State of Montana
Department of Fish, Wildlife, and Parks

2013 Forest Inventory and Sustained Yield Calculation

Prepared by:
Mason, Bruce & Girard, Inc

December 31, 2013

[Page Intentionally Left Blank]

Table of Contents

Tables and Figures

Tables

Figures

Appendices

Glossary and Abbreviations

Analysis Unit (AU) - A set of non-contiguous parcels of land, homogenous with respect to factors that affect outputs, costs, revenues, management choices, and management opportunities.

Basal Area - The area, expressed in square feet, of the bole of the trees on an acre at breast height.

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.

Crown Ratio – the ratio of tree crown (live) length to the tree's total height.

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

DNRC - The Montana Department of Natural Resources and Conservation.

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

Forest Management Model - A linear programming model developed to calculate the sustainable yield, given management objectives and constraints.

FVS – Growth and yield model called Forest Vegetation Simulator that is developed and maintained by the U.S. Forest Service

GIS - Geographic Information System – a computer-based tool used to store, analyze and report spatial data.

Linear Programming - A mathematical technique used to find an optimal solution, given many choices, a defined objective, and constraints that limit available choices.

Long-term sustainable yield – the sustainable yield (see definition for Sustainable Yield) on MT-FWP lands during the last 100 years of the planning horizon.

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 planting, natural regeneration, precommercial thinning, commercial thinning, final harvest, partial cutting, etc.

Mbf - Thousand board feet; **MMbf** – million board feet; **Bbf** – Billion board feet, all in Scribner measure. These are measures of timber volume. A log truck typically carries 4-5 Mbf.

MT-FWP – Montana Department of Fish, Wildlife, and Parks.

Net Present Value (NPV) - The value of future cash flows, discounted to the present using a discount rate.

Q-factor – describes the ratio of the number of trees in one diameter class in relation to the number of trees in the previous diameter class.

Short-term sustainable yield – the sustainable yield (see definition for Sustainable Yield) on MT-FWP lands during the first 50 years of the planning horizon.

Site Index - A measure of the productivity of timberland. Expressed in terms of the height of dominant Douglas-fir trees at age 50. A site index of 75, for example, means that 50-year old Douglas-fir trees would be expected to be 75 feet tall.

Sustainable yield "…the quantity of timber that can be harvested from forested department lands each year, taking into account the ability of forested lands to generate replacement tree growth and in accordance with (a) the provisions of MCA 87-1-201 (9)(a)(iv);(b) state and federal laws, including but not limited to the laws pertaining to wildlife, recreation, and maintenance of watershed; and (c) water quality standards that protect fisheries and aquatic life and that are adopted under the provisions of Title 75, Chapter 5." MCA 87-1-201 and 87-1-621

Timber stand - A tract of forest land relatively homogenous with respect to species mix, size and stocking of tree species.

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

Uneven-aged management – A management regime that does not have a final harvest. The stand will contain trees of two or more age classes. New trees are regenerated under a canopy of older trees.

USFS – United States Forest Service

Acknowledgments

MB&G would like to extend appreciation for the hard work and valuable insight provided by the dedicated professionals of the Montana Department of Fish, Wildlife, and Parks. We are especially grateful for Rick Northrup's guidance throughout the process as well as the input from Allan Kuser and Roger Semler. We also appreciate the MT-FWP staff who took an active role in translating their management objectives to us, provided important insight related to specific management areas, and offered their assistance to our field inventory crews.

We further acknowledge and appreciate the members of our project team for their hard work and collective professional experience and knowledge that made the completion of this study possible. Brian Long, of BDL Forestry, LLC., completed a majority of the photo interpretation work across 360,000 acres of MT-FWP land and continued to offer valuable insight throughout the project. Cougar Environmental, Inc. conducted a forest inventory across the state of Montana that was well executed in a timely manner. Peter Sawyer, of Sawyer Consulting, LLC., conducted valuable forest inventory work throughout the state. We appreciate the help of everyone involved in this study.

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

Executive Summary

In 2011, Montana's 62nd Legislature passed House Bill 619 (since codified in 87-1-201 and 87-1-621, MCA), which revised MT-FWP's forest management laws by requiring the calculation of an annual sustained yield on MT-FWP lands. Pursuant to this law, MT-FWP contracted with Mason, Bruce and Girard, Inc. to perform a forest inventory and an annual sustained yield calculation on the Department's forest land.

Approximately 360,000 acres of MT-FWP land was included in this study and from that, about 151,000 acres are considered to have potential commercial value. From that commercial forest land base, about 57,000 acres are available for harvest and it is these acres that contribute to the annual sustained yield calculation.

Currently, the timber inventory on those 57,000 acres is approximately 272 million board feet (MMbf). Available acres and timber volume are distributed across the state as follows:

Acres and Timber Volumes included in annual sustained yield calculation

Region	Commercial Forested Acres	Commercial Forested Acres Available for Harvest	Timber Volume (Mbf) on Available Acres
1	10,986	8,227	55,302
2	81,831	37,875	152,437
3	46,337	10,171	60,011
4	11,426	659	3,609
5	896	472	794
7	-	-	-
Total	**151,477**	**57,403**	**272,153**

Growth and yield modeling utilized the forest inventory data, which was then incorporated into a Forest Management Model used to calculate the annual sustained yield. The model maximizes net present value of timber harvests while meeting constraints designed to reflect the legal and administrative policies, and management objectives of MT-FWP.

Sustained yield is typically thought of as the sustained harvest level that managed forest land can support over the long-term (50+ years). Because most of MT-FWP's forest land hasn't been in active management, many stands are currently either over-stocked or under-stocked. Due to the characteristics of these stands, this study provides a short-term and a long-term sustained yield. It is a usual and customary practice to express sustained yield in terms of an annual volume, and that convention is followed in this study. Harvest opportunities on several units, however, are small enough that the annual volume would not support a viable timber sale. Sales on those units are expected to be less frequent in order to have enough volume to make a viable timber sale.

In the short-term (<50 years), under-stocked stands will have less of a harvest as stands grow and reach a point in time where a commercial thin is appropriate. Alternatively, more harvest will be scheduled in over-stocked stands to bring them down to desired stocking levels. Over the long-term (>50 years), stands will eventually reach regulated stocking conditions resulting in a relatively consistent annual sustained yield moving forward through time.

With this in mind, the following table shows the short-term and long-term annual sustained yield on each management unit included in this study:

Region	Unit	Unit Type	Available Acres	Short-term SYC (Mbf/Year)	Long-term SYC (Mbf/Year)
1	Bull River	WMA	991	53	129
1	Kootenai/Falls	WMA	-	-	-
1	Kootenai/West	WMA	881	152	103
1	Kootenai/Woods Ranch	WMA	406	46	37
1	Mount Silcox	WMA	632	92	62
1	North Swan Valley	WMA	1,375	172	142
1	Ray Kuhns	WMA	954	120	94
1	Lake Mary Ronan	State Park	104	12	8
1	Lone Pine	State Park	215	30	19
1	Thompson Chain Of Lakes (East)	State Park	287	3	23
1	Thompson Chain Of Lakes (West)	State Park	1,300	107	119
1	Wayfarers	State Park	27	4	2
1	West Shore	State Park	86	10	9
1	Wild Horse Island	State Park	870	97	82
1	Kokanee Bend	FAS	47	2	4
1	Old Steel Bridge	FAS	-	-	-
1	Swan River	FAS	52	3	5
2	Blackfoot-Clearwater 1	WMA	1,438	133	110
2	Blackfoot-Clearwater/ Harpers Lake	WMA	6,686	440	364
2	Calf Creek	WMA	712	70	58
2	Fish Creek	WMA	9,763	341	321
2	Fish Creek	State Park	2,217	72	64
2	Garrity Mountain	WMA	3,360	88	368
2	Lost Creek	WMA + State Park	107	5	4
2	Marshall Creek	WMA	8,692	522	431
2	Mount Jumbo	WMA	99	6	5
2	Nevada Lake	WMA	396	36	19
2	Spotted Dog	WMA	-	-	-
2	Threemile	WMA	4,070	353	292
2	Beavertail Hill	State Park	-	-	-
2	Milltown	State Park	90	5	5
2	Erskine	FAS	-	-	-
2	Monture Creek	FAS	-	-	-
2	River Junction	FAS	44	4	2
2	Stuart Mill Bay	FAS	201	24	25
3	Canyon Creek	WMA	1,696	78	65
3	Fleecer Mountain	WMA	460	39	19

Region	Unit	Unit Type	Available Acres	Short-term SYC (Mbf/Year)	Long-term SYC (Mbf/Year)
3	Gallatin	WMA	-	-	-
3	Madison-Bear Creek	WMA	-	-	-
3	Madison-Wall Creek	WMA	-	-	-
3	Mt. Haggin	WMA	7,632	913	589
3	Robb-Ledford	WMA	-	-	-
3	Bannack	State Park	-	-	-
3	Lewis And Clark Caverns	State Park	383	27	16
3	Missouri Headwaters	State Park	-	-	-
4	Beartooth	WMA	-	-	-
4	Beckman	WMA	-	-	-
4	Blackleaf	WMA	-	-	-
4	Ear Mountain	WMA	-	-	-
4	Judith River	WMA	-	-	-
4	Marias River	WMA	-	-	-
4	Smith River/Fort Logan	WMA	-	-	-
4	Sun River	WMA	-	-	-
4	Sun River 2	WMA	-	-	-
4	Sluice Boxes	State Park	414	24	16
4	Smith River (Central)	State Park	166	13	6
4	Smith River (North)	State Park	-	-	-
4	Smith River (South)	State Park	78	6	3
4	Tower Rock	State Park	-	-	-
5	Haymaker	WMA	472	3	4
5	Silver Run	WMA	-	-	-
5	Yellowstone	WMA	-	-	-
7	Isaac Homestead	WMA	-	-	-
7	Makoshika	State Park	-	-	-
Total			**57,403**	**4,105**	**3,624**

Across the entire state, on acres available for harvest, this study calculated the total annual sustained yield in the short-term to be **4.1 million board feet per year** and **3.6 million board feet per year** in the long-term. These sustained yield calculations meet the intent of the enacted legislation as well as the policies, goals, and objectives specified by the Montana Department of Fish, Wildlife, and Parks. The results presented above represent the annual sustained yield on commercial forested acres available for harvest as determined by MT-FWP. This study also calculated the maximum biological yield and annual sustained yield on all commercial forested and operable acres. Those results are found within the body of this report.

It is important to realize that this plan represents a strategic level plan and is intended to establish guiding harvest levels. Implementing a plan like this would require another layer of planning, which would consider the operational issues associated with harvesting and could result in a harvest schedule different from the one presented here.

The following sections of this report explain the methods and rationale for this annual sustained yield calculation for MT-FWP.

Chapter 1: Purpose & Need

Marshall Creek Wildlife Management Area (view of Marshall Lake)

Purpose of Montana Fish, Wildlife, & Parks Lands

The State of Montana's Department of Fish, Wildlife, & Parks (MT-FWP) manages approximately 422,000 acres of land in fee title across the state with a broad mission to provide for the stewardship of the fish, wildlife, parks, and recreational resources of Montana. MT-FWP works towards its mission through three management divisions: (1) Wildlife; (2) Fisheries; and (3) Parks.

The Wildlife Division is responsible for the state's Wildlife Management Areas. These land holdings were acquired by the state to provide for high priority wildlife habitat and, secondarily, for public hunting and other forms of outdoor recreation.

Fishing Access Sites are administered by the Fisheries Division. The primary function/mission of the Fishing Access Site program is to provide public access to Montana's streams and lakes for the purpose of enhancing opportunities for angling and other water based recreation.

The Parks Division manages Montana's State Parks and is responsible for conserving the scenic, historic, archeological, scientific, and recreational resources of the state and providing for their use and enjoyment.

MT-FWP classifies its forest land based on the following ecological settings and associated wildlife habitat values:

- Riparian Forest: high value for a variety of wildlife and fisheries, bank stability, habitat diversity, and travel corridors.

- Mountain Foothill Big Game Winter Range: critical winter habitats; forests provide security, thermal protection, bedding, and travel routes.

- Forested Big Game Winter Range: critical forests of deep snow areas in western Montana – forests provide snow capture, forage, cover, and thermal protection.

- Upper Elevation Forests; forests provide a variety of wildlife habitat functions, depending on location, including security, travel corridors, big game summer range, and year-round furbearer habitat.

- Aspen Forests: key function for a variety of species (e.g., ruffed grouse, species of song birds, important browse for big game, etc.), seasonal wildlife habitat value for a broad mix of species.

The Need for a Sustainable Yield Calculation

In 2011, Montana's 62nd Legislature passed House Bill 619 (since codified in 87-1-201 and 87-1-621, MCA[1]), which revised MT-FWP's forest management laws by requiring the calculation of an annual sustained yield on MT-FWP lands.

MCA 87-1-201 and 87-1-621 (Appendix A) defines "annual sustained yield" as:

> *"…the quantity of timber that can be harvested from forested department lands each year, taking into account the ability of forested lands to generate replacement tree growth and in accordance with*
>
> *a. the provisions of MCA 87-1-201 (9)(a)(iv);*
> *b. state and federal laws, including but not limited to the laws pertaining to wildlife, recreation, and maintenance of watershed; and*
> *c. water quality standards that protect fisheries and aquatic life and that are adopted under the provisions of Title 75, Chapter 5."*

MT-FWP contracted with Mason, Bruce & Girard, Inc. (MB&G) to conduct a sustainable yield study to calculate the annual sustained yield required by legislation. Established in 1921, MB&G is a natural resource consulting firm located in Portland, Oregon. MB&G has performed similar calculations for a variety of federal, state, private, and tribal landowners across the United States. MB&G formed a team of forestry professionals including Brian Long (BDL Forestry, LLC. of Missoula, MT), Cougar Environmental, Inc. of Naples, ID, and Peter Sawyer (Sawyer Consulting, LLC. of Virginia City, MT) who worked closely with MT-FWP staff through the course of this project.

Uses & Limitations

The sustained yield calculation resulting from this study is based on a great deal of spatial and tabular data about MT-FWP's forested land base. Some of the data are site specific, other data are more generalized. A Forest Management Model was designed to reflect the management objectives of MT-FWP while conforming to all the applicable laws and regulations. Specifically, the model was designed to provide a reasonable and defensible estimate of:

- An annual sustainable harvest level from MT-FWP's forest land.
- A projection of forest conditions across MT-FWP's forest land.

MB&G urges managers and stakeholders to consider the strategic nature of this study when using and interpreting the annual sustained yield. The Forest Management Model was not designed to address tactical or operational questions.[2]

[1] MCA – Montana Code Annotated

[2] Strategic questions: How can MT-FWP manage its forest land to meet a range of objectives? What kinds of management regimes are most compatible with those objectives?
Tactical questions: Which roads should we build and which stands should we harvest first?
Operational questions: Where should the landings go? To what degree are temporary roads closed after harvest?

[Page Left Intentionally Blank]

Chapter 2: Forest Inventory Methodology

Monture Creek Fishing Access Site

MT-FWP divides its land base into seven administrative regions across the state and management units with a minimum of 50 contiguous acres of forest cover were included in this study. Across the entire state, 64 units met this criterion and make up approximately 360,000 acres.

As a first step in developing a Forest Management Model to calculate the annual sustained yield on these 360,000 acres, a comprehensive forest inventory was conducted to collect forest resource information.

No prior forest inventory data exists for MT-FWP land and as such, the following tasks were performed to build a stand-level inventory of the 360,000 acres included in this study:

1. Stand delineation
2. Stand typing
3. Forest inventory design & implementation
4. Forest inventory data compilation

The following sections provide the study's methodology, process, and procedures in completing the forest inventory tasks to MT-FWP specifications.

Section 2.1: Timber Stand Delineation

A timber stand is, ideally, a tract of land that is homogenous with respect to key descriptors or timber quality and quantity. The more homogenous the stand, the greater the confidence in current and future projections of stand conditions, habitat attributes, timber volumes and values. In practice, there is a tradeoff between homogeneity and management practicality – very homogenous stands might be very small, meaning there is a very large number of stands. This is especially true of uneven aged stands, both managed and unmanaged. There is often a gradient of differences between areas, rather than sharp distinctions.

With these considerations, a semi-automated approach was employed to stand delineation that couples state of the art image processing software with high resolution data sets (NAIP 2011 and NAIP 2009) and foresters with extensive experience in Montana to delineate individual stand polygons.

First, Trimble's eCognition software was used to delineate the imagery into spectrally unique objects. Similar to the manual delineation of timber stands in more traditional photo interpretation, the eCognition software delineates digital imagery into polygons (stands) of pixels that have more spectral variation between than within polygons. Secondly, remote sensing analysts and field foresters refined the automated image segments for each management unit to ensure that the stand lines met MT-FWP goals. This process allowed for the creation of stand delineation maps across the entire 360,000 acres that are more accurate, contain a greater level of detail and have greater consistency than stand delineation maps produced by the traditional manual photo interpretation approach. In all, about 20,400 stands were delineated throughout this process.

Figures 2.1-1 and 2.1-2 show an example of the 2011 NAIP imagery and final stand delineation in a portion of the Mt. Haggin WMA.

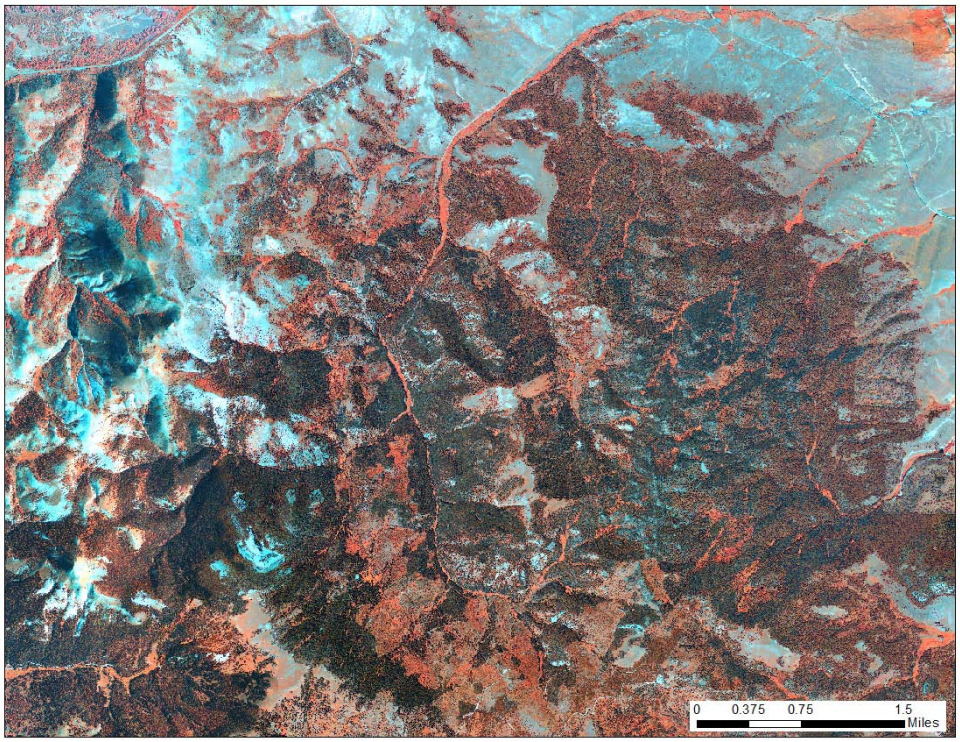

Figure 2.1-1: 2011 Infrared NAIP image of a portion of the MT. Haggin WMA, prior to stand delineation

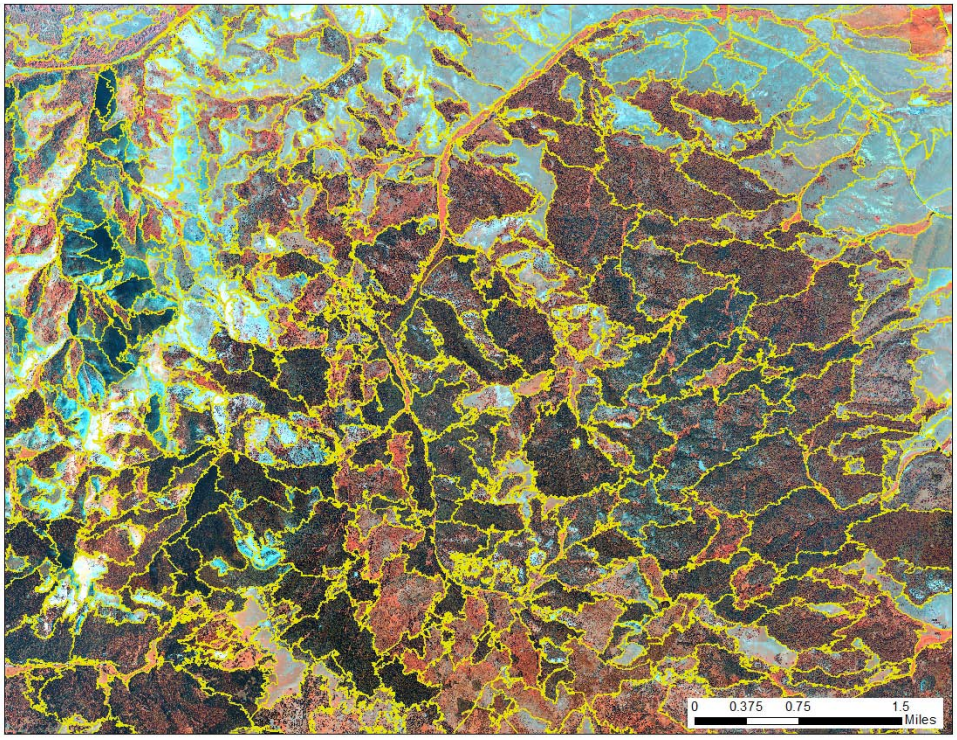

Figure 2.1-2: 2011 Infrared NAIP image of a portion of the MT. Haggin WMA, after stand delineation

Section 2.2: Timber Stand Typing

After completing the initial stand delineation process described above, all stands were assigned a timber type using photo-interpretation. Photo interpretation was conducted by field foresters familiar with Montana's tree species distribution across the state. Each delineated stand was typed with respect to its species mix, size of trees, and the general stocking of trees based on standing trees with live crowns.

A description of the timber typing criteria is show in Table 2.2-1, below.

Table 2.2-1: Timber typing criteria used to type MT-FWP delineated stands

Species ID: Stand contains 50% or more of the tree species or species mix.	Size Class ID	Stocking ID
DF = Douglas-fir	1 = Nonstocked	1 = Poor , <10% crown cover
PP = Ponderosa pine	2 = Seedling/Sapling	2 = Low, 10-25% crown cover
LP = Lodgepole pine	3 = Pole 4-7" DBH	3 = Medium 26-50% crown cover
MM = Mixed conifer moist and/or relatively warm – Stands contains 50% or more of the following mix of species. (westside: western redcedar, western hemlock, grand fir, Engelmann spruce, subalpine fir, mid to lower elevation mix) (eastside: mostly riparian areas with Engelmann spruce, other conifers, and sometimes subalpine fir)	4 = Sawtimber 8+"DBH	4 = Medium High 50-75% crown cover
		5 = High > 75% crown cover
MC = Mixed conifer moderately dry – Stands contain 50% or more of the following mix of species. (westside: mostly Douglas-fir, western larch, ponderosa pine, lodgepole pine, western white pine) (eastside: mostly Douglas-fir, ponderosa pine, lodgepole pine)		
SS = Spruce, subalpine fir (upper elevation subalpine and alpine forest type)		
NF = Noncommercial Forest (limber pine, juniper, whitebark pine, subalpine fir, subalpine larch, scrub ponderosa pine, scrub Douglas-fir)		
AS = Aspen		
HW = Hardwood species (cottonwood, river alder, green ash, etc)		
XX = Non Forest		
W = Water		

Appendix B shows the acres of each timber type within each administrative region.

Section 2.3: MT-FWP Forested Land Base

From the 360,000 acres of MT-FWP eligible for this study, about 151,000 acres are considered to be potential commercial forest land.[3] Table 2.3-1 shows the number of total acres and commercial forested acres for each management unit type (WMA, FAS, and State Park) by administrative region. Note that there are no MT-FWP units in Region 6 included in this study.

Table 2.3-1: MT-FWP land base on units with >=50 continuous acres of forest cover

Administrative Region & Unit Type	Number of Units	All Acres	Commercial Forested Acres
Region 1			
WMA	7	9,295	6,704
FAS	3	367	112
State Park	7	5,617	4,170
Region 2			
WMA	11	134,809	81,066
FAS	4	1,020	316
State Park	3	2,042	448
Region 3			
WMA	7	102,711	45,796
FAS	0	-	-
State Park	3	5,169	542
Region 4			
WMA	9	78,028	10,241
FAS	0	-	-
State Park	5	2,064	1,184
Region 5			
WMA	3	5,946	896
FAS	0	-	-
State Park	0	-	-
Region 7			
WMA	2	12,752	-
FAS	0	-	-
State Park	0	-	-
TOTAL	**64**	**359,820**	**151,447**

[3] Commercial forest land acres do not include aspen or other hardwood stands. These stands are typically considered non-commercial and would therefore, not contribute the annual sustained yield.

Section 2.4: Forest Inventory Design & Implementation

The forest inventory provides the data necessary to render timber volume and stand condition information, which forms the basis for the annual sustained yield calculation. To support credible projections of timber growth, the inventory was designed to collect a representative sample of plots in each timber type with commercial forest species. We did not install inventory plots in noncommercial forest, aspen, or hardwood species timber types. In addition, MB&G did not inventory certain management units primarily due to lack of commercial forest land. Appendix C shows a list of these management units.

In accordance with MT-FWP's inventory specifications, enough plots were established to meet the required allowable error. The Department specified that the inventory should provide a sampling error on both Scribner net board foot volume and total cubic foot volume of ±10% or less at the 90% confidence level for the sawtimber sized timber types, for each administrative region.[4] Sufficient plots were also established in the pole-sized and smaller categories to support the modeling effort.

At each plot, the inventory crew established two "nested" plots to sample trees and snags. A variable radius plot was used to sample live trees greater than or equal to 4.0 inches diameter at breast height (DBH) and a fixed area plot was used to sample trees greater than 1.0 foot tall and less than 4.0 inches DBH. On the variable radius plot, snag data was collected on any dead tree that had a DBH greater than 4.0 inches and was standing at an angle straighter than 45 degrees.

An important component of the forest inventory was timber-type verification by the inventory crew as stands were being inventoried, and of those stands walked through or driven through in the course of their inventory work. Timber types that were different in the field than from what was photo-interpreted were adjusted according to field observations. Finally, routine checks on the inventory crew were conducted to ensure that the data collection was consistent and accurate throughout the duration of the inventory. The Forest Inventory Design Specifications developed for this study have been provided to MT-FWP.

In total, 2,364 forest inventory plots on 151,000 acres typed as commercial forest land were established. Table 2.4-1, below, shows the number of plots for each administrative region.

Table 2.4-1: Number of forest inventory plots by administrative region

Administrative Region	Total Number of Inventory Plots
1	428
2	556
3	557
4	434
5	389
Total	**2,364**

Appendix C shows the number of plots in each timber type within each administrative region.

[4] See Appendix C for forest inventory statistics demonstrating MB&G's sampling intensity.

Section 2.5: Forest Inventory Information

The calculation of a sustained yield is based on projections about how timber stands will grow and change over time, under different management regimes. These projections also provide information about stand conditions that are important for understanding impacts on other resources (e.g. number of large trees per acre, species composition, crown closure, etc.).

Fundamental input to most growth and yield models is a "stand table" for each timber type. The stand table can be thought of as a summarized list of the trees in the stand. With information about the species, size, and number of trees in a stand, and any management applied to the stand, the growth model projects the stand into the future. The remainder of this section describes the process to derive stand tables to be input into the growth and yield model.

Deriving Average Stand Tables

The individual plot data for each timber type was grouped by administrative region and was compiled using MBGTools - a comprehensive software system for stand-based forest inventory data compilation and management. During this process, extensive data quality control was performed to ensure the plot data was recorded and compiled correctly. In addition, data checks were conducted to make sure that the plot data matched up to the intended stand and that the data characterized each stand's timber type. Finally, plots within each timber type by administrative region were averaged together using the MBGTools expander, resulting in average stand tables for each timber type in each administrative region. As an example, Table 2.5-1 shows several records from a stand table for a medium stocked Douglas-fir sawtimber (DF34) stand in Region 1.

Table 2.5-1: Several records from an average stand table for a DF34 timber type in Region 1

StandID	Species	DBH	TPA	HT	CRN
4	DF	1.2	2.50	8.00	50.00
4	DF	2.3	1.25	12.00	60.00
4	DF	3.1	2.50	19.50	40.00
4	DF	4.5	28.65	35.32	30.00
4	DF	5.4	18.33	43.75	30.00
4	DF	6.1	12.73	50.62	20.00
4	DF	9.1	2.83	54.90	20.00
4	DF	10.2	24.57	61.30	17.46
4	DF	11.8	9.47	67.02	26.00
4	DF	13.2	6.78	72.16	30.00
4	DF	16.1	1.79	80.85	30.00
4	DF	19.4	1.27	82.00	40.00
4	DF	25.2	0.37	105.00	40.00
4	DF	27.2	0.63	98.71	55.00
4	WL	11.4	1.89	72.00	60.00
4	WL	19.8	0.63	82.00	80.00
4	WL	20.4	1.15	100.00	30.00

Note: DBH = diameter-breast height, TPA = trees per acre, HT = tree height, CRN = crown ratio in percent

Each existing timber type was assigned an average stand table. In some cases, there was no plot data to make an exact match between average stand tables and the existing stands. In those cases, the next best match was selected based on similar timber types that had sufficient plots. This only occurred on a few timber types that represent a small number of acres. In all, plot data was collected on timber types that represent 97% of acres typed commercial forest land – a total of approximately 147,440 acres.

Stand tables for regenerated stands did not go through this process, since there was no plot data for MT-FWP lands in these types. Stand tables for these types were derived from previous work in Montana for the Department of Natural Resources and Conservation (DNRC). Montana DNRC has average stand tables for regenerated stands, which are based on large number of regeneration surveys and field observations.

The growth model and the Forest Management Model use stand age as a way to keep track of time and to schedule management activities. Stand age is sometimes a nebulous concept given that many stands contain trees with a wide range of ages. Tree age, furthermore, is a difficult and expensive measurement to collect. For the purposes of modeling, a stand age was assigned to each timber type based on the size class – as described below:

- Size Class 1 (non-stocked) = 10 years old
- Size Class 2 (seedlings and saplings) = 30 years old
- Size Class 3 (poles) = 50 years old
- Size Class 4 (sawtimber) = 80 years old

These ages should not be used to draw inferences about the "age" of the forest nor any age-based definitions for forest stage development or condition. They are simply used to track passage of time in the Forest Management Model.

Site productivity is another critical stand attribute for the growth model and Forest Management Model. Site productivity determines how fast trees of a certain timber type will grow through time. Site index was derived for each stand from the forest productivity GIS layer maintained by the Montana Department of Revenue.[5]

Using this layer, stands were assigned a site productivity class based on the class that represented the majority of acres within each stand. Each site productivity class represents a range of forest productivity, measured in board feet per acre per year.[6] Site index was then interpolated for each stand using the relationship between productivity and Douglas-fir site index (base age 50).[7]

With site index determined for each stand, stand tables were replicated for each timber type and its associated site indices. These became the initial stand tables grown forward with the growth model.

Table 2.5-2, below, shows how the site index values are assigned to each site productivity class.

[5] Zurring, Hans. 2008. Department of Revenue Forest Productivity Project. Contract #104-06. 6/30/2008.
[6] This measurement is called Culmination of Mean Annual Increment (CMAI).
[7] Zurring, 2008 includes a table showing the relationship between CMAI and Douglas-fir site index based on a Douglas-fir site index curve (base age 50) developed by Dr. Kelsey Milner.

Table 2.5-2: Interpolation of site index from site productivity

Site Class	Site Class Description	Site Productivity (Bf/acre/year)	Site Index (DF 50)
1	Excellent	> 400	85
2	Very good	325.1 - 400	68
3	Good	250.1 - 325	60
4	Average	175.1 - 250	55
5	Fair	100 - 175	48

As a final step in the process of deriving average stand tables, the growth model variant used for Region 1 required habitat types as a surrogate for site productivity, rather than site index. In this case, Habitat Types were assigned to each timber type based species and site index.[8]

Table 2.5-3 shows the associated Habitat Type for each timber type based on species and site index in Region 1.

Table 2.5-3: Region 1 – site index and associated habitat type codes

Species	Site Index	Habitat Description	Habitat Name
DF	48	PSME/FESC	Pseudotsuga menziesii/Festuca scabrelia
DF	55	PSME/PHMA	Pseudotsuga menziesii/Physocarpus malvceus
DF	60	PSME/CARU	Pseudotsuga menziesii/Calamagrostis rubescens
DF	68	PSME/VACA	Pseudotsuga menziesii/Vaccinium caespitosum
DF	85	ABGR/CLUN	Abies grandis/Clintonia uniflora
LP	48	PSME/VAGL	Pseudotsuga menziesii/Vaccinium globulare
LP	60	ABLA/MEFE	Abies lasiocarpa/Menziesia ferruginea
LP	68	THPL/CLUN	Thuja plicata/Clintonia uniflora
LP	85	ABLA/OPHO	Abies lasiocarpa/Oplopanax horridum
MC	48	PSME/VAGL	Pseudotsuga menziesii/Vaccinium globulare
MC	55	ABLA/VAGL	Abies lasiocarpa/Vaccinium globulare
MC	60	ABLA/XETE	Abies lasiocarpa/Xerophyllum tenax
MC	68	ABLA/CLUN	Abies lasiocarpa/Clintonia uniflora
MC	85	ABLA/OPHO	Abies lasiocarpa/Oplopanax horridum
MM	48	PSME/VAGL	Pseudotsuga menziesii/Vaccinium globulare
MM	55	PICEA/SMST	Picea/Smilacina stellata
MM	60	ABLA/LIBO	Abies lasiocarpa/Linnaea borealis
MM	68	ABLA/CLUN	Abies lasiocarpa/Clintonia uniflora
MM	85	ABLA/OPHO	Abies lasiocarpa/Oplopanax horridum
PP	48	PSME/FESC	Pseudotsuga menziesii/Festuca scabrelia
PP	55	PSME/PHMA	Pseudotsuga menziesii/Physocarpus malvceus
PP	60	PSME/CARU	Pseudotsuga menziesii/Calamagrostis rubescens
PP	68	ABGR/XETE	Abies lasiocarpa/Xerophyllum tenax
PP	85	ABGR/CLUN	Abies lasiocarpa/Clintonia uniflora

[8] Pfister, Robert D., B.L. Kovalchik, S.F. Arno, and R.C. Presby. 1977. Forest Habitat Types of Montana. Gen. Tech. Rep. INT-GTR-34. Ogden, UT. US Department of Agriculture, Forest Service, Intermountain Forest & Range Experiment Station. 174p.

Section 2.6: Summary of Forest Inventory

The following section provides a brief summary of the forest inventory data. More detailed information is provided in Appendices B, C, and G. As mentioned above, there are about 151,447 commercial forested acres of MT-FWP included in this study. The current timber inventory on those acres is approximately 750 million board feet.

Table 2.6-1: Commercial forested acres by site index for each administrative region

Region	48	55	60	68	85	Total
1	25	2,625	5,327	1,962	1,048	10,987
2	15,288	51,025	13,141	2,310	66	81,831
3	38,613	7,724	-	-	-	46,337
4	9,551	1,875	-	-	-	11,426
5	896	-	-	-	-	896
7	-	-	-	-	-	-
Total	**64,374**	**63,249**	**18,468**	**4,271**	**1,114**	**151,477**

Table 2.6-2: Commercial forested acres by species type for each administrative region

Region	DF	LP	MC	MM	PP	SS	Total
1	1,112	161	6,594	1,148	1,972	-	10,987
2	38,786	10,931	21,167	1,072	9,804	71	81,831
3	17,257	24,109	1,687	8	-	3,276	46,337
4	5,789	412	1,051	27	4,126	21	11,426
5	184	15	84	-	614	-	896
7	-	-	-	-	-	-	-
Total	**63,129**	**35,627**	**30,583**	**2,255**	**16,515**	**3,367**	**151,477**

Table 2.6-3: Commercial forested acres by size class for each administrative region

Region	Non-Stocked	Seeds/Saps	Pole	Sawtimber	Total
1	-	1,157	2,061	7,768	10,987
2	605	12,366	28,719	40,141	81,831
3	123	3,907	10,545	31,763	46,337
4	26	423	2,473	8,504	11,426
5	-	257	214	426	896
7	-	-	-	-	-
Total	**754**	**18,110**	**44,011**	**88,602**	**151,477**

Table 2.6-4: Commercial forested acres by stocking class for each administrative region

Region	Poor	Low	Medium	Med-High	High	Total
1	20	1,035	1,902	3,760	4,269	10,987
2	4,501	18,470	22,333	24,235	12,293	81,831
3	162	3,545	7,123	16,647	18,860	46,337
4	159	1,166	2,058	3,384	4,659	11,426
5	-	290	342	205	59	896
7	-	-	-	-	-	-
Total	**4,842**	**24,505**	**33,758**	**48,231**	**40,140**	**151,477**

Table 2.6-5: Volume (Mbf) on commercial forested acres by site index for each administrative region

Region	48	55	60	68	85	Total
1	234	18,113	39,322	14,629	3,424	75,722
2	60,537	202,350	45,787	8,202	653	317,529
3	243,485	50,887	-	-		294,372
4	49,268	10,995	-	-	-	60,263
5	1,765	-	-	-	-	1,765
7	-	-	-	-	-	-
Total	**355,289**	**282,345**	**85,109**	**22,831**	**4,077**	**749,651**

Table 2.6-6: Volume (Mbf) on commercial forested acres by species type for each administrative region

Region	DF	LP	MC	MM	PP	SS	Total
1	12,101	1,322	35,484	12,743	14,072	-	75,722
2	150,834	50,966	63,983	12,839	38,775	132	317,529
3	80,793	181,001	12,687	23	-	19,868	294,372
4	34,462	2,322	7,209	73	16,070	127	60,263
5	745	12	187	-	821	-	1,765
7	-	-	-	-	-	-	-
Total	**278,935**	**235,623**	**119,550**	**25,678**	**69,738**	**20,127**	**749,651**

Table 2.6-7: Volume (Mbf) on commercial forested acres by size class for each administrative region

Region	Non-Stocked	Seeds/Saps	Pole	Sawtimber	Total
1	-	2,678	14,952	58,092	75,722
2	409	18,819	65,152	233,149	317,529
3	-	9,524	68,228	216,620	294,372
4	42	1,246	11,262	47,714	60,263
5	-	108	431	1,227	1,765
7	-	-	-	-	-
Total	**451**	**32,374**	**160,024**	**556,802**	**749,651**

Table 2.6-8: Volume (Mbf) on commercial forested acres by stocking class for each administrative region

Region	Poor	Low	Medium	Med-High	High	Total
1	-	4,898	8,502	18,543	43,779	75,722
2	4,333	38,636	50,740	156,911	66,909	317,529
3	-	8,845	27,413	92,275	165,839	294,372
4	97	2,844	6,053	17,776	33,493	60,263
5	-	374	492	660	239	1,765
7	-	-	-	-	-	-
Total	**4,430**	**55,597**	**93,200**	**286,165**	**310,259**	**749,651**

Insect, Disease, and Fire Damage

In our typing, stocking was classified based on green trees and because of this, the timber inventory on forested acres takes into account standing live trees only. For example, acres with high mortality from insects and diseases or fire damage were classified as having lower stocking levels and the inventory on those acres would reflect that lower stocking level. This is appropriate as future growth will reflect the post-event stocking. Furthermore, dead trees were not included in estimates of inventory or harvest because of their short shelf live and because they have little or no commercial value after just a couple of years. If there is salvageable volume, it could be added to the volumes determined by the Forest Management Model.

Similarly, future yield projections do not estimate future loss from insects and disease or fire. These projections were not calculated because treating stands will decrease the likelihood of catastrophic losses as the treated stands will be managed to more resilient and sustainable levels.

An estimate of affected acres by insects and diseases (I&D) was calculated by using data provided by the USFS's Aerial Detection Survey. Table 2.6-9, below, summarizes the acres affected by I&D since 2008 in each administrative region. These estimates are not cumulative across years and apply to all MT-FWP acres included in this study.

Table 2.6-9: Acres affected by insect and disease damage in each administrative region since 2008

Region	2008	2009	2010	2011	2012
1	105	108	66	684	294
2	5,627	13,679	6,825	10,289	12,508
3	34,044	33,178	12,876	3,792	8,189
4	2,153	4,319	4,328	2,607	3,566
5	-	173	-	-	126
7	-	-	-	-	-
Total	**41,929**	**51,457**	**24,095**	**17,372**	**24,683**

In addition, an estimate of acres affected by fire damage (1984-2012) was also calculated using data provided by the Monitoring Trends in Burn Severity (MTBS) Project. Table 2.6-10 shows a summary of acres affected by burn severity for all acres in each administrative region.

Table 2.6-10: Acres affected by wildfires (by burn severity) in each administrative region, 1984-2012

Region	Low	Medium	High	Total
1	-	-	-	**-**
2	15,867	5,763	1,271	**22,900**
3	-	-	-	**-**
4	571	125	39	**736**
5	-	-	-	**-**
7	-	-	-	**-**
Total	**16,438**	**5,888**	**1,310**	**23,636**

Appendix E provides additional information on insect, disease, and fire damage.

Chapter 3: Forest Management Model

Blackfoot-Clearwater Wildlife Management Area

Section 3.1: Overview of the Forest Management Model

The Forest Management Model is the tool used to calculate the annual sustained yield for MT-FWP. Over the years, foresters have developed a number of methods to calculate sustained yield. In the beginning, sustained yield was calculated with a simple formula that relied on just a few forest-wide parameters – total inventory, current annual growth, and potential annual growth. While these are still critical parameters in current methods, current methods of calculating sustained yield are much more robust, capturing more detail, addressing more complicated problems, and allowing the examination of alternative management scenarios.

For this study, Woodstock, a commercially available linear programming harvest scheduling model published by Remsoft was used. Over the last several years, Woodstock has become the industry standard and MB&G has become very proficient at building Woodstock models – we have built over 100 Woodstock models covering almost 42 million acres since 2006.

Woodstock is a linear programming model formulated to optimize some objective function while meeting a set of constraints. We have found optimization models to be most effective for forest planning. The problem formulation – defining objective and constraints – seems to fit how most forest managers think about strategic planning.

For this study, the objective function was defined as maximizing net present value[9] of timber harvests while meeting constraints designed to reflect the legal and administrative policies, and wildlife management objectives of MT-FWP. Constraints for this model, for example, include limiting timber harvest in riparian areas and steep slopes, and ensuring a sustainable flow of harvest.

Key inputs into the Woodstock model are:

- **MT-FWP's Land Base**: This is the geographical representation of MT-FWP land and was created through the stand delineation and timber typing process described in Sections 2.1 and 2.2, above.

- **Projected Stand Conditions:** A growth model was used to project the current stand conditions forward for each stand under a variety of silvicultural regimes (See Sections 3.2 and 3.3.2 for further detail). From these projections yield tables were built for the Woodstock model. The yield tables include timber volumes by species and outputs needed by Woodstock to arrive at an optimal solution (See Section 3.3.3 for more detail).

- **Economic Inputs:** Economic inputs include timber prices, management costs, and a discount rate. These inputs were used to ensure model solutions that are economically feasible (See Section 3.3.4 for more detail).

- **Objectives and Constraints:** These inputs described the objective function that the model would strive to optimize while subject to specific management constraints (See Section 3.3.5 for more detail).

[9] Net present value was used as the objective function only to ensure that the model chose the most efficient solution.

Figure 3.1-1 illustrates the flow of information in developing the Forest Management Model to calculate annual sustained yield.

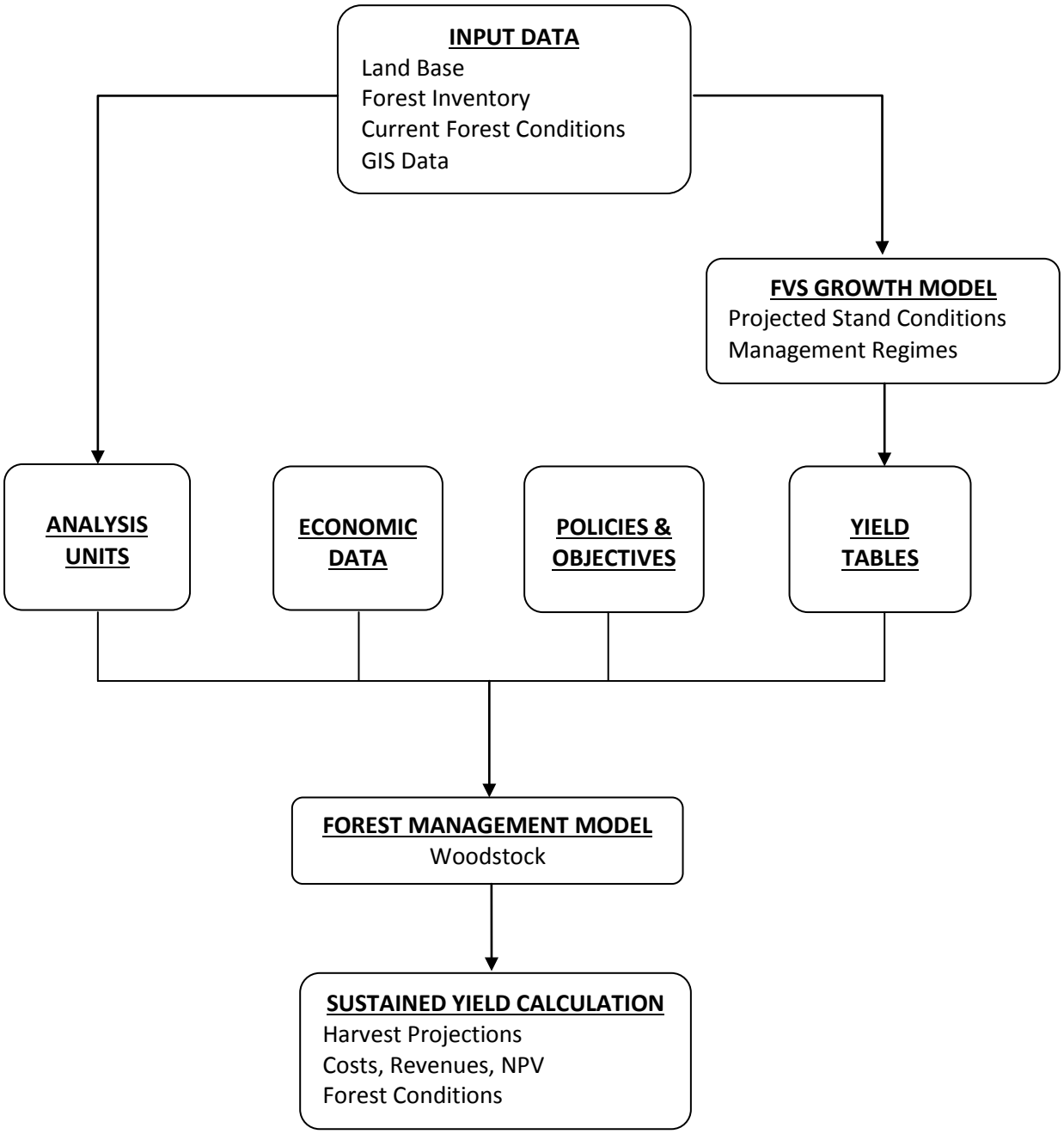

Figure 3.1-1: Flowchart illustrating development of the Forest Management Model

Section 3.2: Forest Growth & Yield

The following sections describe the growth model used for this study along with important assumptions associated with the growth and yield modeling conducted.

Section 3.2.1: Forest Growth Model

A timber growth and yield model called Forest Vegetation Simulator (FVS) was used to project future timber volumes and forest conditions. FVS is a growth and yield model developed and maintained by the U.S. Forest Service (USFS).[10] FVS was selected for this project because the project team has experience and confidence with using the FVS growth and yield model developed for Northern Idaho and Montana. FVS is an individual tree, distance independent growth and yield model that can simulate a wide variety of forest types, stand structures, and pure or mixed species stands.

FVS projects tree growth primarily as a function of species, site, stocking and the size of tree relative to other trees in the stand. An 18" DBH Douglas-fir, for example, grows faster in a stand heavy to 8" DBH trees than it does in a stand of 28" DBH trees. Trees grow faster in properly stocked stands than they do in over-stocked stands.

An important feature of FVS is that it can be calibrated to local conditions by using specific 'variants' of the model that include unique tree growth, mortality, and volume equations for a particular geographic area. For the purposes of this study, the Inland Empire FVS Variant was used to project growth in Region 1 and the Eastern Montana Variant was used for Regions 2, 3, 4, and 5. Within these variants, the user can further adjust the local calibration by assigning a location code based on the nearest national forest in the region. Representative national forests were chosen in each region to assign the location code within FVS.

The yield projections reflect improved growth from stocking control and proper tending of young stands. The FVS growth model calculates timber volume based on internal volume equations from the national volume estimator library. In addition, the FVS growth model projects growth and yield of commercial tree species only. The model does not project non-timber vegetation, nor does it project snags, coarse woody debris, etc.

[10] For an overview of FVS, please consult: Dixon, Gary E. comp. 2002. Essential FVS: A user's guide to the Forest Management Simulator. Internal Rep. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Forest Management Service Center. 226p. (Revised: February 7, 2013).

Section 3.2.2: Important Assumptions

There are a number of assumptions unique to this modeling process used to create the data for the growth and yield modeling:

- The timber typing of MT-FWP's land base was based on photo interpretation and visual estimates made during the forest inventory process. We assume that there is a good correlation between the stand's timber type and the average stand table assigned to that type.

- We grew the average stand tables forward under each site index. This procedure assumes that site-related effects are expressed through the differences in yield that the growth model produces because of variable productivity.

- The Forest Management Model incorporates assumptions regarding log prices and the costs to conduct a timber sale. We are confident that the prices and costs used in this study characterize the current economics of forest management.

Section 3.3: Structure of Forest Management Model

The Forest Management Model is a linear programming optimization model. The model finds an optimal solution, given a mathematical representation of management objectives and constraints.

The MT-FWP Forest Management Model seeks to optimize net present value[11] over the planning horizon. A wide variety of constraints reflect MT-FWP's management policies and objectives, as well as physical limitations on management opportunities and capabilities.

The Forest Management Model projects activities, outputs and conditions for 150 years (15 ten-year periods) into the future. While MT-FWP expects to reassess and perhaps recalculate the sustained yield every five years, a long planning horizon is important to help ensure that management strategies and harvest levels implemented during the short run are compatible with long-term objectives.

The remainder of the section describes the components of the Forest Management Model.

Section 3.3.1: Analysis Units

In the Forest Management Model, forest land is represented as a set of "Analysis Units" (AUs). Analysis Units are non-contiguous parcels of land, homogeneous with respect to factors that: (a) affect outputs, costs, and revenues (e.g. timber species, size, stocking, and site index) and (b) are important from an administrative stand point (e.g. administrative region).

Analysis units in the Forest Management Model are stratified by the following characteristics:

- **Level 1**: Administrative Region (Regions 1, 2, 3, 4, and 5)

[11] Optimizing net present value was used to ensure that model solutions were economically feasible.

- **Level 2:** Timber Species Type
- **Level 3:** Timber Size Class and Stocking
- **Level 4:** Timber Site Index

Conceptually, the Analysis Units are formed by overlaying a number of maps. Each of the individual polygons resulting from the overlay has a complete set of characteristics for Level 1 through 4. Polygons with identical characteristics are grouped together in the Forest Management Model into Analysis Units. Each Analysis Unit, therefore, has a unique set of characteristics.

Section 3.3.2: Management Regimes

The Forest Management Model contains a number of alternative management regimes for each Analysis Unit. Each management regime describes the activities, outputs, costs, and revenues, and forest conditions resulting from managing the Analysis Unit as specified. One regime, for example, might apply even-aged management techniques to a given Analysis Unit. An alternative management regime might enter the Analysis Unit once every thirty years to harvest some of these trees, leaving a residual stand designed to meet some management objectives.

Details about the management regimes developed for this Forest Management Model can be found in Appendix D. A brief summary of the design of the regimes follows.

- Grow Only – No Harvest

  Under this regime, no active management is scheduled. This regime served as a baseline to reference the growth and yield of stands with active management applied. Also, this regime was assigned to areas that cannot or will not be managed due to geographical reasons or anticipated conflicts with wildlife, fisheries, recreational, and/or social values.

- Even-aged regimes

  Even-aged regimes applied standard even-aged management practice of one final harvest during an Analysis Unit's rotation. The final harvest is completed through a clear-cut and the new stand is established either through planting or natural regeneration. These regimes were only used to determine the maximum biological potential yield of timber volume on MT-FWP management units (BM001, BM002, and BM003).

  The sustained yield calculation used an even-aged regime for all lodgepole pine stands. Lodgepole pine stands in every administrative region received a clear-cut prescription with natural regeneration on a 90-year rotation. Implementing a clear cut regeneration harvest in lodgepole pine stands emulates a stand replacement fire, which initiates natural regeneration as sunlight will open their serontinous cones. Because lodgepole pine seeds need full sunlight to germinate, shelterwood systems or partial cutting reduces germination and survival of the seedlings.

- Uneven-aged regimes

  Under these regimes, stands are entered on a 30 or 50 year cycle. Harvest reduces the basal area to a target diameter class distribution. For all uneven-aged regimes, the desired diameter class distribution uses a 'q-factor' of 1.2 on 4" classes with a maximum diameter of 19" DBH to achieve target forest conditions.[12] A 'q-factor' describes the ratio of the number of trees in one diameter class in relation to the number of trees in the previous diameter class.[13] The chosen diameter distributions reflect the management objectives of MT-FWP and were designed to create forested stands that are resilient to insect and disease outbreaks, and wildfire events. These conditions may take decades to develop, but can be achieved through active management.

  These regimes were designed in coordination with MT-FWP to meet management objectives and are the regimes used to calculate annual sustained yield. In Region 1, uneven-aged regimes were designed to thin stands to a residual stocking of either 60 square feet of basal area or 80 square feet of basal area. In Regions 2, 3, 4, and 5, the target residual stocking was either 40 square feet of basal area or 60 square feet of basal area.

  Target residual stocking levels were chosen based on input from MT-FWP and the modeling team's knowledge of standard silvicultural practices in Montana. The residual stocking levels will provide the commercial thinning intensity necessary to open up the forest canopy enough to ensure optimal levels of light and open space necessary for successful regeneration of new trees as well as developing forest conditions that meet MT-FWP objectives.

  Figures 3.3.2-1 and 3.3.2-2, below, provides an illustration of the current basal area distribution on commercial forested MT-FWP land. Currently, about 29% of the MT-FWP commercial forested land base is within the 40-80 basal area target range (see red lines on Figure 3.3.2-1). Seventy-one percent of the land base is outside the desired target stocking – 59% of those acres are greater than 80 square feet of basal area. This distribution is important to consider because as management regimes are implemented, acres that are greater than the desired residual stocking will be thinned earlier to bring those stands down within the desired range. Thinned stands with higher stocking levels generally have larger trees and more volume resulting in higher harvest volumes during early growth periods than in the later periods as stands become more regulated.

  Appendix D provides more detail regarding these uneven-aged management regimes used to calculate the annual sustained yield.

[12] The maximum diameter of 19" DBH does not imply that the uneven-aged regimes were designed to remove all trees greater than 19" DBH leaving managed stands with no trees greater than 19" DBH. This maximum diameter was chosen to develop the target diameter class distributions – trees were allowed to grow larger than 19" DBH in the Forest Management Model.

[13] Nyland, Ralph A. 2002. Silviculture: Concepts and Applications. New York, NY: McGraw-Hill.

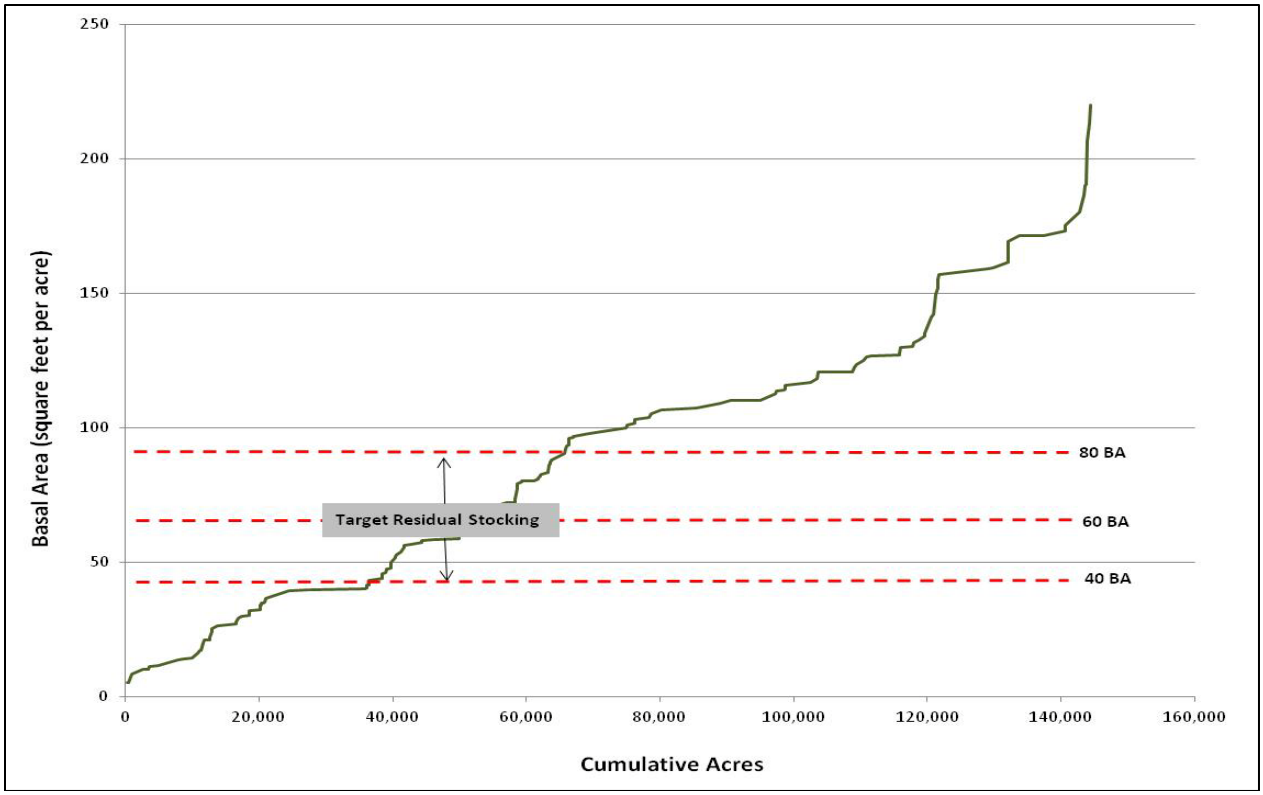

Figure 3.3.2-1: Basal area distribution on all commercial forested acres on MT-FWP lands

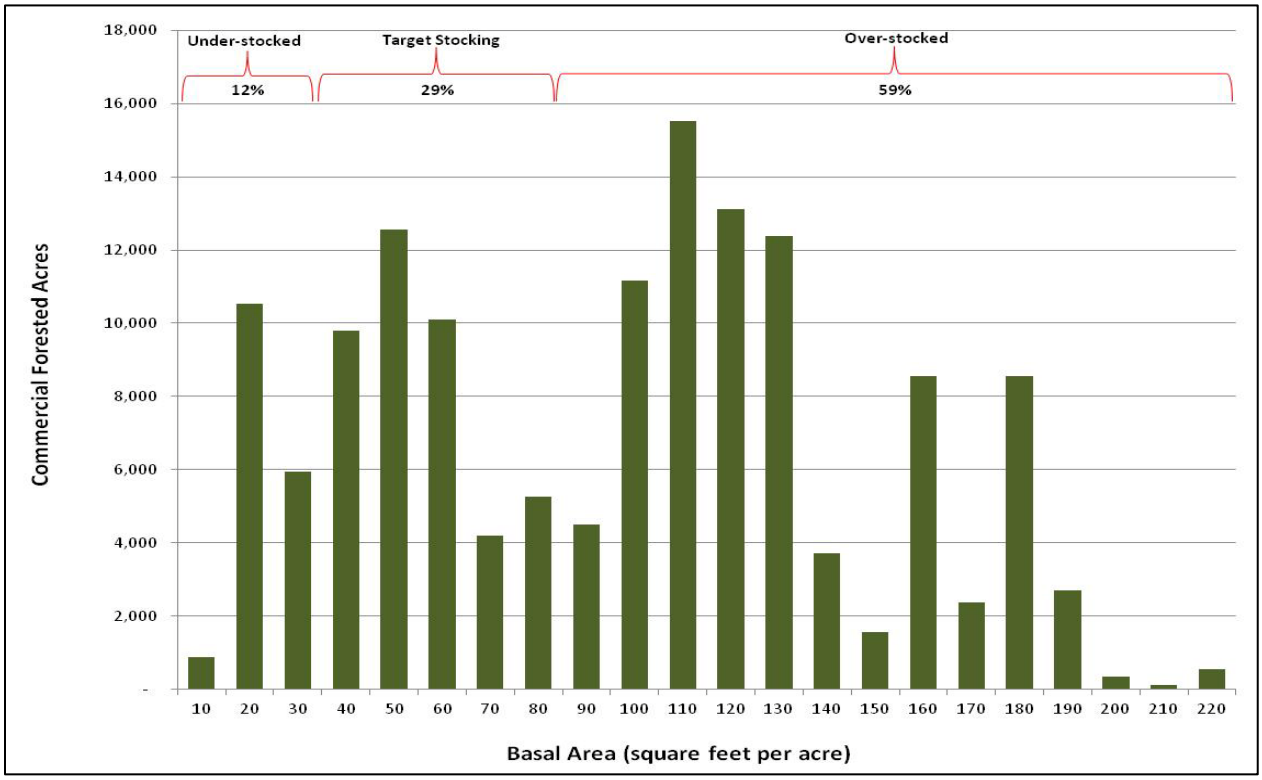

Figure 3.3.2-2: Commercial forested acres by basal area class on MT-FWP lands

Section 3.3.3: Yield Projections

Applying management regimes to forested lands results in a variety of outputs including costs, revenues, timber volume, and various measures of forest condition, all of which become inputs into the Forest Management Model. Section 3.2 describes the FVS growth model in detail. This section provides more information on the yield projections themselves.

For each Analysis Unit, a number of yield tables were generated, each reflecting a different management regime. Overall, close to 4,000 yield tables were generated, and were brought into the Forest Management Model. The FVS growth model returns a complete stand table for each Analysis Unit, under each management regime, at each 10-year growth period.

Figure 3.3.3-1, below, shows an example of yield projections on a single Analysis Unit (DF34 stand in Region 1 growing with a site index of 60) for three management regimes used in this study – (1) Grow Only; (2) Uneven-aged regime with a target basal area of 60 square feet per acre (U DF 60BA 30 L); and (3) Uneven-aged regime with a target basal area of 80 square feet per acre (U DF 80 BA 30 L).

Figure 3.3.3-1: Example yield projection for an Analysis Unit under three different management regimes.

Note: The red and blue lines show the timing of harvest events based on the definition of each management regime. For example, harvests occur in Period 2 and in Period 8 for both regimes as illustrated by the sharp decrease in volume per acre.

Section 3.3.4: Economic Data

In the model, timber harvests produce timber revenues, and incur management costs. Timber revenues are determined by log prices and are input by major species group. In this study, we utilized economic data as the objective function within the Forest Management Model to maximize net present value across all model runs. The net present value calculation only describes the economics of a forest management program designed to meet the annual sustained yield and does not cover the annual overhead of MT-FWP administration.

The log prices used in the Forest Management Model are shown in Table 3.3.4-1.

Table 3.3.4-1: Delivered log prices, 2013

Species	Log price ($2013/Mbf)
Douglas-fir	$ 400
Western Larch	$ 400
Grand Fir	$ 390
Western Hemlock	$ 390
Red Cedar	$ 695
Engleman Spruce	$ 360
White Fir	$ 360
Ponderosa Pine	$ 315
Lodgepole Pine	$ 385
White Pine	$ 350

Sources: Composite delivered log prices from Idaho Department of Lands, Montana Bureau of Business & Economic Research, Northwest Forest Management, and Inland Forest Management.

In addition, variable costs associated with timber production (logging, hauling, sale preparation, etc.) were incorporated into the model. Logging costs are typically a function of the harvest volume per acre – logging costs decrease as the harvest volume per acre increases. Table 3.3.4-2 shows the logging costs used in the model.

Table 3.3.4-2: Logging costs

Harvest Volume (Mbf/acre)	Logging Cost ($/Mbf)
2 to 4	$ 170
5 to 7	$ 165
8 to 10	$ 130
11 to 13	$ 120
14 to 16	$ 115
17 +	$ 110

Hauling costs of $100/Mbf as well as sale preparation/planning costs of $15/Mbf harvested were also incorporated into the model.

The Net Present Value calculations were made using a 5.5% discount rate, which is consistent with the discount rate in current timberland purchases.

Section 3.3.5: Objectives and Constraints

The Forest Management Model is an optimization model that selects management regimes for each Analysis Unit in a manner that meets management objectives in the most economically efficient manner. Objectives and constraints used in the model reflect MT-FWP goals, objectives, policies, and administrative rules. We change these objectives and constraints between model runs to evaluate management decisions, and/or to evaluate the cost of management decisions.

A summary of the objective functions and constraints are as follows:

Objective Functions
The objective function in The Forest Management Model is to maximize net present value over the entire planning horizon.

Model Constraints

- Harvest Flow: constraints regulate the relationship between timber harvest in one period and the next. This model used even flow constraints for both the Benchmark and Sustained Yield Calculation runs, which requires the minimum harvest volume to be within a certain percentage from the maximum harvest volume. The default value of this percentage was 10%, but it was varied as was required to generate an optimal solution. These constraints were applied in two sets, one for Periods 1 to 5, and another for Periods 6 to 15. This created more flexibility in the solution and presented the option to create two sustainability tiers over the planning horizon. In most cases this was required for reaching the optimal solution, depending on whether the forest condition was over- or under-stocked in the beginning.

- Operability: operability constraints regulate which acres in the model are made available to the management regimes. MT-FWP developed a policy to exclude forest management in riparian areas and on steep slopes.

    - A 300-foot riparian buffer was established on either side of a stream or creek (or 300-foot band around a body of water) in which no forest management activity would be permitted.

    - Forest management activities would also be excluded on slopes greater than 60%.

    These areas are considered ‘Non-Operable’.

- Administrative: MT-FWP administratively identified specific areas on management units that would be excluded from forest management activity.

    MT-FWP withdrew forest stands and entire units from potential harvest for a variety of reasons. These included: units that are dominated by streamside management zones, particularly common among Fishing Access Sites; forests that are in scattered patches within roadless settings such as mountain foothill big game winter ranges, which include forests along upper slopes of the unit; forests that provide key wildlife habitat values that would be negatively impacted by forest harvest such as drainage stringers, which are important for wildlife movement corridors; forests that are of low productivity or would be difficult to establish road

access such as forested boulder fields; sound and view shed buffer zones for recreation areas; recreation sites that lack substantial tree cover; and areas where impacts and economic cost of harvest would substantially outweigh possible benefits.

These areas are considered ‘Administratively Withdrawn’.

Section 3.3.6: Limitations

Within the Forest Management Model, the average stand tables are used to represent the stand characteristics across all of the stands within a type. All of the well-stocked Douglas-fir sawtimber stands in Region 1, for example, are assumed to have the same characteristics at the beginning of model runs – the model is unaware of any material differences between stands within a type. This is common is strategic models. Operational activities will require refinement with site specific considerations.

For any given set of characteristics, the model is unaware of how many polygons contribute to the total acres or the spatial juxtaposition of the polygons. As a result, we are careful not to disaggregate the model solution to the stand level and not to ask questions that presume more spatial detail than is available. For example, it would be inappropriate to look to this model solution to identify where to conduct a timber sale, or to design a future transportation network.

[Page Intentionally Left Blank]

Chapter 4: Sustained Yield Calculation Results

Beartooth Wildlife Management Area

Section 4.1: Forest Management Model Runs

The Forest Management Model was used to calculate an annual sustained yield to guide MT-FWP's forest management for the next 150 years. The model representing the final sustained yield calculation was built incrementally by adding one set of constraints at a time. This incremental approach had two purposes. First it allowed us to see that each new set of constraints had a reasonable and explainable impact on the harvest schedule. Second, it provides the marginal cost of each set of constraints.

Table 4.1-1 lists the model runs discussed in the following sections. The Benchmark Runs (BM001-BM003) were designed to determine the maximum biological potential yield using both even-aged and uneven-aged management regimes. The Sustained Yield Calculation Runs (SYC001-SYC003) were designed to determine the annual sustained yield using mostly uneven-aged regimes designed for the MT-FWP land base.[14]

Table 4.1-1: Summary of Forest Management Model Runs

Run	Description	Regimes Available	Land Base
BM001	Maximum Biological Potential Yield	Even-aged AND uneven-aged	Commercial Forested
BM002	Maximum Biological Potential Yield	Even-aged AND uneven-aged	Commercial Forested Operable
BM003	Maximum Biological Potential Yield	Even-aged AND uneven-aged	Commercial Forested Available
SYC001	MT-FWP Potential Yield	Uneven-aged with even-aged on LP stands only	Commercial Forested
SYC002	MT-FWP Potential Yield	Uneven-aged with even-aged on LP stands only	Commercial Forested Operable
SYC003	MT-FWP Potential Yield	Uneven-aged with even-aged on LP stands only	Commercial Forested Available

Note:
Commercial Forested Operable Acres = Commercial Forested Acres *minus* Non-Operable Acres
Commercial Forested Available Acres = Commercial Forested Acres *minus* Non-Operable Acres *minus* Administratively Withdrawn Acres

Table 4.1-2: Statewide Summary of Forest Management Model Land Base

Land Base	Acreage
All Units	359,820
Non-Forested	208,342
Commercial Forested	151,477
Commercial Forested Non-Operable	29,332
Commercial Forested Operable	122,145
Commercial Forested Available	57,403

The following sections summarize the results of each model run for each management unit, by each administrative region. For each management unit, Appendix G contains a set of graphs and tables that displays summary data for each model run.

[14] Uneven-aged regimes were used to calculate the annual sustained yield on all forest land except for lodgepole pine (LP) stands. Even-aged regimes were applied to these stands.

Section 4.1.1: Region 1

Acre Summary

Table 4.1.1-1: Summary of acres used the by Forest Management Model in Region 1

Unit	Unit Type	Total Unit Size	Total Non Forested	Total Commercial Forested	Commercial Forested Non Operable		Commercial Forested Operable	Commercial Forested Available
					Riparian	Slope		
Bull River	WMA	1,576	317	1,258	91	2	1,166	991
Kootenai/Falls	WMA	171	103	68	33	-	35	-
Kootenai/West	WMA	927	46	881	-	-	881	881
Kootenai/Woods Ranch	WMA	1,485	957	528	113	5	409	406
Mount Silcox	WMA	1,535	576	959	96	66	797	632
North Swan Valley	WMA	2,045	242	1,804	404	-	1,400	1,375
Ray Kuhns	WMA	1,556	350	1,206	159	-	1,047	954
Lake Mary Ronan	State Park	122	9	113	8	-	104	104
Lone Pine	State Park	250	31	219	-	3	217	215
Thompson Chain Of Lakes (East)	State Park	490	98	392	105	-	287	287
Thompson Chain Of Lakes (West)	State Park	2,454	444	2,009	709	-	1,299	1,300
Wayfarers	State Park	46	14	31	5	-	27	27
West Shore	State Park	140	5	135	49	-	86	86
Wild Horse Island	State Park	2,116	844	1,271	231	12	1,029	870
Kokanee Bend	FAS	180	123	57	9	-	48	47
Old Steel Bridge	FAS	128	128	-	-	-	-	-
Swan River	FAS	59	5	54	2	-	52	52
Total		**15,279**	**4,293**	**10,986**	**2,016**	**87**	**8,882**	**8,227**

Short-Term SYC Volume Summary

Table 4.1.1-2: Summary of short-term harvest volumes by modeling run in Region 1

Unit	Unit Type	Short-Term Biological Potential (Mbf/Year)*			Short-Term MT-FWP Potential (Mbf/Year)**		
		BM001	BM002	BM003	SYC001	SYC002	SYC003
Bull River	WMA	115.4	101.0	85.0	72.6	63.4	52.8
Kootenai/Falls	WMA	17.3	8.4	-	13.1	6.8	-
Kootenai/West	WMA	174.7	174.7	174.7	152.2	152.2	152.2
Kootenai/Woods Ranch	WMA	74.8	56.8	56.4	61.6	46.6	46.3
Mount Silcox	WMA	164.2	135.7	112.9	133.9	108.7	92.2
North Swan Valley	WMA	368.1	271.0	262.6	238.2	179.1	172.4
Ray Kuhns	WMA	200.5	173.3	151.1	158.9	138.4	119.6
Lake Mary Ronan	State Park	16.7	15.7	15.7	13.3	12.1	12.1
Lone Pine	State Park	35.2	34.8	34.6	30.6	30.3	30.1
Thompson Chain Of Lakes (East)	State Park	20.3	14.1	14.1	4.7	3.4	3.4
Thompson Chain Of Lakes (West)	State Park	289.7	185.8	177.1	185.0	107.1	107.1
Wayfarers	State Park	6.8	5.7	5.3	4.7	3.8	3.8
West Shore	State Park	21.1	13.5	13.5	17.3	10.2	10.2
Wild Horse Island	State Park	142.1	126.3	104.9	133.6	108.5	96.7
Kokanee Bend	FAS	5.1	4.4	4.1	2.0	1.8	1.6
Old Steel Bridge	FAS	-	-	-	-	-	-
Swan River	FAS	5.4	5.3	5.3	3.0	3.0	3.0
Total		**1,657.3**	**1,326.5**	**1,217.3**	**1,224.7**	**975.4**	**903.3**

* Short-term maximum biological potential determined through clear-cut and plant management regimes - represents an average from Year 0 – 50.

** Short-term MT-FWP potential determined through management regimes designed to meet MTFWP goals and objectives - represents an average from Year 0 – 50.

Long-Term SYC Volume Summary

Table 4.1.1-3: Summary of long-term harvest volumes by modeling run in Region 1

Unit	Unit Type	Long-Term Biological Potential (Mbf/Year)*			Long-Term MT-FWP Potential (Mbf/Year)**		
		BM001	BM002	BM003	SYC001	SYC002	SYC003
Bull River	WMA	166.1	155.2	134.1	161.0	150.2	129.0
Kootenai/Falls	WMA	11.5	4.6	-	7.9	3.8	-
Kootenai/West	WMA	125.1	125.1	125.1	103.4	103.4	103.4
Kootenai/Woods Ranch	WMA	59.3	45.0	44.6	49.7	37.7	37.4
Mount Silcox	WMA	106.3	85.9	71.3	91.1	75.3	62.4
North Swan Valley	WMA	208.3	162.4	158.7	184.5	144.0	142.0
Ray Kuhns	WMA	151.3	130.7	114.5	120.4	104.9	93.7
Lake Mary Ronan	State Park	9.3	8.8	8.8	8.3	7.7	7.7
Lone Pine	State Park	19.6	19.4	19.3	18.9	18.7	18.6
Thompson Chain Of Lakes (East)	State Park	33.5	24.5	24.5	31.7	23.1	23.1
Thompson Chain Of Lakes (West)	State Park	220.5	132.7	138.5	183.0	119.4	119.4
Wayfarers	State Park	2.5	2.1	2.3	2.9	2.4	2.4
West Shore	State Park	12.9	8.3	8.3	13.6	9.0	9.0
Wild Horse Island	State Park	120.1	97.4	80.9	112.9	91.7	81.6
Kokanee Bend	FAS	5.6	4.8	4.5	4.4	3.7	3.6
Old Steel Bridge	FAS	-	-	-	-	-	-
Swan River	FAS	5.1	4.8	4.8	5.2	4.9	4.9
Total		**1,257.0**	**1,011.5**	**940.3**	**1,099.0**	**899.8**	**838.1**

* Long-term maximum biological potential determined through clear-cut and plant management regimes - represents an average from Year 50 – 150.

** Long-term MT-FWP potential determined through management regimes designed to meet MTFWP goals and objectives - represents an average from Year 50 – 150.

Section 4.1.2: Region 2

Acre Summary

Table 4.1.2-1: Summary of acres used the by Forest Management Model in Region 2

Unit	Unit Type	Total Unit Size	Total Non Forested	Total Commercial Forested	Commercial Forested Non Operable		Commercial Forested Operable	Commercial Forested Available
					Riparian	Slope		
Blackfoot-Clearwater 1	WMA	6,706	955	5,751	972	286	4,493	1,438
Blackfoot-Clearwater/ Harpers Lake	WMA	15,963	8,112	7,850	938	197	6,715	6,686
Calf Creek	WMA	2,416	770	1,647	384	16	1,246	712
Fish Creek	WMA	35,355	18,027	17,328	2,150	3,413	11,765	9,763
Garrity Mountain	WMA	8,997	3,239	5,759	804	414	4,541	3,360
Lost Creek	WMA	530	215	315	24	3	288	15
Marshall Creek	WMA	24,796	4,435	20,360	3,325	220	16,816	8,692
Mount Jumbo	WMA	118	19	99	-	-	99	99
Nevada Lake	WMA	752	282	470	26	-	443	396
Spotted Dog	WMA	27,386	14,127	13,259	2,136	22	11,101	-
Threemile	WMA	6,226	1,130	5,096	842	188	4,066	4,070
Beavertail Hill	State Park	70	66	4	-	-	4	-
Fish Creek	State Park	5,565	2,432	3,133	350	545	2,238	2,217
Lost Creek	State Park	1,375	1,042	333	108	87	138	92
Milltown	State Park	598	486	112	14	8	90	90
Erskine	FAS	423	423	-	-	-	-	-
Monture Creek	FAS	112	102	10	6	-	4	-
River Junction	FAS	129	39	90	46	-	44	44
Stuart Mill Bay	FAS	356	140	216	14	-	202	201
Total		**137,873**	**56,041**	**81,832**	**12,139**	**5,399**	**64,293**	**37,875**

Short-Term SYC Volume Summary

Table 4.1.2-2: Summary of short-term harvest volumes by modeling run in Region 2

Unit	Unit Type	Short-Term Biological Potential (Mbf/Year)*			Short-Term MT-FWP Potential (Mbf/Year)**		
		BM001	BM002	BM003	SYC001	SYC002	SYC003
Blackfoot-Clearwater 1	WMA	631.6	464.6	210.0	361.1	269.5	132.8
Blackfoot-Clearwater/ Harpers Lake	WMA	963.0	821.4	818.5	520.4	442.3	440.3
Calf Creek	WMA	218.5	157.0	113.6	138.9	99.7	70.1
Fish Creek	WMA	1,407.7	805.4	643.4	699.3	426.6	340.7
Garrity Mountain	WMA	394.2	245.7	88.5	394.2	245.7	88.3
Lost Creek	WMA + State Park	71.9	45.0	7.3	45.2	27.2	5.0
Marshall Creek	WMA	2,319.9	1,826.7	813.0	1,408.7	1,106.7	521.8
Mount Jumbo	WMA	11.4	11.4	11.4	6.4	6.4	6.4
Nevada Lake	WMA	60.9	57.5	51.8	39.8	37.2	36.0
Spotted Dog	WMA	656.2	485.8	-	315.9	234.6	-
Threemile	WMA	719.7	570.7	570.6	432.2	353.1	353.0
Beavertail Hill	State Park	0.4	0.4	-	0.4	0.4	-
Fish Creek	State Park	231.2	151.0	148.1	111.0	73.3	71.6
Milltown	State Park	12.8	10.0	10.0	6.8	5.4	5.4
Erskine	FAS	-	-	-	-	-	-
Monture Creek	FAS	1.1	0.5	-	0.9	0.4	-
River Junction	FAS	9.9	5.5	5.5	5.3	3.9	3.9
Stuart Mill Bay	FAS	24.8	23.6	23.7	24.8	23.6	23.7
Total		**7,735.1**	**5,682.0**	**3,515.2**	**4,511.1**	**3,355.9**	**2,099.1**

* Short-term maximum biological potential determined through clear-cut and plant management regimes - represents an average from Year 0 – 50.

** Short-term MT-FWP potential determined through management regimes designed to meet MTFWP goals and objectives - represents an average from Year 0 – 50.

Long-Term SYC Volume Summary

Table 4.1.2-3: Summary of long-term harvest volumes by modeling run in Region 2

Unit	Unit Type	Long-Term Biological Potential (Mbf/Year)*			Long-Term MT-FWP Potential (Mbf/Year)**		
		BM001	BM002	BM003	SYC001	SYC002	SYC003
Blackfoot-Clearwater 1	WMA	439.4	323.2	146.7	298.9	227.8	109.7
Blackfoot-Clearwater/ Harpers Lake	WMA	812.5	693.1	690.6	430.1	365.5	363.9
Calf Creek	WMA	186.4	133.9	94.9	114.8	82.4	58.0
Fish Creek	WMA	1,268.3	885.4	737.4	594.6	384.0	321.1
Garrity Mountain	WMA	461.6	388.8	392.4	377.3	365.6	368.1
Lost Creek	WMA + State Park	61.3	38.4	7.3	37.5	22.5	4.2
Marshall Creek	WMA	1,968.7	1,558.4	686.0	1,164.4	914.7	431.3
Mount Jumbo	WMA	9.6	9.6	9.6	4.9	4.9	4.9
Nevada Lake	WMA	50.4	47.5	42.8	24.1	22.6	19.2
Spotted Dog	WMA	775.6	658.2	-	461.0	342.3	-
Threemile	WMA	607.3	481.5	481.4	357.2	291.8	291.8
Beavertail Hill	State Park	0.3	0.3	-	0.1	0.1	-
Fish Creek	WMA	1,268.3	885.4	737.4	594.6	384.0	321.1
Milltown	State Park	11.5	9.1	9.1	5.8	4.6	4.6
Erskine	FAS	-	-	-	-	-	-
Monture Creek	FAS	1.0	0.4	-	0.5	0.2	-
River Junction	FAS	8.2	4.6	4.6	4.5	2.1	2.1
Stuart Mill Bay	FAS	25.7	24.6	24.6	25.7	24.6	24.6
Total		**6,890.1**	**5,395.4**	**3,465.8**	**3,999.3**	**3,121.1**	**2,067.6**

* Long-term maximum biological potential determined through clear-cut and plant management regimes - represents an average from Year 50 – 150.

** Long-term MT-FWP potential determined through management regimes designed to meet MTFWP goals and objectives - represents an average from Year 50 – 150.

Section 4.1.3: Region 3

Acre Summary

Table 4.1.3-1: Summary of acres used the by Forest Management Model in Region 3

Unit	Unit Type	Total Unit Size	Total Non Forested	Total Commercial Forested	Commercial Forested Non Operable		Commercial Forested Operable	Commercial Forested Available
					Riparian	Slope		
Canyon Creek	WMA	2,369	349	2,020	249	74	1,696	1,696
Fleecer Mountain	WMA	4,490	3,868	621	158	4	460	460
Gallatin	WMA	8,637	3,589	5,048	909	51	4,088	-
Madison-Bear Creek	WMA	3,480	2,081	1,399	219	128	1,052	-
Madison-Wall Creek	WMA	6,152	6,065	87	37	-	50	-
Mt. Haggin	WMA	60,200	24,325	35,875	4,828	545	30,502	7,632
Robb-Ledford	WMA	17,382	16,637	745	99	27	619	-
Bannack	State Park	1,622	1,570	53	-	6	47	-
Lewis And Clark Caverns	State Park	2,954	2,465	489	56	48	385	383
Missouri Headwaters	State Park	592	592	-	-	-	-	-
Total		**107,879**	**61,542**	**46,337**	**6,555**	**882**	**38,901**	**10,171**

Short-Term SYC Volume Summary

Table 4.1.3-2: Summary of short-term harvest volumes by modeling run in Region 3

Unit	Unit Type	Short-Term Biological Potential (Mbf/Year)*			Short-Term MT-FWP Potential (Mbf/Year)**		
		BM001	BM002	BM003	SYC001	SYC002	SYC003
Canyon Creek	WMA	155.8	123.1	123.1	98.1	78.3	78.3
Fleecer Mountain	WMA	58.8	47.8	47.8	50.4	39.0	39.0
Gallatin	WMA	617.7	605.5	-	533.6	517.2	-
Madison-Bear Creek	WMA	201.8	144.8	-	140.4	109.9	-
Madison-Wall Creek	WMA	7.6	4.2	-	4.5	2.3	-
Mt. Haggin	WMA	4,751.0	3,948.6	1,080.7	4,161.0	3,532.5	913.3
Robb-Ledford	WMA	104.8	80.9	-	66.6	56.0	-
Bannack	State Park	3.8	3.2	-	2.5	2.0	-
Lewis And Clark Caverns	State Park	45.9	36.7	35.4	37.1	28.6	27.1
Missouri Headwaters	State Park	-	-	-	-	-	-
Total		**5,947.0**	**4,994.8**	**1,287.0**	**5,094.2**	**4,365.9**	**1,057.6**

* Short-term maximum biological potential determined through clear-cut and plant management regimes - represents an average from Year 0 – 50.

** Short-term MT-FWP potential determined through management regimes designed to meet MTFWP goals and objectives - represents an average from Year 0 – 50.

Long-Term SYC Volume Summary

Table 4.1.3-3: Summary of long-term harvest volumes by modeling run in Region 3

Unit	Unit Type	Long-Term Biological Potential (Mbf/Year)*			Long-Term MT-FWP Potential (Mbf/Year)**		
		BM001	BM002	BM003	SYC001	SYC002	SYC003
Canyon Creek	WMA	135.8	108.5	108.5	81.1	64.8	64.8
Fleecer Mountain	WMA	36.8	24.3	24.3	24.9	18.8	18.8
Gallatin	WMA	649.6	421.2	-	441.0	246.6	-
Madison-Bear Creek	WMA	155.1	122.2	-	117.4	91.9	-
Madison-Wall Creek	WMA	5.3	2.8	-	3.0	1.6	-
Mt. Haggin	WMA	3,600.6	3,159.6	698.0	3,017.9	2,605.4	588.8
Robb-Ledford	WMA	64.1	61.4	-	49.6	41.7	-
Bannack	State Park	3.1	2.7	-	2.1	1.8	-
Lewis And Clark Caverns	State Park	31.1	24.9	24.0	20.5	16.4	15.6
Missouri Headwaters	State Park	-	-	-	-	-	-
Total		**4,681.6**	**3,927.5**	**854.7**	**3,757.5**	**3,088.9**	**687.9**

* Long-term maximum biological potential determined through clear-cut and plant management regimes - represents an average from Year 50 – 150.

** Long-term MT-FWP potential determined through management regimes designed to meet MTFWP goals and objectives - represents an average from Year 50 – 150.

Section 4.1.4: Region 4

Acre Summary

Table 4.1.4-1: Summary of acres used the by Forest Management Model in Region 4

Unit	Unit Type	Total Unit Size	Total Non Forested	Total Commercial Forested	Commercial Forested Non Operable		Commercial Forested Operable	Commercial Forested Available
					Riparian	Slope		
Beartooth	WMA	26,976	23,094	3,882	520	290	3,072	-
Beckman	WMA	6,635	5,978	656	64	5	588	-
Blackleaf	WMA	9,784	8,655	1,129	50	19	1,060	-
Ear Mountain	WMA	3,052	2,496	556	95	16	445	-
Judith River	WMA	8,672	6,756	1,915	250	33	1,633	-
Marias River	WMA	7,348	7,348	-	-	-	-	-
Smith River/Fort Logan	WMA	3,217	2,719	498	78	20	400	-
Sun River	WMA	169	169	-	-	-	-	-
Sun River 2	WMA	12,176	10,572	1,604	131	13	1,460	-
Sluice Boxes	State Park	1,143	394	749	197	121	431	414
Smith River (Central)	State Park	528	255	273	65	38	170	166
Smith River (North)	State Park	4	4	-	-	-	-	-
Smith River (South)	State Park	252	90	162	49	37	77	78
Tower Rock	State Park	137	137	-	-	-	-	-
Total		**80,092**	**68,667**	**11,426**	**1,499**	**591**	**9,336**	**658**

Short-Term SYC Volume Summary

Table 4.1.4-2: Summary of short-term harvest volumes by modeling run in Region 4

Unit	Unit Type	Short-Term Biological Potential (Mbf/Year)*			Short-Term MT-FWP Potential (Mbf/Year)**		
		BM001	BM002	BM003	SYC001	SYC002	SYC003
Beartooth	WMA	428.8	335.8	-	269.3	210.1	-
Beckman	WMA	42.4	37.6	-	23.6	20.3	-
Blackleaf	WMA	141.4	133.2	-	93.0	88.1	-
Ear Mountain	WMA	70.1	55.8	-	50.5	39.5	-
Judith River	WMA	125.9	102.3	-	70.5	56.0	-
Marias River	WMA	-	-	-	-	-	-
Smith River/Fort Logan	WMA	19.6	14.6	-	5.2	3.7	-
Sun River	WMA	-	-	-	-	-	-
Sun River 2	WMA	213.5	194.1	-	139.1	126.7	-
Sluice Boxes	State Park	66.0	36.8	34.1	45.1	25.1	23.6
Smith River (Central)	State Park	25.1	16.6	15.7	19.8	13.5	12.7
Smith River (North)	State Park	-	-	-	-	-	-
Smith River (South)	State Park	16.7	8.2	8.2	12.2	6.2	6.2
Tower Rock	State Park	-	-	-	-	-	-
Total		**1,149.4**	**934.8**	**57.9**	**728.4**	**589.2**	**42.5**

* Short-term maximum biological potential determined through clear-cut and plant management regimes - represents an average from Year 0 – 50.

** Short-term MT-FWP potential determined through management regimes designed to meet MTFWP goals and objectives - represents an average from Year 0 – 50.

Long-Term SYC Volume Summary

Table 4.1.4-3: Summary of long-term harvest volumes by modeling run in Region 4

Unit	Unit Type	Long-Term Biological Potential (Mbf/Year)*			Long-Term MT-FWP Potential (Mbf/Year)**		
		BM001	BM002	BM003	SYC001	SYC002	SYC003
Beartooth	WMA	358.4	280.6	-	223.4	174.6	-
Beckman	WMA	35.8	31.7	-	19.8	18.3	-
Blackleaf	WMA	118.1	111.4	-	77.5	73.3	-
Ear Mountain	WMA	58.6	46.6	-	41.8	32.6	-
Judith River	WMA	104.0	84.5	-	58.3	47.4	-
Marias River	WMA	-	-	-	-	-	-
Smith River/Fort Logan	WMA	17.1	12.6	-	12.5	8.6	-
Sun River	WMA	-	-	-	-	-	-
Sun River 2	WMA	178.4	162.2	-	105.7	96.1	-
Sluice Boxes	State Park	54.6	30.4	28.2	30.8	17.2	16.1
Smith River (Central)	State Park	21.0	13.8	13.1	10.2	6.5	6.1
Smith River (North)	State Park	-	-	-	-	-	-
Smith River (South)	State Park	13.9	6.8	6.8	7.0	3.4	3.4
Tower Rock	State Park	-	-	-	-	-	-
Total		**959.9**	**780.7**	**48.1**	**587.0**	**478.0**	**25.6**

* Long-term maximum biological potential determined through clear-cut and plant management regimes - represents an average from Year 50 – 150.

** Long-term MT-FWP potential determined through management regimes designed to meet MTFWP goals and objectives - represents an average from Year 50 – 150.

Section 4.1.5: Region 5

Acre Summary

Table 4.1.5-1: Summary of acres used the by Forest Management Model in Region 5

Unit	Unit Type	Total Unit Size	Total Non Forested	Total Commercial Forested	Commercial Forested Non Operable		Commercial Forested Operable	Commercial Forested Available
					Riparian	Slope		
Haymaker	WMA	1,334	826	508	36	-	472	472
Silver Run	WMA	651	452	198	4	21	173	-
Yellowstone	WMA	3,961	3,771	190	18	-	171	-
Total		**5,946**	**5,049**	**896**	**58**	**21**	**817**	**472**

Short-Term SYC Volume Summary

Table 4.1.5-2: Summary of short-term harvest volumes by modeling run in Region 5

Unit	Unit Type	Short-Term Biological Potential (Mbf/Year)*			Short-Term MT-FWP Potential (Mbf/Year)**		
		BM001	BM002	BM003	SYC001	SYC002	SYC003
Haymaker	WMA	9.4	8.8	8.8	3.1	2.9	2.9
Silver Run	WMA	-	-	-	0.6	0.4	-
Yellowstone	WMA	2.3	2.3	-	1.7	1.6	-
Total		**11.7**	**11.1**	**8.8**	**5.3**	**4.9**	**2.9**

* Short-term maximum biological potential determined through clear-cut and plant management regimes - represents an average from Year 0 – 50.

** Short-term MT-FWP potential determined through management regimes designed to meet MTFWP goals and objectives - represents an average from Year 0 – 50.

Long-Term SYC Volume Summary

Table 4.1.5-3: Summary of long-term harvest volumes by modeling run in Region 5

Unit	Unit Type	Long-Term Biological Potential (Mbf/Year)*			Long-Term MT-FWP Potential (Mbf/Year)**		
		BM001	BM002	BM003	SYC001	SYC002	SYC003
Haymaker	WMA	14.3	13.4	13.4	4.1	3.7	3.7
Silver Run	WMA	30.8	25.7	-	2.7	1.7	-
Yellowstone	WMA	2.6	2.5	-	3.5	3.3	-
Total		**47.7**	**41.6**	**13.4**	**10.3**	**8.6**	**3.7**

* Long-term maximum biological potential determined through clear-cut and plant management regimes - represents an average from Year 50 – 150.

** Long-term MT-FWP potential determined through management regimes designed to meet MTFWP goals and objectives - represents an average from Year 50 – 150.

Section 4.1.6: Region 7

Acre Summary

Table 4.1.6-1: Summary of acres used the by Forest Management Model in Region 7

Unit	Unit Type	Total Unit Size	Total Non Forested	Total Commercial Forested	Commercial Forested Non Operable		Commercial Forested Operable	Commercial Forested Available
					Riparian	Slope		
Isaac Homestead	WMA	1,261	1,261	-	-	-	-	-
Makoshika	State Park	11,491	11,491	-	-	-	-	-
Total		**12,752**	**12,752**	**-**	**-**	**-**	**-**	**-**

Short-Term SYC Volume Summary

Table 4.1.6-2: Summary of short-term harvest volumes by modeling run in Region 7

Unit	Unit Type	Short-Term Biological Potential (Mbf/Year)*			Short-Term MT-FWP Potential (Mbf/Year)**		
		BM001	BM002	BM003	SYC001	SYC002	SYC003
Isaac Homestead	WMA	-	-	-	-	-	-
Makoshika	State Park	-	-	-	-	-	-
Total			**-**	**-**	**-**	**-**	**-**

* Short-term maximum biological potential determined through clear-cut and plant management regimes - represents an average from Year 0 – 50.

** Short-term MT-FWP potential determined through management regimes designed to meet MTFWP goals and objectives - represents an average from Year 0 – 50.

Long-Term SYC Volume Summary

Table 4.1.6-3: Summary of long-term harvest volumes by modeling run in Region 7

Unit	Unit Type	Long-Term Biological Potential (Mbf/Year)*			Long-Term MT-FWP Potential (Mbf/Year)**		
		BM001	BM002	BM003	SYC001	SYC002	SYC003
Isaac Homestead	WMA	-	-	-	-	-	-
Makoshika	State Park	-	-	-	-	-	-
Total		**-**	**-**	**-**	**-**	**-**	**-**

* Long-term maximum biological potential determined through clear-cut and plant management regimes - represents an average from Year 50 – 150.

** Long-term MT-FWP potential determined through management regimes designed to meet MTFWP goals and objectives - represents an average from Year 50 – 150.

Appendices

Appendix A: Forest Inventory & Sustained Yield Calculation Legislation

62nd Legislature HB0619

AN ACT REVISING FISH, WILDLIFE, AND PARKS FOREST MANAGEMENT LAWS BY REQUIRING THE CALCULATION OF AN ANNUAL SUSTAINABLE YIELD; ESTABLISHING A FOREST MANAGEMENT PLAN AND A SUSTAINABLE YIELD STUDY; ESTABLISHING THAT COSTS TO IMPLEMENT THE FOREST MANAGEMENT PLAN ARE AN AUTHORIZED EXPENDITURE; AMENDING SECTIONS 87-1-201 AND 87-1-621, MCA; AND PROVIDING AN EFFECTIVE DATE.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF MONTANA:

Section 1. Forest management plan -- sustainable yield study required -- definition. (1) The commission shall adopt a forest management plan, based on an annual sustainable yield, to implement the provisions of 87-1-201(9)(a)(iv).

(2) The department, under the direction of the commission, shall, before July 1, 2012, commission a study by a qualified independent third party to determine, using scientific principles, the annual sustainable yield on forested department lands. The department shall direct the qualified independent third party to determine the annual sustainable yield pursuant to all state and federal laws.

(3) The annual timber sale requirement for the timber sale program administered by the department to address fire mitigation, pine beetle infestation, and wildlife habitat enhancement may not exceed the annual sustainable yield.

(4) The commission shall review and redetermine the annual sustainable yield at least once every 5 years.

(5) Expenditures necessary to meet the requirements of this section are authorized to be made by the department pursuant to 87-1-601.

(6) For the purposes of this section, the term "annual sustainable yield" means the quantity of timber that can be harvested from forested department lands each year, taking into account the ability of forested lands to generate replacement tree growth and in accordance with:

(a) the provisions of 87-1-201(9)(a)(iv);

(b) state and federal laws, including but not limited to the laws pertaining to wildlife, recreations, and maintenance of watersheds; and

(c) water quality standards that protect fisheries and aquatic life and that are adopted under the provisions of Title 75, chapter 5.

-1 -*Authorized Print Version* - HB 619

Section 2. Section 87-1-201, MCA, is amended to read:

"87-1-201. Powers and duties. (1) The department shall supervise all the wildlife, fish, game, game and nongame birds, waterfowl, and the game and fur-bearing animals of the state and may implement voluntary programs that encourage hunting access on private lands and that promote harmonious relations between landowners and the hunting public. The department possesses all powers necessary to fulfill the duties prescribed by law and to bring actions in the proper courts of this state for the enforcement of the fish and game laws and the rules adopted by the department.

(2) The department shall enforce all the laws of the state regarding the protection, preservation, management, and propagation of fish, game, fur-bearing animals, and game and nongame birds within the state.

(3) The department has the exclusive power to spend for the protection, preservation, management, and propagation of fish, game, fur-bearing animals, and game and nongame birds all state funds collected or acquired for that purpose, whether arising from state appropriation, licenses, fines, gifts, or otherwise. Money collected or received from the sale of hunting and fishing licenses or permits, from the sale of seized game or hides, from fines or damages collected for violations of the fish and game laws, or from appropriations or received by the department from any other sources is under the control of the department and is available for appropriation to the department.

(4) The department may discharge any appointee or employee of the department for cause at any time.

(5) The department may dispose of all property owned by the state used for the protection, preservation, management, and propagation of fish, game, fur-bearing animals, and game and nongame birds that is of no further value or use to the state and shall turn over the proceeds from the sale to the state treasurer to be credited to the fish and game account in the state special revenue fund.

(6) The department may not issue permits to carry firearms within this state to anyone except regularly appointed officers or wardens.

(7) The department is authorized to make, promulgate, and enforce reasonable rules and regulations

-2 -*Authorized Print Version* - HB 619

Appendix B: Timber Type Summary

Table B-1: Total acres within each timber type by administrative region

Timber Type	Region 1	Region 2	Region 3	Region 4	Region 5	Region 7	Total
00	-	-	-	2.28	-	-	**2.28**
11	42.96	-	-	4,728.22	-	-	**4,771.18**
AS23	-	3.76	27.26	16.60	-	-	**47.62**
AS24	-	60.37	21.79	60.91	-	-	**143.07**
AS25	-	4.21	4.58	75.01	-	-	**83.80**
AS30	-	-	-	4.33	-	-	**4.33**
AS32	-	2.82	22.29	-	-	-	**25.11**
AS33	-	8.66	42.59	6.01	-	-	**57.26**
AS34	-	42.02	232.09	198.99	-	-	**473.10**
AS35	-	23.95	134.87	178.36	-	-	**337.18**
AS42	-	5.84	3.62	-	-	-	**9.46**
AS43	-	3.87	23.71	12.18	-	-	**39.76**
AS44	-	26.05	91.92	77.35	-	-	**195.32**
AS45	-	34.64	115.20	28.51	-	-	**178.35**
DF11	-	299.69	123.12	9.53	-	-	**432.34**
DF21	-	777.99	4.71	-	-	-	**782.70**
DF22	14.14	1,720.08	214.86	24.40	28.70	-	**2,002.18**
DF23	2.53	1,870.87	168.80	107.42	16.99	-	**2,166.61**
DF24	-	791.89	98.70	138.85	-	-	**1,029.44**
DF25	-	131.64	-	56.27	-	-	**187.91**
DF31	-	952.75	4.33	2.94	-	-	**960.02**
DF32	-	3,462.94	337.52	50.48	18.74	-	**3,869.68**
DF33	4.53	8,123.34	605.18	115.83	22.50	-	**8,871.38**
DF34	92.88	2,170.77	356.50	415.65	12.05	-	**3,047.85**
DF35	48.66	606.20	175.00	667.65	-	-	**1,497.51**
DF41	-	862.76	30.32	43.94	-	-	**937.02**
DF42	68.13	3,934.96	1,626.80	233.15	-	-	**5,863.04**
DF43	188.95	4,470.82	2,919.64	393.76	-	-	**7,973.17**
DF44	316.48	5,335.20	5,448.57	1,164.96	52.46	-	**12,317.67**
DF45	375.93	3,274.69	5,143.50	2,363.89	32.86	-	**11,190.87**
HW11	-	14.52	6.66	4.82	-	-	**26.00**
HW21	-	-	-	5.74	-	-	**5.74**
HW22	-	62.89	-	32.81	-	-	**95.70**
HW23	-	78.09	-	51.55	-	-	**129.64**
HW24	1.05	29.10	-	6.57	-	-	**36.72**
HW25	-	24.13	-	-	-	-	**24.13**
HW31	-	5.82	-	-	-	-	**5.82**
HW32	-	7.23	6.82	70.26	-	34.10	**118.41**
HW33	-	41.94	11.63	134.31	-	51.03	**238.91**
HW34	6.57	11.82	16.37	58.94	-	16.26	**109.96**
HW35	18.20	22.25	-	3.92	-	11.89	**56.26**
HW41	-	-	-	31.85	2.66	-	**34.51**
HW42	35.54	79.48	120.24	206.06	9.54	49.98	**500.84**
HW43	41.19	101.64	76.62	299.60	5.25	68.92	**593.22**

Timber Type	Region 1	Region 2	Region 3	Region 4	Region 5	Region 7	Total
HW44	88.82	104.66	34.90	163.92	1.28	101.88	**495.46**
HW45	56.61	5.26	3.45	0.37	1.60	85.91	**153.20**
LP11	-	10.85	-	-	-	-	**10.85**
LP21	-	202.10	-	-	-	-	**202.10**
LP22	9.78	236.84	399.79	-	-	-	**646.41**
LP23	6.07	783.80	1,144.99	-	-	-	**1,934.86**
LP24	32.92	801.70	1,271.14	-	-	-	**2,105.76**
LP25	-	229.56	580.13	-	-	-	**809.69**
LP31	-	-	-	7.13	-	-	**7.13**
LP32	3.89	205.87	366.44	-	-	-	**576.20**
LP33	6.65	956.01	1,125.27	-	-	-	**2,087.93**
LP34	-	1,976.36	3,689.24	11.09	-	-	**5,676.69**
LP35	34.83	1,031.31	3,527.87	127.12	14.92	-	**4,736.05**
LP41	-	2.45	-	-	-	-	**2.45**
LP42	-	134.91	366.68	-	-	-	**501.59**
LP43	9.13	690.24	806.46	-	-	-	**1,505.83**
LP44	-	1,643.92	3,630.48	-	-	-	**5,274.40**
LP45	57.49	2,024.77	7,200.40	266.48	-	-	**9,549.14**
MC11	-	215.84	-	-	-	-	**215.84**
MC13	-	1.36	-	-	-	-	**1.36**
MC21	-	102.46	-	-	-	-	**102.46**
MC22	68.86	498.10	5.98	-	10.06	-	**583.00**
MC23	205.95	1,474.09	-	-	-	-	**1,680.04**
MC24	516.63	1,573.46	-	-	11.48	-	**2,101.57**
MC25	181.41	670.40	-	-	-	-	**851.81**
MC31	-	215.01	-	-	-	-	**215.01**
MC32	34.79	816.23	-	-	-	-	**851.02**
MC33	87.55	1,723.33	10.46	-	-	-	**1,821.34**
MC34	519.98	2,362.01	76.43	17.37	20.61	-	**2,996.40**
MC35	859.84	1,518.84	22.71	31.13	10.92	-	**2,443.44**
MC41	4.36	747.81	-	-	-	-	**752.17**
MC42	322.43	2,881.48	92.59	2.49	-	-	**3,298.99**
MC43	584.45	73.88	181.19	10.30	-	-	**849.82**
MC44	1,437.38	4,345.47	600.22	204.52	30.49	-	**6,618.08**
MC45	1,770.08	1,947.53	697.34	785.69	-	-	**5,200.64**
MM23	-	8.12	-	-	-	-	**8.12**
MM24	-	6.99	-	-	-	-	**6.99**
MM31	-	41.09	-	-	-	-	**41.09**
MM32	-	29.11	-	-	-	-	**29.11**
MM33	30.29	61.40	-	-	-	-	**91.69**
MM34	21.54	75.51	8.35	-	-	-	**105.40**
MM35	166.40	51.46	-	-	-	-	**217.86**
MM41	15.14	-	-	-	-	-	**15.14**
MM42	38.57	105.37	-	-	-	-	**143.94**
MM43	122.81	-	-	-	-	-	**122.81**
MM44	192.23	355.49	-	-	-	-	**547.72**
MM45	560.80	337.28	-	27.00	-	-	**925.08**
NF11	-	1,282.61	-	142.17	-	-	**1,424.78**

Timber Type	Region 1	Region 2	Region 3	Region 4	Region 5	Region 7	Total
NF21	-	-	-	24.19	10.35	-	**34.54**
NF22	5.48	119.09	32.51	839.57	79.18	212.82	**1,288.65**
NF23	-	157.63	34.74	542.30	-	382.10	**1,116.77**
NF24	-	13.96	-	181.57	-	88.02	**283.55**
NF25	-	16.27	-	59.50	-	13.77	**89.54**
NF31	-	-	4.68	76.91	30.02	15.62	**127.23**
NF32	4.10	245.07	172.43	1,353.66	179.65	77.00	**2,031.91**
NF33	14.39	348.86	170.11	914.96	33.34	329.85	**1,811.51**
NF34	4.96	147.75	133.76	995.06	-	219.06	**1,500.59**
NF35	3.59	12.99	2.43	245.48	-	41.83	**306.32**
NF41	-	48.04	15.67	198.49	12.51	-	**274.71**
NF42	39.27	275.69	176.20	947.31	87.21	-	**1,525.68**
NF43	21.89	118.47	267.84	369.15	24.41	3.68	**805.44**
NF44	-	451.11	377.31	197.41	-	-	**1,025.83**
NF45	-	68.90	241.76	71.75	-	-	**382.41**
PP11	-	54.82	-	16.09	-	-	**70.91**
PP12	-	22.56	-	-	-	-	**22.56**
PP22	115.17	285.73	-	52.46	73.64	6.57	**533.57**
PP23	3.93	148.24	-	41.47	65.81	-	**259.45**
PP24	-	45.23	-	1.84	50.06	-	**97.13**
PP25	-	6.82	-	-	-	-	**6.82**
PP31	-	15.33	-	-	-	-	**15.33**
PP32	25.63	1,291.12	-	221.03	63.15	97.42	**1,698.35**
PP33	19.12	466.25	-	420.02	38.77	80.24	**1,024.40**
PP34	36.40	426.87	-	321.95	12.14	5.10	**802.46**
PP35	67.78	68.83	-	63.85	-	-	**200.46**
PP41	-	-	-	79.79	-	-	**79.79**
PP42	333.83	2,783.26	-	581.77	95.80	-	**3,794.66**
PP43	630.25	1,480.93	-	968.74	197.97	-	**3,277.89**
PP44	593.75	2,314.47	-	1,107.27	16.20	-	**4,031.69**
PP45	146.20	393.46	-	249.52	-	-	**789.18**
SS23	-	-	17.95	-	-	-	**17.95**
SS32	-	61.17	40.46	-	-	-	**101.63**
SS33	-	-	32.32	-	-	-	**32.32**
SS34	-	9.56	91.59	-	-	-	**101.15**
SS35	-	-	74.90	-	-	-	**74.90**
SS42	-	-	93.49	-	-	-	**93.49**
SS43	-	-	111.15	-	-	-	**111.15**
SS44	-	-	1,375.82	-	-	-	**1,375.82**
SS45	-	-	1,438.12	20.80	-	-	**1,458.92**
W00	279.22	565.32	161.91	735.85	14.31	83.05	**1,839.66**
XX00	3,628.34	28,976.94	58,753.90	54,301.90	4,558.02	10,675.97	**160,895.07**
XX10	-	92.16	-	-	-	-	**92.16**
XX11	-	22,217.85	-	-	-	-	**22,217.85**
XX22	-	4.58	-	-	-	-	**4.58**
XX23	-	1.97	-	5.78	-	-	**7.75**
XX24	-	1.38	-	-	-	-	**1.38**
XX31	-	3.50	-	-	-	-	**3.50**

Timber Type	Region 1	Region 2	Region 3	Region 4	Region 5	Region 7	Total
XX32	-	29.20	-	-	-	-	**29.20**
XX33	-	13.46	-	3.49	-	-	**16.95**
XX34	-	2.05	-	-	-	-	**2.05**
XX41	-	4.64	-	-	-	-	**4.64**
XX42	-	0.77	-	-	-	-	**0.77**
XX43	-	13.55	-	0.69	-	-	**14.24**
XX45	-	0.99	-	-	-	-	**0.99**
XX99	-	-	-	-	-	-	**-**
TOTAL	**15,279**	**137,871**	**107,879**	**80,092**	**5,946**	**12,752**	**359,819**

Note: See Section 2.2, page 8 for timber type definitions. Timber type = Species, Size Class, Stocking

Appendix C: Forest Inventory Summary Data

Table C-1: Number of inventory plots within each timber type by administrative region

Timber Type	Region 1	Region 2	Region 3	Region 4	Region 5	Total
DF11	N/A	7	-	-	N/A	**7**
DF21	N/A	3	-	-	N/A	**3**
DF22	4	3	5	-	10	**22**
DF23	-	2	14	6	7	**29**
DF24	N/A	1	8	3	N/A	**12**
DF25	N/A	2	N/A	3	N/A	**5**
DF31	N/A	12	-	-	N/A	**12**
DF32	N/A	22	2	3	5	**32**
DF33	-	38	16	8	12	**74**
DF34	8	15	4	13	5	**45**
DF35	10	-	9	14	N/A	**33**
DF41	N/A	15	N/A	-	N/A	**15**
DF42	3	23	28	6	N/A	**60**
DF43	21	33	27	15	N/A	**96**
DF44	25	21	77	30	47	**200**
DF45	22	6	55	100	19	**202**
LP11	N/A	-	N/A	N/A	N/A	**-**
LP21	N/A	-	N/A	N/A	N/A	**-**
LP22	-	1	13	-	N/A	**14**
LP23	-	6	2	N/A	N/A	**8**
LP24	13	1	3	N/A	N/A	**17**
LP25	N/A	9	2	N/A	N/A	**11**
LP31	N/A	N/A	N/A	-	N/A	**-**
LP32	-	7	4	N/A	N/A	**11**
LP33	-	1	31	N/A	N/A	**32**
LP34	N/A	24	26	1	N/A	**51**
LP35	4	7	13	7	7	**38**
LP41	N/A	-	N/A	N/A	N/A	**-**
LP42	N/A	2	9	N/A	N/A	**11**
LP43	-	-	13	-	N/A	**13**
LP44	N/A	17	66	-	N/A	**83**
LP45	21	27	51	23	N/A	**122**
MC11	N/A	-	N/A	N/A	N/A	**-**
MC13	N/A	-	N/A	N/A	N/A	**-**
MC21	N/A	-	N/A	N/A	N/A	**-**
MC22	-	17	-	-	3	**20**
MC23	23	16	N/A	N/A	N/A	**39**
MC24	21	9	N/A	N/A	6	**36**
MC25	4	6	N/A	N/A	N/A	**10**
MC31	N/A	3	N/A	N/A	N/A	**3**
MC32	-	5	N/A	N/A	N/A	**5**
MC33	10	2	-	N/A	N/A	**12**
MC34	8	5	9	6	9	**37**
MC35	13	6	-	3	5	**27**
MC41	N/A	10	N/A	N/A	N/A	**10**

Timber Type	Region 1	Region 2	Region 3	Region 4	Region 5	Total
MC42	20	42	7	-	N/A	**69**
MC43	16	16	15	-	N/A	**47**
MC44	34	5	12	4	34	**89**
MC45	31	10	16	23	N/A	**80**
MM23	N/A	-	N/A	N/A	N/A	**-**
MM24	N/A	-	N/A	N/A	N/A	**-**
MM31	N/A	2	N/A	N/A	N/A	**2**
MM32	N/A	-	N/A	N/A	N/A	**-**
MM33	-	1	N/A	N/A	N/A	**1**
MM34	-	-	-	N/A	N/A	**-**
MM35	6	3	N/A	N/A	N/A	**9**
MM41	-	N/A	N/A	N/A	N/A	**-**
MM42	5	-	N/A	N/A	N/A	**5**
MM43	-	N/A	N/A	N/A	N/A	**-**
MM44	9	5	N/A	N/A	N/A	**14**
MM45	7	2	N/A	4	N/A	**13**
PP11	N/A	5	N/A	5	N/A	**10**
PP12	N/A	-	N/A	N/A	N/A	**-**
PP22	1	1	N/A	3	29	**34**
PP23	-	2	N/A	8	27	**37**
PP24	N/A	-	N/A	-	23	**23**
PP25	N/A	-	N/A	N/A	N/A	**-**
PP31	N/A	-	N/A	N/A	N/A	**-**
PP32	10	7	N/A	12	8	**37**
PP33	3	5	N/A	15	17	**40**
PP34	-	9	N/A	14	3	**26**
PP35	-	3	N/A	-	N/A	**3**
PP41	N/A	N/A	N/A	16	N/A	**16**
PP42	18	28	N/A	16	47	**109**
PP43	32	6	N/A	37	58	**133**
PP44	20	17	N/A	30	8	**75**
PP45	6	3	N/A	6	N/A	**15**
SS23	N/A	N/A	-	N/A	N/A	**-**
SS32	N/A	-	-	N/A	N/A	**-**
SS33	N/A	N/A	-	N/A	N/A	**-**
SS34	N/A	-	-	N/A	N/A	**-**
SS35	N/A	N/A	-	N/A	N/A	**-**
SS42	N/A	N/A	-	N/A	N/A	**-**
SS43	N/A	N/A	5	N/A	N/A	**5**
SS44	N/A	N/A	15	N/A	N/A	**15**
SS45	N/A	N/A	-	-	N/A	**-**
TOTAL	**428**	**556**	**557**	**434**	**389**	**2,364**

Note: N/A = Timber Type does not exist in that administrative region.

Forest Inventory Sampling Intensity

The following tables show the statistical results of the forest inventory on the sawtimber sized (Size Class 4) timber types, which demonstrates the sampling intensity to satisfy MT-FWP specifications.

Table C-2: Region 1 Scribner net board foot – inventory statistics

MBG Total BF/Ac Estimate of Region 1 =	7,724
Variance of the Mean =	149,185
Estimate of Standard Error =	386
Standard Error as Percent of Mean =	5.00%
90% Confidence Interval Half Width as Percent =	8.25%
90% C.I. Lower Bound (BF/Ac) =	7,087
90% C.I. Upper Bound (BF/Ac) =	8,362

Table C-3: Region 1 total cubic foot – inventory statistics

MBG Total CF/Ac Estimate of Region 1 =	2,103
Variance of the Mean =	7,142
Estimate of Standard Error =	85
Standard Error as Percent of Mean =	4.02%
90% Confidence Interval Half Width as Percent =	6.63%
90% C.I. Lower Bound (CF/Ac) =	1,964
90% C.I. Upper Bound (CF/Ac) =	2,242

Table C-4: Region 2 Scribner net board foot – inventory statistics

MBG Total BF/Ac Estimate of Region 2 =	6,449
Variance of the Mean =	117,997
Estimate of Standard Error =	344
Standard Error as Percent of Mean =	5.33%
90% Confidence Interval Half Width as Percent =	8.79%
90% C.I. Lower Bound (BF/Ac) =	5,882
90% C.I. Upper Bound (BF/Ac) =	7,016

Table C-5: Region 2 total cubic foot – inventory statistics

MBG Total CF/Ac Estimate of Region 2 =	2,093
Variance of the Mean =	9,041
Estimate of Standard Error =	95
Standard Error as Percent of Mean =	4.54%
90% Confidence Interval Half Width as Percent =	7.50%
90% C.I. Lower Bound (CF/Ac) =	1,936
90% C.I. Upper Bound (CF/Ac) =	2,250

Table C-6: Region 3 Scribner net board foot – inventory statistics

MBG Total BF/Ac Estimate of Region 3 =	5,577
Variance of the Mean =	80,248
Estimate of Standard Error =	283
Standard Error as Percent of Mean =	5.08%
90% Confidence Interval Half Width as Percent =	8.38%
90% C.I. Lower Bound (BF/Ac) =	5,109
90% C.I. Upper Bound (BF/Ac) =	6,044

Table C-7: Region 3 total cubic foot – inventory statistics

MBG Total CF/Ac Estimate of Region 3 =	1,855
Variance of the Mean =	4,945
Estimate of Standard Error =	70
Standard Error as Percent of Mean =	3.79%
90% Confidence Interval Half Width as Percent =	6.25%
90% C.I. Lower Bound (CF/Ac) =	1,739
90% C.I. Upper Bound (CF/Ac) =	1,971

Table C-8: Region 4 Scribner net board foot – inventory statistics

MBG Total BF/Ac Estimate of Region 4 =	6,619
Variance of the Mean =	105,802
Estimate of Standard Error =	325
Standard Error as Percent of Mean =	4.91%
90% Confidence Interval Half Width as Percent =	8.11%
90% C.I. Lower Bound (BF/Ac) =	6,083
90% C.I. Upper Bound (BF/Ac) =	7,156

Table C-9: Region 4 total cubic foot – inventory statistics

MBG Total CF/Ac Estimate of Region 4 =	2,091
Variance of the Mean =	5,703
Estimate of Standard Error =	76
Standard Error as Percent of Mean =	3.61%
90% Confidence Interval Half Width as Percent =	5.96%
90% C.I. Lower Bound (CF/Ac) =	1,966
90% C.I. Upper Bound (CF/Ac) =	2,216

Table C-10: Region 5 Scribner net board foot – inventory statistics

MBG Total BF/Ac Estimate of Region 5 =	3,245
Variance of the Mean =	48,249
Estimate of Standard Error =	220
Standard Error as Percent of Mean =	6.77%
90% Confidence Interval Half Width as Percent =	11.18%
90% C.I. Lower Bound (BF/Ac) =	2,882
90% C.I. Upper Bound (BF/Ac) =	3,608

Table C-11: Region 5 total cubic foot – inventory statistics

MBG Total CF/Ac Estimate of Region 5 =	1,278
Variance of the Mean =	5,337
Estimate of Standard Error =	73
Standard Error as Percent of Mean =	5.72%
90% Confidence Interval Half Width as Percent =	9.44%
90% C.I. Lower Bound (CF/Ac) =	1,158
90% C.I. Upper Bound (CF/Ac) =	1,399

Note: Regarding Region 5 (Haymaker and Silver Run units):
Because the stands in Region 5 are highly variable and trees are high in defect, additional plots would cause only a marginal change in the net Scribner Decimal C volume confidence level (a measure the merchantable portion of the tree).

For these reasons, we are confident that the cubic foot volume (includes top and stump) confidence level will suffice in illustrating MB&G's sampling intensity in Region 5.

MT-FWP Management Units – excluded from inventory

These units are entirely non-commercial forestland and were not included in the forest inventory. Units were visited to confirm their status. Some data was collected at these units to calculate tree growth rates to verify the non-commercial forest land classification. Administratively withdrawn units or stands are not included in this table.

Table C-12: MT-FWP management units excluded from the forest inventory

Region	Unit	Unit Type	Total Acres
1	Old Steel Bridge	FAS	128
2	Erskine	FAS	423
3	Bannack	State Park	1,622
3	Missouri Headwaters	State Park	592
4	Marias River	WMA	7,348
4	Tower Rock	State Park	137
5	Yellowstone	WMA	3,961
7	Isaac Homestead	WMA	1,261
7	Makoshika	State Park	11,491
Total			**26,963**

Appendix D: Management Regime Summary

This section shows the management regimes used to calculate the annual sustained yield in each administrative region.

All regime names were constructed in the following format:

Regime Name: A B C D E where:

- A = Management emphasis [E = even-aged; U = uneven-aged]
- B = Potential vegetation/residual species goal
- C = Residual Basal Area (square feet/acre)
- D = Re-entry (in years)
- E = Residual stand composition [L = more large trees; E = even distribution of size classes]

Management regimes were designed to thin down to a target basal area within specific diameter classes to achieve the desired stand composition. For all basal area targets, the desired diameter class distribution used a 'q-factor' of 1.2 and a target DBH of 19". The following tables show the target basal area by diameter class distribution for the different thinning intensities. These distributions remained consistent in every administrative region and apply to the regimes that have large trees as the desired stand composition. Regimes that strive to have an even distribution of tree sizes as the desired stand composition have equal residual basal area targets for the different thinning intensities.

A q-factor of 1.2 was chosen to provide enough small trees in stands to provide some hiding cover while also developing large trees that provide thermal cover and large tree habitat. A q-factor of 1.1 or 1.0 would provide larger diameter trees after harvest, but not enough small trees to sustain the distribution over time. A higher q-factor of 1.3 or 1.4 would provide more small trees, but fewer large diameter trees. The choice of a q-factor of 1.2 represents a compromise between the two extremes, which will result in stand conditions that meet MT-FWP's management objectives.

Table D-1: Target basal area diameter class distribution – 80 square feet/acre

DBH Class	Residual Basal Area	Residual Trees Per Acre
2 – 5"	9	140
6 – 9"	20	67
10 – 14"	28	38
15" +	23	15
Total	**80**	**260**

Table D-2: Target basal area diameter class distribution – 60 square feet/acre

DBH Class	Residual Basal Area	Residual Trees Per Acre
2 – 5"	7	105
6 – 9"	15	50
10 – 14"	21	28
15" +	17	11
Total	**60**	**195**

Table D-3: Target basal area diameter class distribution – 40 square feet/acre

DBH Class	Residual Basal Area	Residual Trees Per Acre
2 – 5”	5	70
6 – 9”	10	34
10 – 14”	14	19
15” +	11	8
Total	**40**	**130**

For comparison purposes and to give MT-FWP an idea of what the planning thinning intensities look like on the ground, the follow pictures generally show forest stands after a commercial thin to 80, 60, and 40 square feet of residual basal area. For the most part, these are examples of how a forest stand looks after a first thinning entry. After subsequent entries, the stands will begin to develop the desired multi-storied canopy characteristics of uneven-aged management.

<u>80 Square Feet of Residual Basal Area</u>:

BEFORE

AFTER

60 Square Feet of Residual Basal Area:

BEFORE

AFTER

<u>40 Square Feet of Residual Basal Area</u>:

BEFORE

AFTER

Table D-4: Region 1 management regimes

MT Management Regime	MBG Management Regime	Thinning Intensity	Re-entry (years)	Composition	Timber Type Species
U DF ReduceBy30%BA 30 L	U DF 60BA 30 L	Residual BA of 60	30	Large Trees	DF, MC, MM
U DF ReduceBy30%BA 50 L	U DF 60BA 50 L	Residual BA of 60	50	Large Trees	DF, MC, MM
U DF ReduceBy10%-20%BA 30 L	U DF 80BA 30 L	Residual BA of 80	30	Large Trees	DF, MC, MM
U DF ReduceBy10%-20%BA 50 L	U DF 80BA 50 L	Residual BA of 80	50	Large Trees	DF, MC, MM
U PP ReduceBy30%BA 30 L	U PP 60BA 30 L	Residual BA of 60	30	Large Trees	PP
U PP ReduceBy30%BA 50 L	U PP 60BA 50 L	Residual BA of 60	50	Large Trees	PP
U PP ReduceBy10%-20%BA 30 L	U PP 80BA 30 L	Residual BA of 80	30	Large Trees	PP

Note: All LP timber types were assigned to a 90 year even-aged management regime = clear-cut and regenerate every 90 years. This is a standard management approach for lodgepole pine stands throughout Montana.

Column Headings:
MT Management Regime = management regime provided by MT-FWP
MBG Management Regime = MBG's translation of the regime provided by MT-FWP
Thinning Intensity = the residual basal area after thinning
Re-entry (years) = the minimum number of years between a thinning (harvest) for a particular forest stand
Composition = residual stand composition
Timber Type Species = management regimes are applied to stands according to these timber type species

Table D-5: Region 2 management regimes

MT Management Regime	MBG Management Regime	Thinning Intensity	Re-entry (years)	Composition	Timber Type Species
U DF 60BA 30 L	U DF 60BA 30 E	Residual BA of 60	30	Even Distribution	DF
U DF 60BA 40 L	U DF 60BA 50 E	Residual BA of 60	50	Even Distribution	DF
U DF 60BA 20 E	U DF 40BA 30 E	Residual BA of 40	30	Even Distribution	DF
U DF 60BA 30 E	U DF 40BA 50 E	Residual BA of 40	50	Even Distribution	DF
U MC 80BA 40 L	U MC 60BA 30 L	Residual BA of 60	30	Large trees	MC
U MC 80BA 50 L	U MC 60BA 50 L	Residual BA of 60	50	Large trees	MC
U MC 60BA 40 L	U MC 40BA 30 L	Residual BA of 40	30	Large trees	MC
U MC 60BA 50 L	U MC 40BA 50 L	Residual BA of 40	50	Large trees	MC
U MM 100BA 20 E	U MM 80BA 30 E	Residual BA of 80	30	Even Distribution	MM
U MM 100BA 30 E	U MM 80BA 50 E	Residual BA of 80	50	Even Distribution	MM
N/A	U MM 60BA 30 E	Residual BA of 60	30	Even Distribution	MM
N/A	U MM 60BA 50 E	Residual BA of 60	50	Even Distribution	MM
U PP 80BA 30 L	U PP 60BA 30 L	Residual BA of 60	30	Large trees	PP
U PP 80BA 40 L	U PP 60BA 40 L	Residual BA of 60	50	Large trees	PP
U PP 60BA 30 L	U PP 40BA 30 L	Residual BA of 40	30	Large trees	PP
U PP 60BA 40 L	U PP 40BA 50 L	Residual BA of 40	50	Large trees	PP
U SS 100BA 20 E	U SS 60BA 30 E	Residual BA of 60	30	Even Distribution	SS
U SS 100BA 30 E	U SS 60BA 50 E	Residual BA of 60	50	Even Distribution	SS
N/A	U SS 40BA 30 E	Residual BA of 40	30	Even Distribution	SS
N/A	U SS 40BA 50 E	Residual BA of 40	50	Even Distribution	SS

Note: All LP timber types were assigned to a 90 year even-aged management regime = clear-cut and regenerate every 90 years. This is a standard management approach for lodgepole pine stands throughout Montana.

Column Headings:
MT Management Regime = management regime provided by MT-FWP
MBG Management Regime = MBG's translation of the regime provided by MT-FWP
Thinning Intensity = the residual basal area after thinning
Re-entry (years) = the minimum number of years between a thinning (harvest) for a particular forest stand
Composition = residual stand composition
Timber Type Species = management regimes are applied to stands according to these timber type species

Table D-6: Region 3 management regimes

MT Management Regime	MBG Management Regime	Thinning Intensity	Re-entry (years)	Composition	Timber Type Species
U DF ReduceBy10%BA 30 L	U DF 60BA 30 L	Residual BA of 60	30	Large trees	DF
U DF ReduceBy10%BA 50 L	U DF 60BA 50 L	Residual BA of 60	50	Large trees	DF
U DF ReduceBy20%BA 30 L	U DF 40BA 30 L	Residual BA of 40	30	Large trees	DF
U DF ReduceBy20%BA 50 L	U DF 40BA 50 L	Residual BA of 40	50	Large trees	DF
U MC 80BA 40 L	U MC 60BA 30 L	Residual BA of 60	30	Large trees	MC
U MC 80BA 50 L	U MC 60BA 50 L	Residual BA of 60	50	Large trees	MC
U MC 60BA 40 L	U MC 40BA 30 L	Residual BA of 40	30	Large trees	MC
U MC 60BA 50 L	U MC 40BA 50 L	Residual BA of 40	50	Large trees	MC
U PP 80BA 30 L	U PP 60BA 30 L	Residual BA of 60	30	Large trees	PP
U PP 80BA 40 L	U PP 60BA 50 L	Residual BA of 60	50	Large trees	PP
U PP 60BA 30 L	U PP 40BA 30 L	Residual BA of 40	30	Large trees	PP
U PP 60BA 40 L	U PP 40BA 50 L	Residual BA of 40	50	Large trees	PP
U SS 100BA 20 E	U SS 60BA 30 L	Residual BA of 60	30	Large trees	SS
U SS 100BA 30 E	U SS 60BA 50 L	Residual BA of 60	50	Large trees	SS
N/A	U SS 40BA 30 L	Residual BA of 40	30	Large trees	SS
N/A	U SS 40BA 50 L	Residual BA of 40	50	Large trees	SS

Note: All LP timber types were assigned to a 90 year even-aged management regime = clear-cut and regenerate every 90 years. This is a standard management approach for lodgepole pine stands throughout Montana.

Column Headings:
MT Management Regime = management regime provided by MT-FWP
MBG Management Regime = MBG's translation of the regime provided by MT-FWP
Thinning Intensity = the residual basal area after thinning
Re-entry (years) = the minimum number of years between a thinning (harvest) for a particular forest stand
Composition = residual stand composition
Timber Type Species = management regimes are applied to stands according to these timber type species

Table D-7: Region 4 management regimes

MT Management Regime	MBG Management Regime	Thinning Intensity	Re-entry (years)	Composition	Timber Type Species
N/A	U DF 60BA 30 L	Residual BA of 60	30	Large trees	DF
N/A	U DF 60BA 50 L	Residual BA of 60	50	Large trees	DF
N/A	U DF 40BA 30 L	Residual BA of 40	30	Large trees	DF
N/A	U DF 40BA 50 L	Residual BA of 40	50	Large trees	DF
N/A	U MC 60BA 30 L	Residual BA of 60	30	Large trees	MC
N/A	U MC 60BA 50 L	Residual BA of 60	50	Large trees	MC
N/A	U MC 40BA 30 L	Residual BA of 40	30	Large trees	MC
N/A	U MC 40BA 50 L	Residual BA of 40	50	Large trees	MC
N/A	U PP 60BA 30 L	Residual BA of 60	30	Large trees	PP
N/A	U PP 60BA 50 L	Residual BA of 60	50	Large trees	PP
N/A	U PP 40BA 30 L	Residual BA of 40	30	Large trees	PP
N/A	U PP 40BA 50 L	Residual BA of 40	50	Large trees	PP
N/A	U SS 60BA 30 L	Residual BA of 60	30	Large trees	SS
N/A	U SS 60BA 50 L	Residual BA of 60	50	Large trees	SS
N/A	U SS 40BA 30 L	Residual BA of 40	30	Large trees	SS
N/A	U SS 40BA 50 L	Residual BA of 40	50	Large trees	SS

Note: All LP timber types were assigned to a 90 year even-aged management regime = clear-cut and regenerate every 90 years. This is a standard management approach for lodgepole pine stands throughout Montana.

Column Headings:
MT Management Regime = management regime provided by MT-FWP
MBG Management Regime = MBG's translation of the regime provided by MT-FWP
Thinning Intensity = the residual basal area after thinning
Re-entry (years) = the minimum number of years between a thinning (harvest) for a particular forest stand
Composition = residual stand composition
Timber Type Species = management regimes are applied to stands according to these timber type species

Table D-8: Region 5 management regimes

MT Management Regime	MBG Management Regime	Thinning Intensity	Re-entry (years)	Composition	Timber Type Species
U PP ReduceBy20%BA 30 E	U PP 60BA 30 L	Residual BA of 60	30	Large trees	PP
U PP ReduceBy20%BA 50 E	U PP 60BA 50 L	Residual BA of 60	50	Large trees	PP
U PP ReduceBy30%BA 30 L	U PP 40BA 30 L	Residual BA of 40	30	Large trees	PP
U PP ReduceBy30%BA 50 L	U PP 40BA 50 L	Residual BA of 40	50	Large trees	PP

Note: All LP timber types were assigned to a 90 year even-aged management regime = clear-cut and regenerate every 90 years. This is a standard management approach for lodgepole pine stands throughout Montana.

Column Headings:
MT Management Regime = management regime provided by MT-FWP
MBG Management Regime = MBG's translation of the regime provided by MT-FWP
Thinning Intensity = the residual basal area after thinning
Re-entry (years) = the minimum number of years between a thinning (harvest) for a particular forest stand
Composition = residual stand composition
Timber Type Species = management regimes are applied to stands according to these timber type species

Appendix E: Insects, Disease, and Fire Mortality on MT-FWP Lands

The following table shows the number of acres within each management unit that have trees which show signs of insect and disease damage. The estimate is derived from the USFS's annual aerial detection survey. The table shows acreage estimates for each year from 2005 to 2012 – the estimates aren't cumulative across years and are intended to serve as a general snapshot of insect and disease damage in any particular year.

Table E-1: Estimated tree mortality (in acres) from insect and disease damage, 2005-2012.

Region	Unit	Type	2005	2006	2007	2008	2009	2010	2011	2012
1	Bull River	WMA	-	-	-	-	-	-	-	-
1	Kokanee Bend	FAS	-	-	-	-	-	-	-	-
1	Kootenai/Falls	WMA	-	-	-	-	-	-	-	-
1	Kootenai/West	WMA	-	-	-	-	-	-	-	-
1	Kootenai/Woods Ranch	WMA	-	-	-	-	2	-	-	-
1	Lake Mary Ronan	State Park	-	-	-	-	36	-	110	-
1	Lone Pine	State Park	109	-	-	2	-	4	-	89
1	Mount Silcox	WMA	4	55	10	-	-	-	2	-
1	North Swan Valley	WMA	68	2	4	2	2	-	271	125
1	Old Steel Bridge	FAS	-	-	-	-	-	-	-	-
1	Ray Kuhns	WMA	2	0	4	3	-	-	259	4
1	Swan River	FAS	-	-	-	-	-	-	21	-
1	Thompson Chain Of Lakes (East)	State Park	2	-	-	40	-	-	-	46
1	Thompson Chain Of Lakes (West)	State Park	4	-	-	54	-	-	-	2
1	Wayfarers	State Park	2	-	-	-	-	-	-	-
1	West Shore	State Park	-	2	-	-	-	-	-	-
1	Wild Horse Island	State Park	328	25	12	5	68	62	21	29
2	Beavertail Hill	State Park	-	-	-	-	2	-	-	-
2	Blackfoot-Clearwater 1	WMA	67	177	-	228	979	589	548	105
2	Blackfoot-Clearwater/Harpers Lake	WMA	4	115	-	116	389	1,786	2,959	597
2	Calf Creek	WMA	95	46	-	2	13	34	200	225
2	Erskine	FAS	-	-	-	-	-	-	-	-

Region	Unit	Type	2005	2006	2007	2008	2009	2010	2011	2012
2	Fish Creek	WMA	176	107	53	2	396	57	190	16
2	Fish Creek	State Park	10	13	3	-	4	-	4	2
2	Garrity Mountain	WMA	11	127	-	3,212	5,680	2,894	928	395
2	Lost Creek	State Park	135	145	-	222	353	87	-	2
2	Lost Creek	WMA	51	2	-	16	419	67	-	-
2	Marshall Creek	WMA	190	115	-	62	526	-	2,246	8,279
2	Milltown	State Park	-	-	-	-	33	-	-	-
2	Monture Creek	FAS	-	-	-	-	2	-	17	-
2	Mount Jumbo	WMA	-	-	-	-	12	-	23	-
2	Nevada Lake	WMA	13	550	-	181	378	372	-	307
2	River Junction	FAS	2	-	2	5	41	-	52	2
2	Spotted Dog	WMA	2,721	4,058	2,151	1,398	3,558	168	2,973	752
2	Stuart Mill Bay	FAS	-	-	-	160	131	138	150	110
2	Threemile	WMA	145	130	-	25	763	634	-	1,718
3	Bannack	State Park	-	-	-	-	-	-	-	17
3	Canyon Creek	WMA	2,099	2,330	2,369	2,335	924	-	2,246	-
3	Fleecer Mountain	WMA	295	644	-	746	500	-	-	138
3	Gallatin	WMA	82	676	569	2,989	4,732	2,186	1,330	219
3	Lewis And Clark Caverns	State Park	-	352	2	-	21	-	-	-
3	Madison-Bear Creek	WMA	-	-	-	29	-	-	2	-
3	Madison-Wall Creek	WMA	-	-	38	-	41	-	7	-
3	Missouri Headwaters	State Park	-	-	-	-	-	-	-	-
3	Mt. Haggin	WMA	5,660	7,750	3,129	27,300	26,423	10,561	162	7,814
3	Robb-Ledford	WMA	112	373	706	647	538	129	45	-
4	Beartooth	WMA	196	959	-	1,880	622	2,214	-	2,806
4	Beckman	WMA	-	-	-	-	-	-	-	-
4	Blackleaf	WMA	-	-	-	-	779	517	864	-
4	Ear Mountain	WMA	-	-	-	-	394	296	303	-
4	Judith River	WMA	5	38	-	-	778	-	740	128
4	Marias River	WMA	-	-	-	-	-	-	-	-
4	Sluice Boxes	State Park	64	129	57	-	840	257	621	118
4	Smith River State Park (Central)	State Park	-	-	-	83	272	-	-	6
4	Smith River State Park	State Park	-	-	-	-	-	-	-	-

Region	Unit	Type	2005	2006	2007	2008	2009	2010	2011	2012
	(North)									
4	Smith River State Park (South)	State Park	-	2	-	139	18	1	-	39
4	Smith River/Fort Logan	WMA	-	33	-	51	500	722	-	470
4	Sun River	WMA	-	-	-	-	-	-	-	-
4	Sun River 2	WMA	-	-	-	-	116	319	79	-
4	Tower Rock	State Park	-	-	-	-	-	-	-	-
5	Haymaker	WMA	2	-	-	-	173	-	-	126
5	Silver Run	WMA	-	-	-	-	-	-	-	-
5	Yellowstone	WMA	-	-	-	-	-	-	-	-
7	Isaac Homestead	WMA	-	-	-	-	-	-	-	-
7	Makoshika	WMA	-	-	-	-	-	-	-	-
Total			**12,654**	**18,955**	**9,109**	**41,934**	**51,458**	**24,094**	**17,373**	**24,686**

Source Data: USFS's aerial detection survey, 2005-2012.

Table E-2, below, provides an estimate of acres affected due to wildfire by the degree of burn severity from 1984 to 2012. These estimates were derived by the Monitoring Trends in Burn Severity Project – a collaborative effort across government agencies to track wildfire damage across the United States. Burn severity refers to the degree to which a site has been altered or disrupted by fire. The severity is determined by comparing high resolution aerial imagery pre- and post-fire to arrive at a normalized burn ratio (NBR), which is then separated into the three burn severity categories.

Table E-2: Acres affected due to wildfire by degree of burn severity (Low, Medium, and High), 1984-2012

Region	Unit	Type	Low	Medium	High
1	Bull River	WMA	-	-	-
1	Kokanee Bend	FAS	-	-	-
1	Kootenai/Falls	WMA	-	-	-
1	Kootenai/West	WMA	-	-	-
1	Kootenai/Woods Ranch	WMA	-	-	-
1	Lake Mary Ronan	State Park	-	-	-
1	Lone Pine	State Park	-	-	-
1	Mount Silcox	WMA	-	-	-
1	North Swan Valley	WMA	-	-	-
1	Old Steel Bridge	FAS	-	-	-
1	Ray Kuhns	WMA	-	-	-
1	Swan River	FAS	-	-	-
1	Thompson Chain Of Lakes (East)	State Park	-	-	-
1	Thompson Chain Of Lakes (West)	State Park	-	-	-
1	Wayfarers	State Park	-	-	-
1	West Shore	State Park	-	-	-
1	Wild Horse Island	State Park	-	-	-
2	Beavertail Hill	State Park	-	-	-
2	Blackfoot-Clearwater 1	WMA	-	-	-
2	Blackfoot-Clearwater/Harpers Lake	WMA	-	-	-
2	Calf Creek	WMA	-	-	-
2	Erskine	FAS	-	-	-
2	Fish Creek	WMA	12,971	3,691	667
2	Fish Creek	State Park	1,134	608	180
2	Garrity Mountain	WMA	-	-	-
2	Lost Creek	State Park	-	-	-

Region	Unit	Type	Low	Medium	High
2	Lost Creek	WMA	-	-	-
2	Marshall Creek	WMA	1,333	1,372	402
2	Milltown	State Park	-	-	-
2	Monture Creek	FAS	-	-	-
2	Mount Jumbo	WMA	-	-	-
2	Nevada Lake	WMA	-	-	-
2	River Junction	FAS	-	-	-
2	Spotted Dog	WMA	-	-	-
2	Stuart Mill Bay	FAS	-	-	-
2	Threemile	WMA	429	91	22
3	Bannack	State Park	-	-	-
3	Canyon Creek	WMA	-	-	-
3	Fleecer Mountain	WMA	-	-	-
3	Gallatin	WMA	-	-	-
3	Lewis And Clark Caverns	State Park	-	-	-
3	Madison-Bear Creek	WMA	-	-	-
3	Madison-Wall Creek	WMA	-	-	-
3	Missouri Headwaters	State Park	-	-	-
3	Mt. Haggin	WMA	-	-	-
3	Robb-Ledford	WMA	-	-	-
4	Beartooth	WMA	571	125	39
4	Beckman	WMA	-	-	-
4	Blackleaf	WMA	-	-	-
4	Ear Mountain	WMA	-	-	-
4	Judith River	WMA	-	-	-
4	Marias River	WMA	-	-	-
4	Sluice Boxes	State Park	-	-	-
4	Smith River State Park (Central)	State Park	-	-	-
4	Smith River State Park (North)	State Park	-	-	-
4	Smith River State Park (South)	State Park	-	-	-
4	Smith River/Fort Logan	WMA	-	-	-
4	Sun River	WMA	-	-	-
4	Sun River 2	WMA	-	-	-
4	Tower Rock	State Park	-	-	-

Region	Unit	Type	Low	Medium	High
5	Haymaker	WMA	-	-	-
5	Silver Run	WMA	-	-	-
5	Yellowstone	WMA	-	-	-
7	Isaac Homestead	WMA	-	-	-
7	Makoshika	WMA	-	-	-
Total			**16,438**	**5,887**	**1,310**

Source Data: Monitoring Trends in Burn Severity (MTBS) Project, 2012.

Appendix F: Considerations for a MT-FWP Timber Sale Program

The forestry program of Montana Department of Fish, Wildlife and Parks (MT-FWP) is in its initial stages. MT-FWP has conducted several forest management projects that involved harvesting and selling forest products. One of the key questions to answer when developing a forest management program is how much volume can sustainably be harvested. Now that MT-FWP has an estimate of their sustainable annual board foot yield, they could offer for sale up to that amount of volume each year or over a number of years, or sell an amount of volume that had an annual average equivalent to the annual sustainable yield. The purpose of this appendix is to provide MT-FWP with an overview of the elements of a forest management program run by a state agency. Assuming MT-FWP will continue to develop a forest management program in the near future; this information is intended to help MT-FWP initiate their program. The information in this document may help MT-FWP establish the program more efficiently, and keep them from "re-inventing the wheel". The operational components of MT-FWP's forest management program could and logically probably should have many similarities to the Montana Department of Natural Resources and Conservation's (DNRC) forest management program.

Forest Management Goals and Objectives

An essential part of a successful program is having clear and attainable goals and objectives to guide the organization in its planning, decision making, and implementation. The goals and objectives are developed within the context of the organization's vision or mission statement. Often programs within an organization will have their own vision or mission statement in addition to the organization's overall mission statement. The MT-FWP forest management program should develop its own mission statement, goals, and objectives that support the agency's overall functions. As part of the process to determine their sustainable yield, MT-FWP has developed forested habitat objectives for their Wildlife Management Areas and shared their vision for managing the forest land in the Fishing Access Sites and State Parks. The habitat objectives are critically important for forest management planning, determining desired future condition, identifying potential forest management projects on the ground, and selecting appropriate sustainable silvicultural regimes. MT-FWP forest management planning is in its early years and will become more sophisticated and detailed over time as the agency gains experience managing its forest land.

Resources: Budget/Personnel

Ideally, the MT-FWP forest management program would have a program manager and a budget. The size of the program and the number of people working for the program manager will largely depend on the amount of volume MT-FWP intends to sell annually and the process required to sell the timber. Most forest management programs include tasks that are in addition to what is necessary to conduct timber sale projects. These include project and program monitoring, road maintenance, maintenance of gates, fences and other assets, forest improvement/maintenance projects (pre-commercial thinning, planting, weed management, etc), and maintenance of the forest inventory. The number of new FTE will depend on how much of the work gets assigned to existing MT-FWP positions and how much of the work will be done by contractors. At the program level a large amount of planning, budget management, bookkeeping, managing and coordinating of resources is required to run the program. At the project level a great deal of planning, coordination, analysis, field work, and administration is required to successfully complete the project. A large and complex timber sale can take six months to a

year or possibly longer to prepare for sale. It could be another two or three years before a timber sale project of any size has been logged and all the work required by the contract has been completed.

Project Management

Even if MT-FWP did only one timber sale project per year, they will eventually have several forest management projects in various stages of planning, analysis, preparation, field work, and harvesting. The program manager will have to keep track of the progress of all active projects. Available resources will have to be allocated when and where needed. This will require a high level of communication, organizational skills, and constant monitoring of the program budget and progress towards meeting program goals and objectives. The program manager will need to develop a list of potential projects for at least one year into the future and probably will need to create a list of potential projects that extends several years and in some cases decades into the future to facilitate planning, budgeting, and coordination of resources.

It is likely there will be more than one project being proposed every year. The program manager will have to decide which projects will be undertaken in the coming year and those that likely will be initiated the year following that year. This will require the program manager to know the following:

- Project objectives, purpose, and need.
- Project location, administrative unit, legal description.
- Project size, gross acres, rough estimate of BF volume and other forest products to be harvested.
- Access status.
- Road construction, reconstruction, and/or other road improvements required.
- Anticipated social and/or environmental issues.
- Anticipated use of contractors.
- Estimate of project complexity; level of analysis, amount of analysis, amount of public participation, and amount of field work.
- Estimate of amount of time required to get project ready to be sold.
- Rough estimate of cost to complete the project.

Once the decision has been made to pursue a timber sale project each project will require:

- A project manager.
- A budget.
- Someone to verify or obtain legal road access required by the project.
- Specialists to participate in project design, do analysis, and perform reviews.
- A forester to write silvicultural prescriptions and design the timber sale.
- A forester(s) and possibly forestry technician(s) to layout the project on the ground and cruise the sale units.
- A forester to write the timber sale contract.
- Someone to sell the timber sale.
- Someone (probably a forester) to administer the timber sale contract which requires inspection of the harvesting operations, and usually making sure road building and/or road improvements, road maintenance and other activities meet contract specifications.

- Someone to track the volume removed and revenue collected.

Project Contract

To protect all parties involved in conducting the timber sale project, MT-FWP should prepare a contract that contains the specifications for all work to be done by the purchaser to complete the project and the price to be paid by the contractor for harvested forest products. The contract could require the contractor to do road construction and/or maintenance and other activities like fencing, weed control, slash disposal, and site preparation. MT-FWP should consider requiring the contractor to post a performance bond to cover MT-FWP costs and damages should the contractor default on the contract.

Marketing and Selling the Wood

MT-FWP should implement a process for marketing their timber sale projects that will increase the likelihood that they will get a fair price for the wood being sold in their sales. A successful marketing program will make sure all potential purchasers are aware of pending projects, be informed about how to find out details about the project, have adequate time to participate in the bidding process, and are provided with adequate information about the bidding process. Effective marketing should increase the number of potential purchasers (bidders) which should increase the likelihood of receiving higher bids and thus collecting more money. Marketing their projects could be done by using traditional media like television, radio, newspapers and trade magazines. MT-FWP should also use the internet which would include their webpage with links to other websites. Possibly they should even consider using social media like Facebook and Twitter. DNRC uses newspapers and their webpage to market their timber sale projects. But the primary method for marketing their timber sales is a mailing list of potential purchasers in the vicinity of their timber sale projects. The purchasers are routinely mailed a notice of sale and a timber sale prospectus. The prospectus includes estimates of volume to be sold, minimum bid price, and maps of the project area. If they are interested the potential purchaser can also request a copy of a sample timber sale contract. The prospectus' volume estimate is obtained by conducting a "cruise" which consists of measuring a sample of the trees being offered for sale. The cruising, calculating the volume estimate, preparation of maps, and other preparation can be done by MT-FWP employees or by hiring contractors. The information provided by the project's sale prospectus is important because the total volume estimate combined with the location of the project, the operating conditions, operating restrictions, and required construction and maintenance allows the potential bidder to calculate their bid price.

A competitive bidding process should be used to determine who will purchase the timber sale project to increase the likelihood that MT-FWP is receiving as much revenue for the forest products offered for sale as possible. The bidding process could be open using some type of auction process where the purchasers know what each other are bidding. Or it could use sealed bids delivered by a certain time and date. Bidders are invited to be present during the opening of the sealed bids.

The bidding process could be done with or without a minimum bid price. If a minimum bid price was not established MT-FWP could still take bids but reserve the right to reject the high bid and not do the project. That would require MT-FWP to re-advertise the project and possibly modify the project in some manner to increase the possibility of getting a higher bid.

Setting a minimum bid price for forest products could be done by one of two commonly used methods, transaction evidence or residual value. Transaction evidence uses regression analysis of factors that significantly influence bidding price to predict the winning bid price. The minimum bid estimate determined by transaction evidence can be lowered by some amount to ensure the minimum is not set too high which could result in no one bidding on the project. For example, DNRC uses transaction evidence to set their minimum bids. Normally the minimum bid price is set at 75 percent of the expected price predicted by the transaction evidence computation. The residual value method uses estimates of logging costs, haul cost, development costs, profit and risk, and delivered log price to estimate a minimum bid. The accuracy of this method depends on good cost data which can be highly variable between operators, changes over time, and is difficult to obtain.

Forest products required to be harvested by the project can be sold as stumpage or delivered logs. Stumpage is the selling of standing trees. The successful bidder is responsible for the logging and everything else required by the contract. Delivered log sales usually involve the seller to hire a contract logger to cut the trees and deck the logs by potential end product on site. The decked logs are offered for sale through a competitive bidding process. Theoretically, delivered logs sales will produce higher net revenue because the decked logs can be merchandised and sold to several different sawmills or other manufacturing facilities which will result in higher prices.

Harvested trees can be sold by weight on a per ton basis, board feet, or in the case of post and poles by the linear foot. The total amount paid by the purchaser is based on the total weight of the logs delivered to the mill or the total amount of board feet times the per unit bid price. The amount delivered to the mill could be significantly different than the estimated sale volume provided to the bidders during the bidding process. Under estimating the amount of volume being sold can be a significant problem for the purchaser if the amount of volume in the project does not have enough value to pay for the project's development costs. This could cause the purchaser to default on the contract. The wood could also be sold "lump sum" which means the successful bidder pays for the estimated amount of volume based on the cruise. The bidders may visit to the sale area and adjusted the cruise's volume estimate if necessary to make their bid. Lump sum sales are riskier for both the seller and the purchaser because neither really knows until all of the wood has been harvested how much volume is actually being sold. Generally higher risk tends to drive bid prices lower.

Timber Sale Contract Administration and Log Accountability

A contract administrator will have to be assigned to each timber sale. The contract administrator will need to visit the site frequently to make sure the purchaser is following the contract specifications. Usually this will include monitoring a wide range of activities in addition to harvesting of the trees. Depending on the specifics or the sensitivity of the timber sale and/or the activities that are occurring on the sale, the contract administrator may need to make several visits to the timber sale per week. Building new road or installing new culverts among other activities could require daily visits to ensure construction meets contract specifications. An important part of effective contract administration is the ability for the administrator to show up at the timber sale site at any moment. Some MT-FWP regions might have enough timber sale activity to warrant MT-FWP to decide to permanently locate one or more persons at strategic locations within each region to provide for effective and efficient timber sale contract administration. Persons doing contract administration could also participate in timber sale preparation and other forest management activities in the area. Timber sale activity that was widely dispersed and occurred infrequently could require the timber sale contract administrators to do a lot of

travel and spend several consecutive weeks or months in travel status. This situation could make MT-FWP to decide to accomplish timber sale contract administration for these sales through the employment of private contractors.

MT-FWP will need a protocol for conducting log accountability of forest products sold to the purchaser. The timber sale contract administrator and/or their designee are usually responsible for this handling this task. The log accountability procedure will need to keeping track of the sawlogs and other commercial material removed from the timber sale and subsequently delivered to the mill(s). Log accountability reduces the likelihood for logs to be stolen and increases the level of integrity of the contract administration, harvesting, and log delivery activities. DNRC uses a truck ticket system to conduct log accountability. The timber sale contract is awarded based on bids using information provided to bidders in the prospectus which includes an estimate of total tons of material to be harvested. But DNRC uses the total gross weight of material hauled from the project based on the truck tickets to determine the actual total value of the material sold in the sale. Every truck ticket must be accounted for by the contract administrator and the purchaser is required to furnish all the weight tickets they have been issued to DNRC. MT-FWP should consider adopting a similar system to do their log accounting.

Potential Program Revenue and Cost

Projects that harvest commercial forest products will generate net revenue if the cost to harvest the forest products, do the road work, and other work required by the contract is less than the value of the forest products being harvested during the project. The potential to generate net revenue means the forest management program could at least partially pay for itself or possibly even generate revenue in excess of program costs. Many organizational, political, and economic factors can influence how much revenue will be produced by projects that harvest commercial forest products. But the policies, organization, and physical makeup of the forest management program will be the most significant factors in the ability of the program to generate revenue.

Forest Management Fund

MT-FWP is required by state law (87-1-621) to direct income from forest projects into a Forest Management Account. Expenditures from this account are limited to forest management projects. Many of these projects do not generate revenue but they are conducted because they help MT-FWP meet their forest management program goals and objectives. These projects could include: tree planting, weed control, fencing, installing gates or other barriers, pre-commercial thinning, removing forest encroachment, etc.

Forest Management Monitoring

MT-FWP should implement a monitoring program to track how well they are meeting forest management program goals and objectives. Monitoring would be conducted at the program and project level. Program monitoring might include the following:

- Volume offered for sale by fiscal year.
- Revenue collected by fiscal year.
- Acres treated by category (planting, pre-commercial thinning, etc.).

- Acres by forest condition class.

Monitoring at the project level might include:

- Regeneration surveys
- Planting survival surveys
- Field review of logging or thinning objectives.
- Documenting what worked well and what didn't work well.

Forest Inventory

MT-FWP will need to maintain their forest inventory. At a minimum the inventory should be updated just prior to each sustained yield calculation. They may decide they need to update their inventory information more often to track some type of change in the forest characteristics and habitats. Catastrophic events like forest fire or large insect and disease outbreaks that affected a large amount of MT-FWP forest acreage might be something that would require a more immediate inventory update.

Managing Forest Operations

MT-FWP should consider implementing a system for facilitating the management of their forest management operations. Forest management causes the forest manager to plan to do lots of activities. Individual stand treatments are usually conducted within the context of plans or objectives for a larger forested administrative area in addition to objectives for the stand. The stand treatment is often part of a silvicultural regime that involves several activities to be conducted in the stand over a period of time that might extend more than 100 years into the future. These planned activities need to be documented and stored in a database system that allows them to be easily retrieved to be compiled into reports and to generate work plans. It provides a place to store institutional memory regarding what was done and what was planned to be done. It is also a place to store silvicultural prescriptions, the management regime being applied to the stand and the stand's desired future condition. In other words, what was the desired outcome of the management being applied to the stand. This database can be designed to support the creation of annual work plans and budgets. The information stored in the forest operations database might include but not be limited to the following:

- Current treatment or activity description, date, acres involved, cost, and map of area.
- The stand's silvicultural prescription.
- Stand's previous treatment history.
- List of planned activities and treatments, dates, estimated costs, acres involved, map of area involved.
- Scheduled monitoring activities, description, map of area involved.

Ideally the maps required by the forest operations management system would be stored in a GIS.

Technology (Software and Hardware)

Program efficiency and implementation can be improved through the effective and wise use of technology. Large forest management programs normally find the following hardware and software are required to conduct their program operations:

- GIS
- Mobile GIS
- Handheld data recorders
- GPS
- Cruising software
- Database management software

Conclusion

MT-FWP not only has to decide when, where, how, and what to harvest guided by their forest management plans, goals, and objectives but they also have to determine how their forest management program is going to operate. In other words, how will they conduct the business of managing their forest land? Their forest management program is going to be a complex blend of business methods, forest operations, application of a broad range of scientific and technological disciplines, social and political issues and influences.

MT-FWP owns a large amount of forest acreage. The MT-FWP forest management program has the potential to produce numerous positive results now and in the future. The program will provide the agency with the opportunity and the means to maintain, modify, or restore forest characteristics and composition to meet agency goals and objectives. The forest can be thinned to reduce fire hazard and trees killed by insects and disease can be salvaged. The forest can be managed to provide a safer and more pleasant place to recreate. Timber sale projects will generate revenue that could be used to offset the cost of the program and perform forest improvement projects. Forest products sold will contribute to the local economy as well as MT-FWP division goals and objectives.

Appendix G: Summary of Forest Management Model Runs

This appendix provides a summary of the modeling results for every unit included in the modeling effort.

For each unit, the following charts and tables are provided:

1. Annual Harvest Volume – annual harvest volume for each model run.
2. Inventory Volume – total inventory volume for each model run.
3. Annual Harvested Acres – number of acres harvested each year for each model run.
4. Acres x Size Class in Period 0 – current number of acres within each timber typing size class, for each model run.
5. Inventory x Size Class in Period 0 – current total inventory volume within each timber type size class, for each model run.
6. Acres x Site Index in Period 0 – current number of acres within each site index class, for each model run.
7. Annual Harvest Volume for SYC003 – annual harvest volume for model run SYC003 only.
8. Annual Harvest Acres for SYC003 – annual harvest acres for model run SYC003 only.
9. Annual Net Revenue for SYC003 – annual net revenue for model run SYC003 only.

Please note that we do not include Appendix G in the hard copy version of this report. A digital copy of Appendix G is on file with the Montana Department of Fish, Wildlife, & Parks and is available upon request.