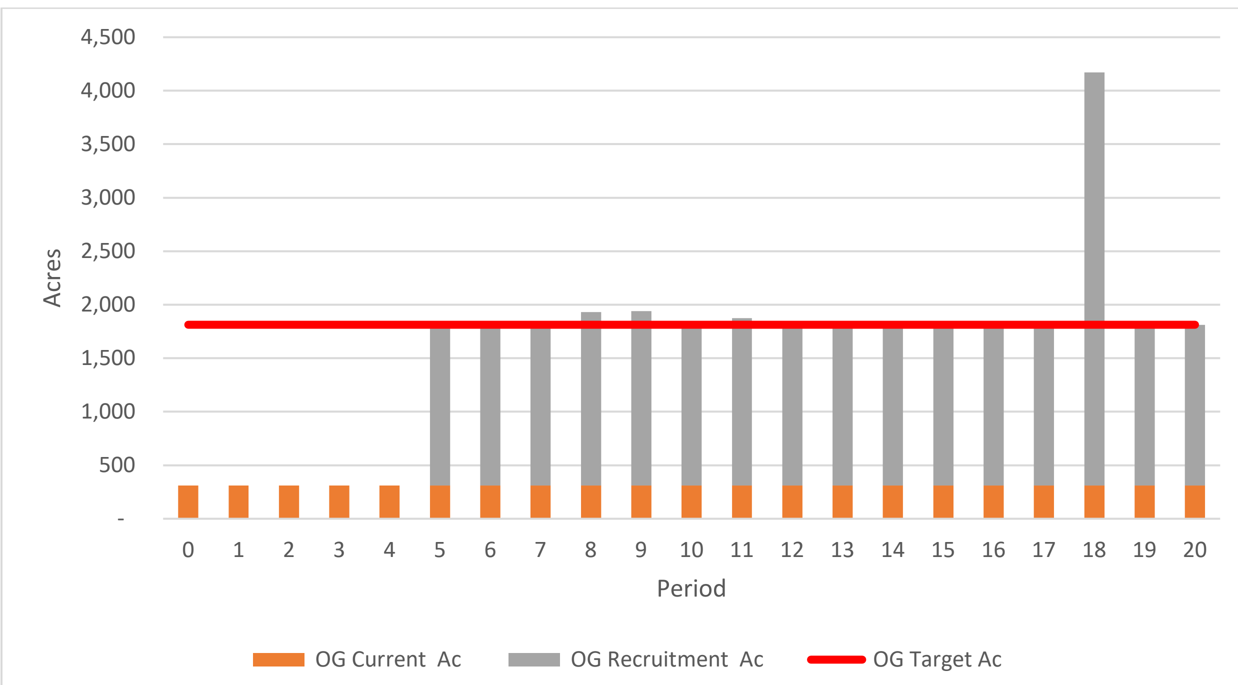

Figure 56: SW Old Growth Acres (Hamilton) – Fully Constrained Model

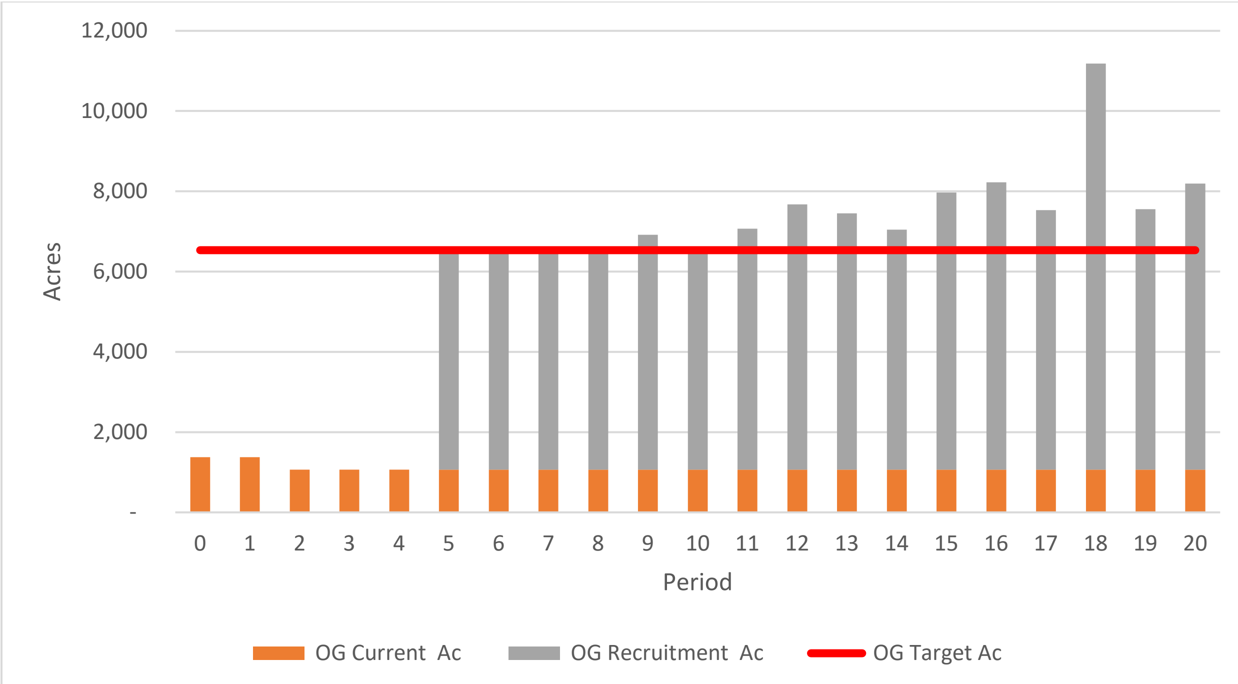

Figure 57: SW Old Growth Acres (Missoula) – Fully Constrained Model

18 Appendix K: Silvicultural Regime Acre Constraints

The following table shows the percentage of acres that was allowed to be allocated towards CCRX, STRX, SWRX and UERX for each unique combination of unit and species. These percentages were used by the silvicultural regime constraint in the LP model to set a threshold value for each management pathway type.

Table 30: Silvicultural Regime Constraint Percentages

Species	Regime	Unit				
		ANA, CLW, HAM, MSO	EA/CE:BIL,LEW,HAV,GLA,MIL	CE: DIL	KAL, LIB, PLN	STW, SWN
PPDF	CC					
	ST	20%	20%		5%	5%
	SW	60%	60%		25%	20%
	Uneven	20%	20%		70%	75%
DPMC	CC					
	ST	44%	60%	40%	49%	53%
	SW	36%	20%	40%	11%	12%
	Uneven	20%	20%	20%	40%	45%
WLDF, OGW4	CC					
	ST	42%	0%	0%	45%	33%
	SW	38%	0%	0%	10%	7%
	UM	20%	0%	0%	45%%	60%
LP	CC	100%	100%	100%	100%	100%
	ST					
	SW					
	Uneven					
GFRC	CC					
	ST	44%	60%	40%	45%	33%
	SW	36%	20%	40%	10%	7%
	Uneven	20%	20%	20%	45%	60%%
SF, SFM, SFC, OGW6	CC	16%	5%	10%	16%	17%
	ST	48%	35%	32%	53%	56%
	SW	16%	40%	38%	16%	17%
	Uneven	20%	20%	20%	15%	10%
W1	CC					
	ST	20%			5%	53%
	SW	60%			25%	12%
	Uneven	20%			70%	35%
NS	CC					
	ST		60%	40%	45%	33%
	SW	25%	20%	40%	10%	7%
	Uneven	75%	20%	20%	45%	60%

19 Appendix L: Calibration Keyfiles, Habitat Types, Substitute Tree Lists, and Substitute Yield Tables

FVS variants, calibration keyfiles, and habitat types used to differentiate among high, low, and moderate productivity classes are shown in Table 31. For strata that did not have associated cruise data or insufficient cruise data, the stratum whose tree list and/or yield table served as substitute are also listed. Habitat type codes in Table 31 refer to the habitat types and codes as described in Pfister et al. (1977).

Table 31: FVS Calibration Keyfile, Habitat Types, Substitute Tree Lists, and Substitute Yield Table for each Stratum

Land Office	Stratum	FVS			Substitution For:
		Variant	keyfile	Habitat	
CE	DPMC7AH	IE	Default	330	---
CE	DPMC7AH	FV	FVSkey_ie_WRD_h2rl	330	---
CE	DPMC7AL	FV	FVSkey_ie_WRD_h2rl	170	CE-DPMC8LL
CE	DPMC7AM	IE	Default	170	CE-DPMC8LM
CE	DPMC7AM	IE	Default	170	CE-DPMC8LM
CE	DPMC7AM	FV	FVSkey_ie_WRD_h2rl	170	CE-DPMC8LM
CE	DPMC7LH	FV	FVSkey_em_CGN	470	---
CE	DPMC7LL	FV	FVSkey_em_CGN	330	CE-LP7LL, CE-LP7LM, CE-LP8LL
CE	DPMC7LM	FV	FVSkey_em_CGN	260	CE-LP8LM
CE	DPMC8AH	FV	FVSkey_ie_WRD_h2rm	330	---
CE	DPMC8AM	FV	FVSkey_ie_WRD_h2rm	170	---
CE	DPMC8AM	FV	FVSkey_ie_WRD_h2rm	170	---
CE	DPMC9AH	FV	FVSkey_ie_WRD_h2rl	330	---
CE	DPMC9AM	FV	FVSkey_ie_WRD_h2rl	260	---
CE	DPMC9AM	FV	FVSkey_ie_WRD_h2rl	260	---
CE	DPMC9LH	FV	FVSkey_ie_WRD_h2rl	260	---
CE	DPMC9LM	FV	FVSkey_ie_WRD_h2rl	330	---
CE	DPMC9LM	FV	FVSkey_ie_WRD_h2rl	330	---
CE	LP7AL	FV	FVSkey_ie_HLC_h2rm	280	CE-NS6NL, CE-NS6NM, CE-SF7LL, CE-SF8AL, CE-SF8AM, CE-SF8LL
CE	LP7AM	FV	FVSkey_ie_HLC_h2rm	690	CE-SF8LM, CE-SF8LM
CE	LP8AL	FV	FVSkey_ie_HLC_h2rh	280	CE-SF9AL, CE-SF9AM, CE-SF9LL
CE	LP8AM	FV	FVSkey_ie_HLC_h2rh	170	CE-SF9LM, EA-LP7AH, EA-LP7AL, EA-LP7AM
CE	LP9AL	FV	FVSkey_ie_HLC_h2rm	140	EA-LP7LL, EA-LP7LM, EA-LP8AH, EA-LP8AL, EA-LP8AM, EA-LP8LL, EA-LP9AH, EA-LP9AL
CE	LP9AM	FV	FVSkey_ie_HLC_h2rm	170	CE-SF8AM, CE-SF8LL, CE-SF8LM, CE-SF8LM
CE	NS6NL	FV	FVSkey_em_CGN	330	---

Land Office	Stratum	FVS			Substitution For:
		Variant	keyfile	Habitat	
CE	NS6NL	FV	FVSkey_ie_WRD_h2rl	330	---
CE	NS6NM	IE	Default	670	---
CE	NS6NM	FV	FVSkey_ie_WRD_h2rl	670	---
CE	SF8AL	FV	FVSkey_ie_WRD_h9rm	470	EA-NS6NM
CE	SF8AM	FV	FVSkey_ie_WRD_h9rm	690	---
CE	SF9AL	FV	FVSkey_ie_WRD_h9rm	470	---
CE	SF9AM	FV	FVSkey_ie_WRD_h9rm	690	---
EA	DPMC7AL	FV	FVSkey_em_CGN	170	---
EA	DPMC7AM	FV	FVSkey_em_CGN	280	---
EA	DPMC7LL	FV	FVSkey_em_CGN	170	---
EA	DPMC7LM	FV	FVSkey_em_CGN	280	---
EA	DPMC8AL	FV	FVSkey_em_CGN_h2rm	170	---
EA	DPMC8AM	FV	FVSkey_em_CGN_h2rm	280	---
EA	DPMC8LL	FV	FVSkey_em_CGN_h2rm	170	---
EA	DPMC8LM	FV	FVSkey_em_CGN_h2rm	280	---
EA	DPMC9AL	FV	FVSkey_em_CGN_h2rm	170	---
EA	DPMC9AM	FV	FVSkey_em_CGN_h2rm	280	---
EA	DPMC9LL	FV	FVSkey_em_CGN_h2rm	170	---
EA	DPMC9LM	FV	FVSkey_em_CGN_h2rm	280	---
EA	LP7AL	EM	Default	310	---
EA	LP7AM	EM	Default	290	---
EA	NS6NL	EM	Default	170	---
EA	NS6NM	EM	Default	280	---
NW	GFRC7AH	FV	FVSkey_ie_WRD_h7rl	520	---
NW	GFRC7AM	FV	FVSkey_ie_WRD_h7rl	510	CE-SF9AM, CE-SF9LL
NW	GFRC8AH	FV	FVSkey_ie_WRD_h7rm	520	---
NW	GFRC8AM	FV	FVSkey_ie_WRD_h7rm	510	CE-SF9LM, EA-LP7AH
NW	GFRC9AH	FV	FVSkey_ie_WRD_h7rh	620	---

Land Office	Stratum	FVS			Substitution For:
		Variant	keyfile	Habitat	
NW	GFRC9AM	FV	FVSkey_ie_WRD_h7rh	660	---
NW	GFRC9LH	FV	FVSkey_ie_WRD_h7rh	620	---
NW	GFRC9LM	FV	FVSkey_ie_WRD_h7rh	660	---
NW	LP7AH	FV	FVSkey_ie_WRD_h9rl	590	---
NW	LP7AH	FV	FVSkey_ie_WRD_h9rm	590	---
NW	LP7AL	FV	FVSkey_ie_WRD_h9rl	280	EA-LP7AL, EA-LP7AM
NW	LP7AL	FV	FVSkey_ie_WRD_h9rm	280	EA-LP7AL, EA-LP7AM
NW	LP7AM	FV	FVSkey_ie_WRD_h9rl	690	NW-LP7LM
NW	LP7AM	FV	FVSkey_ie_WRD_h9rm	690	NW-LP7LM
NW	LP8AH	FV	FVSkey_ie_WRD_h9rm	590	---
NW	LP8AL	FV	FVSkey_ie_WRD_h9rm	280	EA-LP7LM, EA-LP8AH, EA-LP8AL, EA-LP8AM, EA-LP8LL
NW	LP8AM	FV	FVSkey_ie_WRD_h9rm	690	CE-NS6NL, CE-NS6NM
NW	NS6NH	FV	FVSkey_ie_WRD_h7rl	670	---
NW	NS6NH	FV	FVSkey_ie_WRD_h7rm	670	---
NW	NS6NL	FV	FVSkey_ie_WRD_h7rl	330	---
NW	NS6NL	FV	FVSkey_ie_WRD_h7rm	330	---
NW	NS6NM	FV	FVSkey_ie_WRD_h7rl	520	---
NW	NS6NM	FV	FVSkey_ie_WRD_h7rl	520	---
NW	NS6NM	FV	FVSkey_ie_WRD_h7rm	520	---
NW	OGW1W1L	FV	FVSkey_ie_WRD_h2rh	130	---
NW	OGW1W1L	FV	FVSkey_ie_WRD_h2rm	130	---
NW	OGW1W1M	FV	FVSkey_ie_WRD_h2rh	170	---
NW	OGW1W1M	FV	FVSkey_ie_WRD_h2rm	170	---
NW	OGW4W4H	FV	FVSkey_ie_WRD_h7rl	670	---
NW	OGW4W4H	FV	FVSkey_ie_WRD_h7rm	670	---
NW	OGW4W4H	FV	FVSkey_ie_WRD_h7rm	670	---
NW	OGW4W4M	FV	FVSkey_ie_WRD_h7rl	690	---
NW	OGW4W4M	FV	FVSkey_ie_WRD_h7rm	690	---

Land Office	Stratum	FVS			Substitution For:
		Variant	keyfile	Habitat	
NW	OGW4W4M	FV	FVSkey_ie_WRD_h7rm	690	---
NW	OGW6W6H	FV	FVSkey_ie_WRD_h9rm	670	---
NW	OGW6W6L	FV	FVSkey_ie_WRD_h9rm	690	---
NW	OGW6W6L	FV	FVSkey_ie_WRD_h9rm	690	---
NW	OGW6W6M	FV	FVSkey_ie_WRD_h9rm	690	---
NW	OGW6W6M	FV	FVSkey_ie_WRD_h9rm	690	---
NW	PPDF7AH	FV	FVSkey_ie_WRD_h2rl	260	---
NW	PPDF7AH	FV	FVSkey_ie_WRD_h2rm	260	---
NW	PPDF7AL	FV	FVSkey_ie_WRD_h2rl	170	CE-SF8LM, CE-SF9AL
NW	PPDF7AL	FV	FVSkey_ie_WRD_h2rm	170	CE-SF8LM, CE-SF9AL
NW	PPDF7AM	FV	FVSkey_ie_WRD_h2rl	280	NW-SFC7LL
NW	PPDF7AM	FV	FVSkey_ie_WRD_h2rm	280	NW-SFC7LL
NW	PPDF8AH	FV	FVSkey_ie_WRD_h2rm	260	---
NW	PPDF8AL	FV	FVSkey_ie_WRD_h2rm	170	CE-SF9LL, CE-SF9LM
NW	PPDF8AM	FV	FVSkey_ie_WRD_h2rm	280	---
NW	PPDF9AH	FV	FVSkey_ie_WRD_h2rm	260	---
NW	PPDF9AL	FV	FVSkey_ie_WRD_h2rm	170	---
NW	PPDF9AM	FV	FVSkey_ie_WRD_h2rm	280	---
NW	PPDF9LH	FV	FVSkey_ie_WRD_h2rm	520	---
NW	PPDF9LL	FV	FVSkey_ie_WRD_h2rm	170	---
NW	PPDF9LM	FV	FVSkey_ie_WRD_h2rm	520	---
NW	SFC7AL	FV	FVSkey_ie_WRD_h9rm	830	EA-LP7AH, EA-LP7AL
NW	SFC7AM	FV	FVSkey_ie_WRD_h9rm	690	---
NW	SFC9AL	FV	FVSkey_ie_WRD_h9rm	690	EA-LP7AM, EA-LP7LL, EA-LP7LM, EA-LP8AH, EA-LP8AL, EA-LP8AM, EA-LP8LL, EA-LP9AH
NW	SFC9AM	FV	FVSkey_ie_WRD_h9rm	830	---
NW	SFM7AH	IE	Default	620	---
NW	SFM7AH	FV	FVSkey_ie_WRD_h9rm	620	---

Land Office	Stratum	FVS			Substitution For:
		Variant	keyfile	Habitat	
NW	SFM7AL	IE	Default	830	---
NW	SFM7AL	FV	FVSkey_ie_WRD_h9rm	830	---
NW	SFM7AM	IE	Default	690	SW-GFRC8AH
NW	SFM7AM	FV	FVSkey_ie_WRD_h9rm	690	SW-GFRC8AH
NW	SFM7LH	FV	FVSkey_ie_WRD_h9rl	620	EA-LP9AM, EA-LP9LL
NW	SFM7LL	FV	FVSkey_ie_WRD_h9rl	830	---
NW	SFM7LM	FV	FVSkey_ie_WRD_h9rl	660	---
NW	SFM8AH	FV	FVSkey_ie_WRD_h9rm	620	SW-GFRC8LM
NW	SFM8AL	FV	FVSkey_ie_WRD_h9rm	830	SW-LP7LH
NW	SFM8AM	FV	FVSkey_ie_WRD_h9rm	690	EA-NS6NM, NW-GFRC7LH, NW-GFRC7LM
NW	SFM9AH	FV	FVSkey_ie_WRD_h9rh	620	SW-LP8LL
NW	SFM9AL	FV	FVSkey_ie_WRD_h9rh	830	---
NW	SFM9AM	FV	FVSkey_ie_WRD_h9rh	690	SW-LP8LM
NW	SFM9LH	FV	FVSkey_ie_WRD_h9rh	620	---
NW	SFM9LL	FV	FVSkey_ie_WRD_h9rh	830	---
NW	SFM9LM	FV	FVSkey_ie_WRD_h9rh	690	SW-LP9AH
NW	WLDF7AH	FV	FVSkey_ie_WRD_h2rl	520	---
NW	WLDF7AH	FV	FVSkey_ie_WRD_h7rl	520	---
NW	WLDF7AH	FV	FVSkey_ie_WRD_h7rm	520	---
NW	WLDF7AM	FV	FVSkey_ie_WRD_h2rl	640	CE-LP8LM, CE-LP9LL
NW	WLDF7AM	FV	FVSkey_ie_WRD_h7rl	640	CE-LP8LM, CE-LP9LL
NW	WLDF7AM	FV	FVSkey_ie_WRD_h7rm	640	CE-LP8LM, CE-LP9LL
NW	WLDF8AH	FV	FVSkey_ie_WRD_h2rm	520	SW-LP9LH
NW	WLDF8AM	FV	FVSkey_ie_WRD_h2rm	640	CE-NS6NL, CE-NS6NM, CE-SF7LL
NW	WLDF9AH	FV	FVSkey_ie_WRD_h2rh	520	---
NW	WLDF9AM	FV	FVSkey_ie_WRD_h2rh	640	---
NW	WLDF9LH	FV	FVSkey_ie_WRD_h2rh	520	---
NW	WLDF9LM	FV	FVSkey_ie_WRD_h2rh	640	---

Land Office	Stratum	FVS			Substitution For:
		Variant	keyfile	Habitat	
SW	GFRC7AH	FV	FVSkey_ie_WRD_h9rl	660	---
SW	GFRC7AH	FV	FVSkey_ie_WRD_h9rm	660	---
SW	GFRC7AH	FV	FVSkey_ie_WRD_h9rm	660	---
SW	GFRC7AL	FV	FVSkey_ie_WRD_h9rl	280	---
SW	GFRC7AL	FV	FVSkey_ie_WRD_h9rm	280	---
SW	GFRC7AM	FV	FVSkey_ie_WRD_h9rl	640	CE-SF8AL, CE-SF8AM
SW	GFRC7AM	FV	FVSkey_ie_WRD_h9rm	640	CE-SF8AL, CE-SF8AM
SW	GFRC9AH	FV	FVSkey_ie_WRD_h9rh	590	---
SW	GFRC9AL	FV	FVSkey_ie_WRD_h9rh	170	---
SW	GFRC9AM	FV	FVSkey_ie_WRD_h9rh	280	---
SW	GFRC9LH	FV	FVSkey_ie_WRD_h9rh	590	---
SW	GFRC9LL	FV	FVSkey_ie_WRD_h9rh	170	---
SW	GFRC9LM	FV	FVSkey_ie_WRD_h9rh	280	CE-SF8LL, CE-SF8LM
SW	LP7AH	FV	FVSkey_ie_WRD_h2rm	590	---
SW	LP7AL	FV	FVSkey_ie_WRD_h2rm	280	CE-SF8LM, CE-SF9AL, CE-SF9AM
SW	LP7AM	FV	FVSkey_ie_WRD_h2rm	250	SW-PPDF8LM
SW	LP8AH	FV	FVSkey_ie_WRD_h2rm	590	SW-SFC7AL
SW	LP8AL	FV	FVSkey_ie_WRD_h2rm	280	EA-LP7AH, EA-LP7AL, EA-LP7AM, EA-LP7LL
SW	LP8AM	FV	FVSkey_ie_WRD_h2rm	250	EA-LP7LM, EA-LP8AH, EA-LP8AL
SW	NS6NH	FV	FVSkey_ie_WRD_h2rl	310	---
SW	NS6NH	FV	FVSkey_ie_WRD_h2rm	310	---
SW	NS6NH	FV	FVSkey_ie_WRD_h5rl	310	---
SW	NS6NL	FV	FVSkey_ie_WRD_h2rl	170	---
SW	NS6NL	FV	FVSkey_ie_WRD_h2rm	170	---
SW	NS6NL	FV	FVSkey_ie_WRD_h5rl	170	---
SW	NS6NM	FV	FVSkey_ie_WRD_h2rl	280	---
SW	NS6NM	FV	FVSkey_ie_WRD_h2rm	280	---
SW	NS6NM	FV	FVSkey_ie_WRD_h5rl	280	---

Land Office	Stratum	FVS			Substitution For:
		Variant	keyfile	Habitat	
SW	OGW1W1L	FV	FVSkey_ie_WRD_h2rl	170	---
SW	OGW1W1L	FV	FVSkey_ie_WRD_h2rm	170	---
SW	OGW1W1L	FV	FVSkey_ie_WRD_h2rm	170	---
SW	OGW1W1M	FV	FVSkey_ie_WRD_h2rl	280	---
SW	OGW1W1M	FV	FVSkey_ie_WRD_h2rm	280	---
SW	OGW1W1M	FV	FVSkey_ie_WRD_h2rm	280	---
SW	OGW4W4H	FV	FVSkey_ie_WRD_h7rm	520	---
SW	OGW4W4H	FV	FVSkey_ie_WRD_h9rl	520	---
SW	OGW4W4H	FV	FVSkey_ie_WRD_h9rm	520	---
SW	OGW4W4M	FV	FVSkey_ie_WRD_h7rm	660	---
SW	OGW4W4M	FV	FVSkey_ie_WRD_h9rl	660	---
SW	OGW4W4M	FV	FVSkey_ie_WRD_h9rm	660	---
SW	OGW6W6H	FV	FVSkey_ie_WRD_h9rm	670	---
SW	OGW6W6L	FV	FVSkey_ie_WRD_h9rm	830	---
SW	OGW6W6M	FV	FVSkey_ie_WRD_h9rm	690	---
SW	PPDF7AH	FV	FVSkey_ie_WRD_h2rl	310	---
SW	PPDF7AH	FV	FVSkey_ie_WRD_h2rm	310	---
SW	PPDF7AL	FV	FVSkey_ie_WRD_h2rl	170	---
SW	PPDF7AL	FV	FVSkey_ie_WRD_h2rm	170	---
SW	PPDF7AM	FV	FVSkey_ie_WRD_h2rl	280	---
SW	PPDF7AM	FV	FVSkey_ie_WRD_h2rm	280	---
SW	PPDF7LH	FV	FVSkey_ie_WRD_h2rl	310	---
SW	PPDF7LL	FV	FVSkey_ie_WRD_h2rl	170	---
SW	PPDF7LM	FV	FVSkey_ie_WRD_h2rl	280	---
SW	PPDF8AH	FV	FVSkey_ie_WRD_h2rl	520	---
SW	PPDF8AL	FV	FVSkey_ie_WRD_h2rl	280	EA-LP8AM, EA-LP8LL
SW	PPDF8AM	FV	FVSkey_ie_WRD_h2rl	310	---
SW	PPDF9AH	FV	FVSkey_ie_WRD_h2rl	310	---

Land Office	Stratum	FVS			Substitution For:
		Variant	keyfile	Habitat	
SW	PPDF9AL	FV	FVSkey_ie_WRD_h2rl	170	---
SW	PPDF9AM	FV	FVSkey_ie_WRD_h2rl	280	---
SW	PPDF9LH	FV	FVSkey_ie_WRD_h2rl	310	SW-SFM8LM
SW	PPDF9LL	FV	FVSkey_ie_WRD_h2rl	170	---
SW	PPDF9LM	FV	FVSkey_ie_WRD_h2rl	280	SW-SFM9AH
SW	SFC7AL	FV	FVSkey_ie_WRD_h9rm	830	---

20 Appendix M: Strata Starting Age

Age is difficult to determine stands on DNRC land, since most of them are uneven-aged. However, age is an important element in structuring the management pathway and compiling the linear programming model; therefore a starting age was assigned to each stratum by land office, size class, and productivity class as shown in Table 32.

Table 32: Starting Age by Land Office, Size and Productivity Class

Land Office	Size	Productivity Class		
		Low	Medium	High
CE	6	0	0	0
CE	7	15	15	0
CE	8	65	65	0
CE	9	115	115	115
EA	6	0	0	0
EA	7	15	15	0
EA	8	55	55	0
EA	9	95	95	0
NW	6	0	0	0
NW	7	35	25	15
NW	8	65	55	45
NW	9	115	115	115
NW	W1	155	155	---
NW	W4	---	155	155
NW	W6	165	165	165
SW	6	0	0	0
SW	7	15	15	15
SW	8	55	55	55
SW	9	115	115	115
SW	W1	155	145	---
SW	W4	---	155	155
SW	W6	165	165	165

21 Appendix N: Wildlife Habitat Constraints

The DNRC has an obligation towards maintaining and creating habitat for various wildlife species through a number of administrative rules. The following tables list the constraints applied or considered, along with the relevant ARMs and HCP commitments, as well as the rationale behind their inclusion or exclusion from the modeling effort.

Table 33: Wildlife Constraints Developed from Forest Management ARM's and DNRC HCP

Species	**ARM or HCP Measures**	**Constraint Description Summary**	**Related Data Available**	**Geographic Area Applicable**	**Notes**
Grizzly Bear	HCP, GB-PR6 also east side land offices covered under rule: 36.11.434(1)(d)	Hiding cover in riparian areas -- Apply constraints for riparian harvest strategy. All RMZs associated with class 1 streams deferred.	Stream layer(s) and SLI stand data	All forest lands including both HCP and non-HCP lands	Constraint parameters are those defined for aquatic buffers -- taken out of commercial SLI acres and not included as operable. All Class 1 aquatic buffers deferred. Widths: 120 ft. SWN, STW, LIB; 100 ft. MSLA, KU, CLW, PLNS, HAM; 80 ft. East Side and ANA. Class 2 and 3 -- 25 ft. deferrals with the remaining 25 ft. of the 50 ft. buffer harvested.
Grizzly Bear	HCP, GB-RZ2	100 ft. Visual Screening buffers along open roads -- no clear-cut or seed-tree treatments may occur in these buffers.	Road layer, SLI stand data, recovery zone boundary, and NROH CYE boundary	All Recovery Zone lands and CYE NROH.	No notes
Grizzly Bear	ARM 36.11.432(1)(d)	34,363 commercial acres of Core deferred from harvest.	Grizzly Bear Core polygon layer and SLI stand data	Stillwater Block	No notes
Canada Lynx	HCP, LY-HB2(2) and ARM 36.11.411	In lynx habitat, retain average of 2 snags and 2 live recruitment tree/acre >21 inches DBH on warm and moist, and wet habitat type groups; and 1 snags and 1 live recruitment tree/acre.	SLI stand data and/or forest stand polygon layer.	All forested state trust lands	Uses constraint approach similar to 2004. Base constraint on expected trees/ac and volume retained in live recruitment trees by prescription applied in model. Constraint applied to green trees given high defect in most large, dead snags that are retained.

Species	ARM or HCP Measures	Constraint Description Summary	Related Data Available	Geographic Area Applicable	Notes
Canada Lynx	HCP, LY-HB6	At each Land Office, retain at least 65% total potential class lynx habitat in the suitable habitat condition. Suitable habitat consists of stands in appropriate habitat types that possess at least 40% total canopy closure in sapling, pole and/or saw-timber classes.	Modeled lynx habitat fields in SLI and forest stand polygon layer.	All forested scattered lands outside of lynx LMA's	Because the model could not grow canopy cover for in-growth over time in a manner that would closely reflect reality, a basal area requirement of 60 square feet was used in lieu of the 40% canopy cover requirement.
Canada Lynx	HCP, LY-LM1	At scale of each LMA, retain at least 65% total potential class lynx habitat in the suitable habitat condition. Suitable habitat consists of stands in appropriate habitat types that possess at least 40% total canopy closure in sapling, pole and/or saw-timber classes.	Modeled lynx habitat fields in SLI and forest stand polygon layer, and LMA polygon layer.	Applies to lynx habitat on DNRC lands within lynx LMA's	Because the model could not grow canopy cover for in-growth over time in a manner that would closely reflect reality, a basal area requirement of 60 was used in lieu of the 40% canopy cover requirement.
Canada Lynx	HCP, LY-LM2	No more than 15% of total potential habitat class may be converted to non-suitable class in each decade.	Modeled lynx habitat fields in SLI and forest stand polygon layer, and LMA polygon layer.	Applies to lynx habitat on DNRC lands within lynx LMA's	Also viewed as a limit on even-aged harvest acres per decade. Once that limit is hit, only uneven-aged regimes can be selected.

Species	ARM or HCP Measures	Constraint Description Summary	Related Data Available	Geographic Area Applicable	Notes
Canada Lynx	HCP, LY-LM3(1)	At scale of each LMA, retain at least 20% total potential class lynx habitat in the winter foraging habitat condition. Winter foraging habitat consists of saw-timber stands that possess at least 40% total stand canopy closure and contain AF, SP, and/or GF.	Modeled lynx habitat fields in SLI and forest stand polygon layer, and LMA polygon layer.	Applies to lynx habitat on DNRC lands within lynx LMA's	Because the model could not grow canopy cover for in-growth over time in a manner that would closely reflect reality, a basal area requirement of 60 was used in lieu of the 40% canopy cover requirement.
Canada Lynx	ITP constraint	No more than 1,200 acres of lynx habitat can be pre-commercially thinned annually.	Modeled lynx habitat fields in SLI and forest stand polygon layer, and LMA polygon layer.	Applies to lynx habitat on DNRC lands within lynx LMA's	No notes
Bald Eagle	36.11.429 (1)(c)(ii) and (d)(ii)	Allow no harvest prescriptions that would result in residual basal areas lower than 60 sq. feet.	Nest tree point locations and SLI data	Buffer out from nest point to 800m on DNRC lands.	This simplified constraint requires a moderate threshold of cover retention across the entire primary use area. This approach "averages" the harvest across the entire 800m buffer area and would take into account required heavy retention in nest site areas, but allows for more volume removal at greater distance from the nest site area.

Species	ARM or HCP Measures	Constraint Description Summary	Related Data Available	Geographic Area Applicable	Notes
Snags	36.11.411	Retain average of 2 snags and 2 live recruitment tree/acre >21 inches DBH on warm and moist, and wet habitat type groups; and 1 snags and 1 live recruitment tree/acre.	NA	NA	Uses constraint approach similar to 2004. Base constraint on expected trees/ac and volume retained in live recruitment trees by prescription applied in model. Constraint applied to green trees given high defect in most large, dead snags that are retained.

Table 34: Species and Associated Conservation Measures Not Considered

Species	ARM or HCP Measures	Constraint Description Summary	Related Data Available	Geographic Area Applicable	Notes
Grizzly Bear	HCP, GB-ST2	19,000 acres of class A lands under 4 year active/8 year rest mgmt.	Class A lands polygon layer and SLI stand data	Stillwater Block	A constraint for this requirement was not applied in 2015 or 2004. The SYC team discussed the need for a constraint to address HCP, GB-ST2 and concluded that given the presence of interspersed deferred acres in these zones and ability to manage in commercial 4-year windows, no constraint was necessary.
Grizzly Bear	ARM 36.11.431(1)(a)	55,000 of grizzly bear management units under 3 year active/6 year rest mgmt.	Grizzly bear subunit polygon layer and SLI stand data	Swan River State Forest	Did not include a constraint for this in 2015 or 2004. The SYC team discussed the need for a constraint to address this ARM and concluded that given the ability to manage in commercial 3-year windows

Species	ARM or HCP Measures	Constraint Description Summary	Related Data Available	Geographic Area Applicable	Notes
					and winter period, no constraint was necessary.
Grizzly Bear	HCP, GB-SC2	33,300 acres of scattered parcels in recovery zones and CYE NROH under 4 year active/8 year rest mgmt.	Scattered parcels recovery zone layer, CYE NROH, and SLI stand data	All HCP scattered lands in recovery zones and CYE NROH	The SYC team discussed the need for a constraint to address HCP, GB-SC2 and concluded that given the ability to manage in commercial 4-year windows and winter period, no constraint was necessary. The smaller geographic area of "a parcel" compared to a larger subunit makes it inherently less necessary to revisit a section within an 8 year rest window.
Canada Lynx	HCP, LY-HB5 and Fisher ARM 36.11.440(c)	Provide for habitat connectivity of mature forest cover across 3rd order drainages.	DEM, SLI stand data, forest stand polygon layer.	Ridgetops associated with DNRC forest land.	Considerable subjective analysis would be required for a minimal number of acres constrained. The team concluded that this measure typically would be met in deferrals, RMZs, and through application of allowable prescription percentages by cover type.

Species	ARM or HCP Measures	Constraint Description Summary	Related Data Available	Geographic Area Applicable	Notes
Canada Lynx	HCP, LY-LM3(2)	For any treated PCT stand in lynx habitat in LMAs, retain 20% of each project area (i.e., total of all PCT units identified for treatment) in an un-thinned condition until they meet saw-timber size class.	Modeled lynx habitat fields in SLI and forest stand polygon layer, and LMA polygon layer.	Applies to lynx habitat on DNRC lands within lynx LMA's	This constraint was deemed unnecessary given that annual budgetary constraints have a predominant functional limit on thinning in DNRC's program. Also, PCT would be allowed unconstrained on all non-lynx forest types, and the minor acreages of retained patches were deemed to have minimal influence on long-term yield.
Fisher	36.11.440	Apply constraints for riparian harvest strategy, old growth, and snags to cover this species. All RMZs associated with class 1 streams deferred.	NA	NA	Addressed through coarse filter management and general application of allowable harvest regimes, riparian harvest strategies, and snag requirements. No additional specific constraint required.
Flammulated Owl	36.11.437	No Constraint Necessary	NA	NA	Addressed through coarse filter management, old growth, and general application of allowable harvest regimes and snag requirements.
Black-Backed Woodpecker	36.11.438	No Constraint Necessary	NA	NA	Addressed through coarse filter management and general application of allowable harvest regimes. The measure is typically met by retaining desirable live and dead trees in burned areas

Species	ARM or HCP Measures	Constraint Description Summary	Related Data Available	Geographic Area Applicable	Notes
					and intensively burned acreages on inoperable or deferred ground.
Pileated Woodpecker	36.11.439	No Constraint Necessary	NA	NA	Addressed through coarse filter management, old growth, and general application of allowable harvest prescriptions by cover type and snag requirements.
Common Loon	36.11.441	No Constraint Necessary	NA	NA	Harvest-related mitigation requirements are rare and affect a very small number of acres annually on average (i.e., <50 ac per yr.).
Peregrine Falcon	36.11.442	No Constraint Necessary	NA	NA	Harvest-related mitigation requirements are rare and affect a very small number of acres annually on average (i.e., <50 ac per yr.).
Gray Wolf	36.11.430	No Constraint Necessary	NA	NA	No specific forest cover requirements for this species.
Wolverine	n/a	No Constraint Necessary	NA	NA	No specific forest cover requirements for this species, and most limiting habitat areas are relatively non-forested, high elevation zones with persistent snow late into spring.

Species	ARM or HCP Measures	Constraint Description Summary	Related Data Available	Geographic Area Applicable	Notes
Yellow-Billed Cuckoo	n/a	No Constraint Necessary	NA	NA	Suitable habitat for this species in Montana is comprised of cottonwood river bottoms where active timber harvest is not economical and is generally prohibited.
Big Game	36.11.443	No Constraint Necessary	NA	NA	Addressed through coarse filter management and general application of allowable harvest prescriptions by cover type.

22 Appendix O: Growth Rates by Land Office

In this section, the estimated growth rates in board feet per acre per year determined by the calculation are displayed for each Land Office   Growth rates from other published sources are also included for purposes of comparison.

Table 35: Estimated and Historic Growth Rates (bf/ac/yr)

Area	2020 SYC Grow Only	2020 SYC Bio Gross	2014 FIA[25]	1989 FIA[26]	Timber Resources Publications[27]
Statewide	123	123	72	126	111
NW	171	176	129	151	146
SW	117	105	51	148	97
CE	52	72	10	53	97
EA	85	73	60	90	69

[25] Figures shown are for growing stock on State and Local Government ownership; data queried from USFS Forest Inventory and Analysis (FIA), Forest Inventory Data Online (FIDO)

[26] Figures shown are for growing stock on State and Local Government ownership; data queried from USFS Forest Inventory and Analysis (FIA), Forest Inventory Data Online (FIDO)

[27] Figures shown are average annual net growth per acre for State/Other Public ownership reported in the following publications: NW—Timber Resources of Lincoln, Sanders, Flathead, and Lake Counties, Montana Dept. of State Lands, Forestry Division, and Forest Survey, Intermountain Forest and Range Experiment Station, Region 1, USDA Forest Service, 1982; SW—Timber Resources of Mineral, Missoula, and Ravalli Counties, Montana Dept. of State Lands, Forestry Division and Forest Survey, Intermountain Forest and Range Experiment Station, Region 1, USDA Forest Service, 1983; CE—Timber Resources of the Headwater Counties, Montana Dept. of State Lands, Forestry Division and Forest Survey, Intermountain Forest and Range Experiment Station, Region 1, USDA Forest Service, 1984; EA—Timber Resources of Eastern Montana, Montana Dept. of State Lands, Forestry Division and Forest Survey, Intermountain Forest and Range Experiment Station, Region 1, USDA Forest Service, 1984.

23 Appendix P: Map of Commercial Forest Acres Included in the Calculation

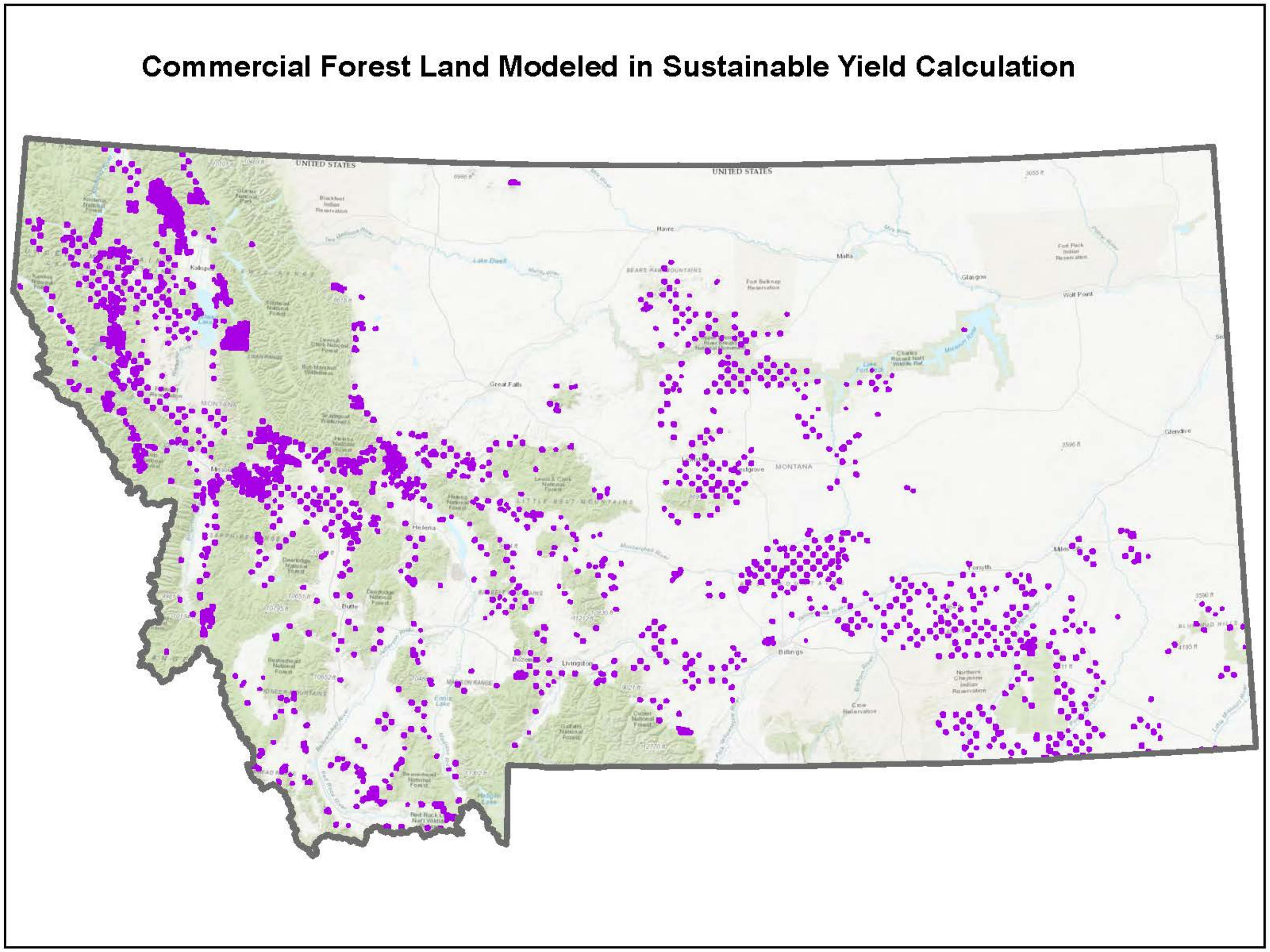

Figure 58: Location of Commercial Forest Acres Included in the Calculation