Appendix 2: Vegetation and Timber Analysis Process

Table of Contents

List of Tables

List of Figures

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Introduction

The basic analytical framework for the revision of the Flathead forest plan is prescribed in the National Environmental Policy Act (NEPA) process. A set of alternative scenarios, representing different approaches to the identified needs for change and issues, was simulated over time by the use of vegetation models to provide information to compare and contrast those alternatives in terms of their ability to achieve the vegetative desired conditions. Analyzing the vegetation conditions and timber outputs of the alternatives included development of desired conditions, identification of lands suitable for timber production and evaluation of movement towards vegetation desired conditions and associated timber harvest levels. This appendix describes the analytical methods and tools used to do the analysis supporting the comparison of alternatives, and summarizes the results.

Data and Information Sources for Vegetation Analyses

A variety of well-researched, documented and accepted datasets and tools are used in the development of the models used for the terrestrial vegetation analysis. They collectively make up the best available science currently available for quantifying vegetation conditions. The primary databases and information sources used for the vegetation analysis process are listed below, along with a brief summary. Detailed information about these data sources can be found in the planning record.

Forest Inventory and Analysis

Forest Inventory and Analysis (FIA) data consists of a set of points established on a nationwide systematic grid across all ownerships and regardless of management emphasis. The sample design and data collection methods are scientifically designed, publicly disclosed, and repeatable. For purposes of describing existing vegetation information for broad-scale analyses, it is infeasible to maintain a field inventory on every acre of a large analysis unit, such as the 2.4 million acres of the Flathead National Forest. The Forest Inventory and Analysis plots provide a systematic, spatially balanced, statistically reliable inventory using national protocols appropriate for providing unbiased estimates of forest conditions for use at broad scales of analysis. Plots are re-measured on a 10 year cycle, allowing evaluation of trends in forest conditions over time. For more detailed information on Forest inventory and analysis, refer to the work of Bush and Reyes,[1] Czaplewski,[2] and the Interior West Forest Inventory and Analysis Program website (http://www.fs.fed.us/rm/ogden/index.shtml).

Region 1 Vegetation Map (VMap)

The Region 1 Vegetation Map (VMap) is a spatially explicit (mapped), polygon-based product derived from remotely sensed data that contains information about the extent, composition and structure of vegetation across National Forest System (NFS) lands.[3] The Flathead National Forest VMap database provides four primary map products; lifeform, tree canopy cover class, tree size class, and tree dominance type. Satellite imagery and airborne acquired imagery is used to develop the database, and refined through field sampling and verification. The VMap was designed to allow consistent, continuous applications

[1] Bush, R. and B. Reyes. 2014. Overview of FIA and Intensified Grid Data. Region One Vegetation Classification, Mapping, Inventory and Analysis Report. Report 14–13 v2.0. July 8, 2014.
[2] Czaplewski, R.L. 2004. “Application of forest inventory and analysis data to estimate the amount of old growth forest and snag density in the Northern Region of the National Forest System.” Unpublished report, on file with USDA, Forest Service. Rocky Mountain Research Station. Fort Collins, Colorado. 13 p.
[3] Vanderzanden, D., S. Brown and R. Ahl. 2009. R10VMap Accuracy Assessment Procedures for Region 1. Region 1 Vegetation Classification, Mapping, Inventory, and Analysis Report. numbered report 09-11.

between regional inventory and map products and across all land ownerships that is of sufficient accuracy and precision. An independent accuracy assessment was conducted to provide a validation of the data, giving an indication of reliability of the map products. Refer to Region 1 *Multi-level Vegetation Classification, Mapping, Inventory and Analysis System*[4] and *Region 1 Existing Vegetation Classification System* (Region 1-ExVeg)[5] for an overview of the map unit design and process used to develop these layers and a detailed description of VMap vegetative data.

Flathead Forest Geographic Information System

The Flathead National Forest has a library of geographic information system (GIS) data for the Forest. The library includes a large number of mapped data layers, with associated metadata. Primary layers referenced for the vegetation analysis include vegetation data layers (VMap), fire history, fire start history, insect and disease aerial detection survey data, grizzly bear habitat, lynx habitat layers, roads, topographical features such as elevation and slope, and administrative-related boundary layers (e.g., ownership, inventoried roadless areas, wilderness areas, wildland urban interface). The link to Flathead National Forest geospatial data can be found on the Forest's web page (http://www.fs.usda.gov/flathead).

Many summaries and assessments of vegetation condition were developed using GIS, which is both an analysis tool and a display technology, meaning it can be used to both track information and display it in a variety of graphic formats. As explained later, the GIS tool was used in determining timber suitability. It was also used to build the acre summaries needed for SPECTRUM analysis areas and spatial data for the SIMPPLLE model.

Potential Vegetation Classifications

Potential vegetation types (PVT) are assemblages of habitat types, which are an aggregation of ecological sites of similar biophysical environments (such as climate, aspect, soil characteristics) that produce plant communities of similar composition, structure and function. The Region has identified potential vegetation groups (broad and mid-level groupings of habitat types) that are recommended for use at the broad levels to provide consistent analysis and monitoring, as described by Milburn and others[6] in the publication *Region 1 Existing and Potential Vegetation Groupings used for Broad-level Analysis and Monitoring.* The groupings used for the classification of potential vegetation types in the Flathead revised forest plan are consistent with the Region 1 broad potential vegetation types classes displayed in this publication, though they are referred to in the Flathead revised plan as "Biophysical Settings". The four biophysical settings for the plan are Warm Dry, Warm Moist, Cool Moist-Moderately Dry, and Cold. Refer to appendix D of the draft environmental impact statement for more information on the biophysical settings.

The potential vegetation group (biophysical setting) is an important consideration when analyzing vegetation conditions and management, and for informed the development of desired conditions and other plan components for vegetation and wildlife. Related biophysical setting descriptions from LANDFIRE

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[4] Barber, J., D. Berglund and R. Bush. 2009. The Region 1 existing vegetation classification system and its relationship to inventory data and the Region 1 existing vegetation map products. Numbered Report 09-03 5.0. Region 1, Vegetation Classification, Mapping, Inventory and Analysis Report. USDA, Forest Service, Region 1, Engineering and Forest and Rangeland Management. Missoula, Montana. 30 pp.

[5] Barber, J., R. Bush and D. Berglund. 2011. The Region 1 Existing Vegetation Classification System and its Relationship to Region 1 Inventory Data and Map Products. USDA, Forest Service, Region 1. Missoula, Montana. 39 pp.

[6] Milburn, A., B. Bollenbacher, M. Manning and R. Bush. 2015. Region 1 Exisiting and Potential Vegetation Groupings used for Broad-level Analysis and Monitoring. Report 15-4 v1.0. USDA, Forest Service. Northern Region 1. Missoula, Montana. November.

(www.landfire.gov), and ecological system descriptions from the Montana Natural Heritage Program (http://fieldguide.mt.gov/PDF_Reports/MT_Fieldguide_Ecological_Systems.pdf), as well as current vegetation conditions, also informed development of forest plan components.

Vegetation Models

The vegetation management strategy for the Flathead is to manage the landscape to maintain or trend towards vegetation desired condition. Changes in vegetation over time and evaluation of movement towards desired conditions was accomplished using the following set of analytical tools and models:

- Forest Vegetation Simulation — This forest growth simulation model was used to estimate timber growth and yield.
- SPECTRUM — This model was used to project alternative resource management scenarios and schedule vegetation treatments in response to vegetative desired conditions
- SIMulating Patterns and Processes at Landscape scaLEs (SIMPPLLE) — This model was used to provide a means of simulating succession and disturbance activities and to summarize fire behavior.

These models are tools that provide information useful for understanding vegetation change over time and the relative differences between alternatives. The SPECTRUM and SIMPPLLE models are best used to provide information of comparative value, and not intended to be predictive or to produce precise values for vegetation conditions. Out of necessity, the models simplify very complex and dynamic relationships between ecosystem processes and disturbances (such as climate, fire and succession) and vegetation over time and space. Though best available information, including corroboration with actual data, professional experience and knowledge, is used to build these models, there is a high degree of variability and an element of uncertainty associated with the results because of the ecological complexity and inability to accurately predict timing/location of future events. The following sections provide more detailed descriptions of each of the above-mentioned tools/models.

Forest Vegetation Simulator

Growth and yield tables for the SPECTRUM model were developed using the Forest Vegetation Simulator. The Forest Vegetation Simulator is a family of forest growth simulation models. The basic Forest Vegetation Simulator model structure has been calibrated to unique geographic areas to produce individual Forest Vegetation Simulator variants. Since its initial development in 1973, it has become a system of highly integrated analytical tools. These tools are based upon a body of scientific knowledge developed from decades of natural resources research. Data from the Forest Inventory and Analysis database were used in developing the growth and yield tables. The use of Forest Vegetation Simulator on the Flathead and the timber prescriptions are documented in the report *Construction of Vegetative Yield Profiles for Forest Plan Revision*[7] The resulting yield tables were used in modeling timber harvest levels in the SPECTRUM model.

SPECTRUM Model

SPECTRUM is a software modeling system designed to assist decision makers in exploring and evaluating multiple resource management choices and objectives. Models constructed with SPECTRUM apply management actions to landscapes through a time horizon and display resulting outcomes. Management actions are selected to achieve desired goals (objectives) while complying with all identified management objectives and limitations (constraints). SPECTRUM makes it possible to display

[7] Vandendriesche, D. 2005. USDA Forest Service. Forest Management Service Center. September.

management actions to landscapes at multiple spatial and temporal scales. It is very effective for modeling alternative resource management scenarios in support of strategic and tactical planning. Examples of this include scheduling vegetation treatments to achieve desired conditions; modeling resource effects and interactions within management scenarios; exploring “tradeoffs” between alternative management scenarios; and analyzing minimum habitat requirements to ensure species viability and diversity.

SPECTRUM was used to model potential vegetation treatments across the Forest over time under the different alternatives. The action alternatives were modeled with an objective based on achievement of desired conditions, as described in the plan, for forest composition and size classes. For example, a downward trend in the small forest size class and upward trend in the large size class is a desired condition forestwide, which the model may achieve with regeneration treatment of some small size class forest to convert to seedling/sapling, and leave some to advance into larger tree size classes. In addition, to meet desired conditions for increased amounts of ponderosa pine and western white pine, the regenerated stands could be converted (i.e., through planting) to desired species.

In addition to the objectives, the model applies constraints to potential actions based on other resource factors that would limit treatments, such as lynx habitat, grizzly bear security, known operational or logistical limitations (such as with prescribed burning), and management area direction (such as suitability for timber production or prohibitions on certain treatments). Limits associated with budget levels are also evaluated. In the end, spectrum model formulation and outcomes provide a schedule of activities for the Flathead Forest (harvest and prescribed fire) that help provide answers to the following questions:

- What vegetative treatments are selected and how should they be scheduled to move towards the desired conditions for vegetation, with and without budget limitations?
- What is the projected timber sale quantity, with and without budget limitations?
- What amount of timber can be removed annually in perpetuity on a sustained-yield basis (i.e., the sustained yield limit)?

The SPECTRUM and SIMPPLLE models are used interactively to analyze vegetation conditions. Wildland fire disturbances are first modeled in SIMPPLLE. Resultant disturbance levels are then input into the SPECTRUM model as acres of projected wildland fire. The SPECTRUM model is then run to meet desired conditions or other objective functions (see discussion below on the SPECTRUM model). The outputs from SPECTRUM are input into the SIMPPLLE model to allow for integration with the ecological processes and disturbances as modeled within SIMPPLLE (fire, insect, disease, succession) and spatial analysis of the change in vegetation conditions over time (refer to later section on SIMPPLLE Modeling Results of Vegetation Change over time, and to appendix 3, Modeled wildlife habitat assessment). Figure 2-1 displays the interaction and relationship between the SPECTRUM and SIMPPLLE models.

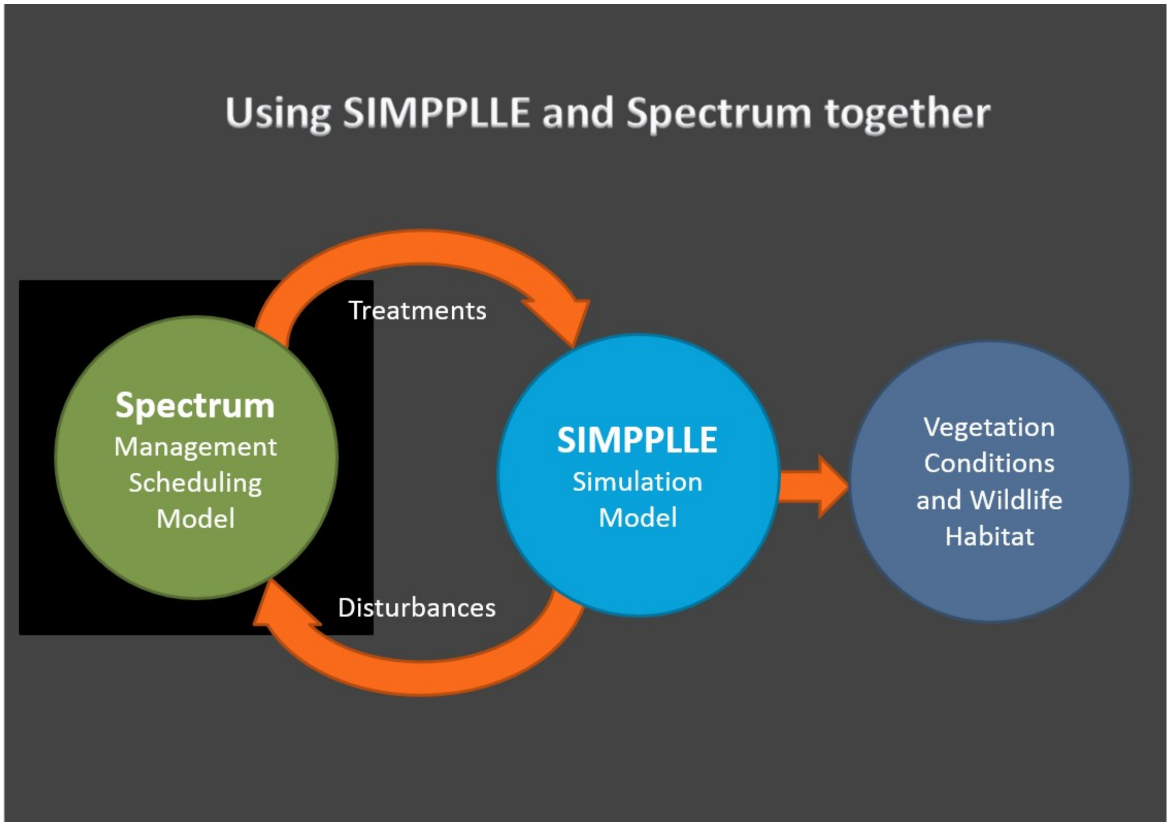

Figure 2-1. Use of SPECTRUM and SIMPPLLE in determining effects on vegetation conditions and habitat

SIMPPLLE Model

SIMulating Patterns and Processes at Landscape scaLEs (SIMPPLLE) is a model that simulates changes in vegetation on landscapes in response to both natural disturbances and management activities, as they interact with climatic conditions. This model was used in the forest plan revision for two purposes: to calculate the natural range of variation (NRV) for vegetation conditions and to project the landscape conditions of the alternatives into the future for analysis in the environmental impact statement. The Region 1 VMap GIS layer is the primary data used for describing the existing vegetation conditions for the Flathead. Potential vegetation types (e.g., biophysical settings), geographic areas, and ownership are also integrated into the existing data layer.

SIMPPLLE takes a landscape condition at the beginning of a simulation (including past disturbances and treatments) and uses logic to grow the landscape through time, while simulating processes (growth, fire, insects, etc.) that might occur on that landscape during the simulation, accounting for the effects of those processes. Simulation timesteps are ten years, and simulations are made for multiple timesteps. The logic assumptions in the model come from a variety of sources, including expert opinion, empirical data, modeled data from other forestry computer applications such as Forest Vegetation Simulator and from initial model logic files that reflect a long history of trial-and-error and research that has been maintained and documented in files that are passed from forest to forest.

One of the main utilities of the SIMPPLLE model is its stochastic nature. The model is typically run for multiple iterations to allow the manager to see a variety of possible projections, look for patterns, and adjust management response accordingly. Managers cannot know with precision the specific types, locations, and extents of natural disturbances that will occur on the landscape. Therefore, the SIMPPLLE model will randomly assign fire, insect, and disease processes on the landscape in a manner consistent with what is known about the nature of these disturbances (e.g., insect-prone stands have a higher hazard and probability of getting an infestation, especially in a dry climate cycle).

The other main utility of the SIMPPLLE model its spatially interactive nature. A process occurring on one site is dependent, to an extent, on the processes that are occurring on adjacent sites. Consider a fire event. SIMPPLLE simulates fire by assigning fire starts with a probability consistent with what historic records indicate for the area and climate. Each start is then given the opportunity to grow. The size the fire grows to is dependent on the surrounding vegetation as well as the historic probability that it will end with a weather event (or, if simulating fire suppression, whether or not there are enough resources, etc. to put the fire out). The type of fire that spreads (lethal, semi-lethal, and non-lethal) is dependent on the vegetation conditions of the site (including past disturbance or treatment), the climate assumption for the timestep, its elevational position relative to the burning fire (uphill, downhill, etc.) and whether it is downwind or not. Again, the fire process will stop according to the probability of a weather ending event, successful fire suppression, or perhaps it runs up against a natural barrier such as the treeline or a lake. SIMPPLLE will then determine the effect of the fire by considering whether there are trees present capable of re-seeding/re-sprouting the site (in the case of a lethal fire), whether the stand's fuel conditions have been reduced (for semi- or non-lethal fires), and if there has been a change in size and/or species on the site.

The SIMPPLLE analysis for the Flathead uses the Region 1 VMap as the existing vegetation conditions layer. SIMPPLLE data was calibrated with Forest Inventory and Analysis data for vegetation species and size classes.

The SIMPPLLE model for the Westside Forest Service Region One zone was the initial source model used for the Flathead (see documentation at http://www.fs.fed.us/rm/missoula/4151/SIMPPLLE/). The Nez Perce Clearwater National Forest revised the logic in this model in 2012, which was then used as the foundation for the Flathead model development and analysis. A number of key updates of the logic files and assumptions were conducted to more closely reflect the ecosystems and processes on the Flathead Forest. These include modification of certain successional pathways, regeneration logic, insect/disease probabilities, and fire logic (e.g., fire severity, fire size/spread, fire event probabilities, and weather ending events). Details on these model updates can be found in the planning record. As discussed earlier, even though best available information was used to develop and update the model, there remains relatively high uncertainty in results due to the ecological complexities and lack of ability to predict the future. Actual amounts of fire or bark beetle activity on the landscape in the future, for example, and the impact to vegetation could be quite different from that modeled. Up to 30 model simulations were run to better capture the variability and uncertainties associated with disturbance events and resulting vegetation change.

Vegetation Desired Conditions

The intent of the Forest Service is to promote ecosystem integrity in the plan area, designing plan components to maintain or restore natural range of variation for key ecosystem components, and establish desired future conditions that enhance the resiliency of the landscape (2012 Planning Rule Directives, Forest Service Handbook 1909.12, chapter 20). The natural range of variation is generally defined in the directives as "the variation of ecological characteristics and processes over scales of time and space that are appropriate for a given management application" (Forest Service Handbook 1909.12, chapter Zero Code). An understanding of the natural range of variation for vegetation components is important for providing insight into the dynamic nature of the Forest ecosystems, the conditions that have sustained the current complement of wildlife and plant species on the Flathead National Forest, and the structural and functional properties of a resilient ecosystem. However, the directives also recognize there may be other factors (social, economic or ecological) that lead the responsible official to determine that the natural range of variation may not be an appropriate desired condition for certain vegetation characteristics (Forest Service Handbook 1909.21, 23.11a).

Desired conditions were developed for the key vegetation components identified on the Flathead Forest. These components are as follows:

- Vegetation composition, as measured by vegetation dominance type (conifer and non-forest types) and tree species presence
- Forest size class (diameter) and very large tree component
- Old growth forest
- Forest density (tree canopy cover percent)
- Snags and downed wood
- Landscape vegetation pattern – forest size class patch characteristics

Development of Desired Conditions

Factors influencing development of desired conditions for the key vegetation components are listed below. All factors are governed by the prevailing concept to maintain ecosystem and forest resilience, as informed by evaluation of natural range of variation. Greater details on these factors and resulting desired conditions can be found in the planning record. The factors have been broadly grouped into the following three themes:

1. Maintain conditions that would better contribute to long-term ecosystem resilience and adaptation to uncertainties of future climate and disturbances

Managing for species that have favorable traits that would improve their ability to persist in light of rapidly changing future environmental conditions. This "trait-based ecology" approach[8] strives to maintain or expand presence of tree species or structures that would increase the probability of maintaining desired composition and structural conditions in the future forest. In the Flathead, this equates mainly to managing for species and structures with resistance to drought, fire, insects or disease, and includes:

- Increased presence and dominance of ponderosa pine, western larch, western white pine and whitebark pine
- Increased tree species diversity (species presence) across the landscape
- Promoting presence of large and very large tree sizes with focus on western larch, ponderosa pine, western white pine, and whitebark pine

2. Sustain important wildlife habitat conditions

Promoting vegetation types and stand structures that provide habitat conditions important to key wildlife species and/or may currently be less common across the landscape. These types include:

- Late successional/old growth forest conditions, particularly ponderosa pine on the warm dry biophysical setting, cedar on portions of the warm moist biophysical setting, and stands with very large western larch overstory on the cool moist-moderately dry biophysical setting.

[8] Laughlin, D.C., R.T. Strahan, D.W. Huffman, and A.J. Sanchez Meador. 2016. Restoration Ecology: *The Journal of the Society for Ecological Restoration*. January. 12 pp.

- Whitebark pine dominated plant communities on the cold biophysical setting
- Multi-story subalpine fir/spruce dominated hare habitat to provide for Canada lynx
- Desired pattern, structure, density and composition of forests on elk/deer winter range
- Non-coniferous vegetation types, specifically hardwood forest types and dry grasslands

3. Consideration of social and economic factors

Influence on desired conditions mainly within wildland urban interface and areas of the forest with greater amounts of human recreational use and access, and intermingled ownerships, including:

- Forest densities within warm moist biophysical setting, the majority of which occurs in wildland urban interface, to reduce expected fire behavior and improve human safety.
- Forest patterns, specifically the size of openings (seedling/sapling forest patches) to address increased visual (scenic) sensitivity and wildlife security.

Evaluation of Natural Range of Variation

The Flathead Forest used a variety of methods to determine natural range of variation for the vegetation components, depending upon available data and methodology. These are described below.

Vegetation composition, forest size class, and forest density

For the Flathead Assessment,[9] a quantified historical range of variability (HRV) analysis conducted on the Flathead in 1999 was the best available data, and was used to inform the discussion of historical reference conditions for vegetation composition and structure in that document (refer to appendix B of the Assessment for detailed discussion of this 1999 historical range of variability analysis). For the revised plan, the SIMPPLLE model was used to develop a quantified estimate of the natural range of variation for these vegetation components. Results from the 1999 historical range of variability analysis helped corroborate the SIMPPLLE model results.

To estimate the natural range of variation for the revised plan, the SIMPPLLE model was used. As suggested in the directives, when considering the period of time over which to evaluate the natural range of variation, "the pre-European influenced reference period considered should be sufficiently long, often several centuries…" and should "…include short-term variation and cycles in climate." (Forest Service Handbook 1909.12, chapter Zero Code). For the Flathead analysis, vegetation conditions back to the year 960 (A.D.) were modeled. This reference period allowed us to simulate the conditions associated with much of the time period known as the Medieval Climate Anomaly (about 950 to 1250), as well as the other end of the climate spectrum known as the Little Ice Age (early 1300s to about 1870s). The inclusion of the Medieval Climate Anomaly in the simulation is potentially valuable in that it might indicate conditions and processes that could occur in the modern climate regime.[10] The model was run under a scenario that assumed only natural ecological processes and disturbances, and their interaction with

[9] USDA. 2014. *Assessment of the Flathead National Forest*, Part 1, Part 2, and Appendices A–E. USDA, Forest Service, Region 1, Flathead National Forest. Kalispell, Montana. April.
[10] Calder, J.W; D. Parker, C.J. Stopka, G. Jimenez-Moreno and B.N. Shuman. 2015. Medieval warming initiated exceptionally large wildfire outbreaks in the Rocky Mountains. In Proceedings of the National Academy of Sciences of the US of America (PNAS). Edited by Monica G. Turner, Univ. Of Wisconsin. Madison, Wisconsin. Approved September 1, 2015. http://www.pnas.org/content/112/43/13261

climate. Thirty simulations were run to better capture the variability and uncertainties associated with disturbance events and resulting vegetation change.

In consultation with the Rocky Mountain Research Station in Missoula Montana, it was determined that the appropriate indicator of past climate was the Palmer Drought Severity Index.[11] Data for the Index is typically reconstructed for localized points, and the data point nearest the Flathead was used to evaluate the climate for the area. The data was categorized into three climate scenarios: wetter, dryer, and normal. Refer to the planning record for greater detail on how climate was used in the modeling process.

Graphs displaying results from the SIMPPLLE natural range of variation analysis are found in the planning record. The natural range of variation is displayed as a range (minimum and maximum) in proportion of area forestwide and for some components, by biophysical settings, for vegetation dominance types, conifer tree species presence, forest size classes, and forest canopy cover classes. The results of this natural range of variation analysis informed the development of desired conditions for the revised forest plan.

The SIMPPLLE model was also used to project vegetation change into the future, as affected by anticipated treatments, natural disturbances and climate change. Because the same methodology was used, these results could then be compared to the natural range of variation or to the desired conditions, and differences between alternatives analyzed in the environmental impact statement.

Old growth forest

There is no means to determine a statistically sound, quantifiable estimate of the natural range of variation for old growth as defined for the Flathead Forest,[12] because the characteristics associated with old growth forest can be determined only through site specific inventory. Forest Plan amendment 21,[13] which incorporated new old growth management direction into the current Flathead Forest Plan[14] evaluated historical old growth conditions using a variety of sources, including historical surveys, dendrochronology studies, and computer modeling (i.e., the 1999 historical range of variability analysis described earlier). This was the main source of information for documenting reference conditions for old growth in the Flathead Assessment. For development of the revised plan, this information was supplemented with results of the SIMPPLLE natural range of variation analysis for the very large forest size class, which could be assumed to correlate closely with old growth forest conditions.

Snags and downed wood

The SIMPPLLE model results do not provide a quantified the natural range of variation for these components. Information sources used to assess snag and downed wood natural range of variation include: (a) Forest Inventory and Analysis reports displaying existing amounts of these components across the forest, and (b) evaluating the natural range of variation for natural disturbance processes (as modeled with SIMPPLLE). Assuming that conditions within wilderness areas would most closely represent ecosystems functioning under natural disturbance regimes, a review of the existing snag and

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[11] Alley, W.M. 1984. The Palmer Drought Severity Index: Limitations and Assumptions. *Journal of Climate and Applied Meteorology* vol. 23. April. http://journals.ametsoc.org/doi/abs/10.1175/1520-0450(1984)023%3C1100:TPDSIL%3E2.0.CO.

[12] Green P., J. Joy, D. Sirucek, W. Hann, A. Zack and B. Naumann. 1992. Old growth forest types of the Northern Region. Errata corrected 2005, 2007, 2008, and 2011. USDA Forest Service, Northern Region Document Number R-1 SES 4/92. Missoula, MT. 609 pp.

[13] USDA. 1998. Flathead National Forest Plan Amendment 21, Final Environmental Impact Statement: Management Direction Related to Old Growth Forests. USDA, Forest Service. Flathead National Forest. Kalispell, Montana.

[14] USDA. 1986. Flathead National Forest Management Plan. USDA, Forest Service, Flathead National Forest. Kalispell, Montana.

downed wood component within and outside wilderness areas provided clues as to what might be an average natural condition for amount/type of snags and downed wood on average across the landscape. A review of the natural range of variation results for fire and insect/disease activity across the forest as to the role they and natural succession play in creating snags and downed wood also aided in understanding the natural range of variation for these components.

Landscape pattern

The 1999 historical range of variability analysis described earlier, that provided estimates of historical range of variability for vegetation composition and structure, also provided quantified estimates related to the pattern of these forest patches across the landscape. As the best available information, results of this analysis were used to inform the discussion of historical reference conditions for vegetation pattern in the Assessment (refer to appendix B of the Assessment for detailed discussion of this 1999 historical range of variability analysis). However, there is very limited ability to use the results of that analysis for development and analysis of the revised forest plan and alternatives. The site and vegetation classifications differ substantially from those used in the revised forest plan, and crosswalking them is problematic, and subject to broad interpretation. The data used is relatively dated (mid 1990s), considering the large amount of area on the Forest altered by wildfire over the past 20 years. It is infeasible to update the 1999 historical range of variability analysis or translate it into our current classification and analysis structure; nor can we project future changes in pattern (either using the same methodology or a different process) that can be correctly compared to current conditions. Use of consistent methodology for evaluating past, present and future landscape patterns would be important to appropriately interpret and evaluate spatial statistics associated with patch dynamics. Therefore, though the 1999 historical range of variability analysis was useful for improving our understanding of the ecosystem conditions on the Flathead and assessing ecological integrity, direct use of the quantitative results from that analysis to develop desired conditions and conduct effects analysis was not possible.

For development of the revised forest plan, an analysis of natural range of variation for patch size of early successional (seedling/sapling) forest was conducted using the SIMPPLLE model natural range of variation results for stand replacement fire events (the primary disturbance that creates these patches) over the past 1000 years. This natural range of variation analysis was used to inform development of forest plan components related to forest pattern and size of openings across the Flathead landscape. The analysis was limited to analysis of seedling/sapling forest patches for several reasons. The 1999 historical range of variability analysis noted the most departure and greatest concern to ecological integrity for the early successional forest patch sizes and densities, when compared to historical conditions. The dominance of grass, forbs, shrubs and short trees within these early successional forests creates a patch – an opening – that forms strong contrast (e.g., forest “edge”) and is distinctly different from the adjacent small, medium, large or very large forest size class patches. Not only does this allow for more accurate detection and measurement of the patch and resulting landscape patterns (past, present and future), the seedling/sapling forest patch type is particularly meaningful for evaluation of wildlife habitat conditions, forest cover and connectivity. The larger trees and denser forest cover present in the adjacent small to very large forest size class patches provide the connectivity of habitat important to many wildlife species. Early successional stages also represent the crucial initiation point of forest development and thus greatly influence potential future conditions and patterns.

Identification of Lands Suitable for Timber Production

The National Forest Management Act (NFMA) directs forests to identify lands which are not suited for timber production. The act states at sec. 6 (k), “the Secretary shall identify lands within the management area which are not suited for timber production, considering physical, economic, and other pertinent factors to the extent feasible, as determined by the Secretary, and shall assure that, except for salvage sales or sales necessitated to protect other multiple-use values, no timber harvesting shall occur on such lands for a period of 10 years."

The assessment of suitable timberlands was accomplished using GIS. Use of GIS resulted in consistent identification of each step in determining suitability.

Criteria for determining lands not suitable for timber production are outlined in Forest Service Handbook 1909.12, section 61. A two-step process is used:

1. Identify lands that are not suited for timber production based on legal and technical factors, as follows:

- Statute, executive order, or regulation prohibits timber harvest on the land, or the Secretary of Agriculture or the Chief of the Forest Service has withdrawn the land from timber harvest as described in section 61.11.
- The technology is not currently available for conducting timber harvest without causing irreversible damage to soil, slope, or other watershed conditions as described in section 61.12.
- There is no reasonable assurance that such lands can be adequately restocked within 5 years after final regeneration harvest as described in section 61.13.
- The land is not forest land as described in section 61.14.

After subtracting the lands that are not suited from the total of NFS lands, the remaining lands are lands that may be suited for timber production, and are considered in step 2.

2. From the lands that may be suited for timber production, identify the lands that are suited for timber production based on their compatibility with the land area's desired conditions and objectives, as described in section 61.2.

This step varies by alternative, based on management area allocation and desired conditions of management areas. After lands suited for timber production have been identified, the remaining lands that may be suited for timber production are identified as not suited for timber production since timber production is not compatible with the land area's desired condition or objectives.

Table 2-1 displays the acres for each step in determining lands suitable for timber production by alternative.

Table 2-1. Timber suitability by alternative

Timber Suitability	Alternative A (acres)	Alternative B (acres)	Alternative C (acres)	Alternative D (acres)
NFS Land	2,392,816	2,392,816	2,392,816	2,392,816
Withdrawn lands	-1,371,709	-1,371,709	-1,371,709	-1,371,709
Irreversible damage potential or restocking not assured	-166,513	-166,513	-166,513	-166,513
Nonforest land	-117,204	-117,204	-117,204	-117,204
Lands that may be suitable for timber production	737,390	737,390	737,390	737,390
Areas where timber harvest is not compatible with the land area's desired conditions and objectives,	-210,406	-238,326	-420,089	-236,947

Timber Suitability	Alternative A (acres)	Alternative B (acres)	Alternative C (acres)	Alternative D (acres)
Suitable for Timber Production	526,984	499,064	317,301	500,443

Alternative A is the current forest plan as amended and implemented. Timber suitability has been updated to reflect forest plan amendments, updated data and current conditions. Alternatives B, C and D are alternatives to the current plan, and reflect a range of possible management options for revision of the current forest plan.

Figures 1-07 (appendix 1 of the draft environmental impact statement) and figures B-27, B-28, B-29 (from appendix B of the revised plan) display lands suitable for timber production for each alternative.

SPECTRUM Modeling for Vegetation Treatments and Timber Outputs

Components of the SPECTRUM Model

The SPECTRUM model is comprised of the following components:

- Planning horizon — A specified time frame broken down into periods of an equal number of years. The horizon may be as short or long as desired. Long planning horizons are used to investigate the sustainability of long-term management actions, such as long rotations.
- Land stratification and analysis units — The planning area is subdivided into areas that facilitate analyzing land allocation and management scheduling analysis. The subdivision is largely a function of two determinants: (1) how managers want the forest subdivided to answer planning questions, and (2) how specialists need the forest subdivided to estimate resource response to management scenarios.
- Management actions and outputs — A SPECTRUM model consists of a set of management actions applied to specific land units. Management actions consist of activities, outputs, treatments, and land conditions.
- Economic information — Basic activity cost and output revenues.
- Transition pathways — The Forest developed pathways to model how vegetation type and size varies over time based on different management actions. These pathways are used to measure movement towards desired conditions.
- Management constraints — These are limits defined to model resource thresholds, relations between and among activities and outputs, policy requirements, or monetary limitations.
- Objective function — Optimization models, such as SPECTRUM, minimize or maximize an objective function subject to a set of constraints. An objective function is defined in terms of its type (maximize or minimize), discount rate (if applicable), duration, and contributing activities and outputs.

Following is a description of the components of the Flathead SPECTRUM model.

Land stratification and analysis units

Land stratification is the process of identifying a set of attributes, or strata, to use in defining the land base. This is done to organize the forest land base into logical subunits that respond similarly to management actions. In SPECTRUM, each stratum is a layer and a unique combination of layers results in an “analysis area.” Up to six layers of information can be used in SPECTRUM to describe analysis areas, and while analysis areas are usually homogenous, they are not always contiguous. The Flathead used five layers of information in developing analysis areas. The attributes used in developing analysis areas are based on the issues to be addressed by the model, and differences in resource response.

The six SPECTRUM land stratification layers identified for the Plan are defined as follows:

- Layer 1 — Inventoried roadless area or not
- Layer 2 — Management area group and timber suitability
- Layer 3 — Not used
- Layer 4 — Wildlife condition
- Layer 5 — Cover type
- Layer 6 — Size class.

Table 2-2 defines the classification for each layer, listing the layer’s codes and descriptions. Analysis areas are developed by combining the six layers in GIS and calculating the amount of acreage for each combination that was present.

Table 2-2. SPECTRUM land stratification

Layer	Description
Layer 1 – Roadless Status	**Layer 1 Description**
IRA	Inventoried Roadless Area
NOIRA	Not Inventoried Roadless Area
Layer 2 – Management Area (MA) Group and Timber Suitability	**Layer 2 Description**
MAG1	Not suitable for timber production, not suitable for timber harvest MAs 1a, 1b, 2a (wild), 2b (wild), 4a Includes all land classified as not suitable for timber harvest because of possible irreversible damage or non-forested condition
MAG2	Not suitable for timber production, suitable for timber harvest at very low intensity MA 2a and 2b (rec and scenic), 3a, 3b, 4b (Coram Exp. Forest), 5a, 5b, 5c, 5d, part of 7 Riparian Habitat Conservation areas (within MAs 2a, 2b, 3a, 3b, 5a-d, and 6a-c, and 7)
MAG3	Not suitable for timber production, suitable for timber harvest at low intensity MA 6a
MAG4	Suitable for timber production at moderate intensity MA 6b, parts of 7
MAG5	Suitable for timber production at higher intensity MA 6c, 4b (Miller Creek Demonstration Forest), parts of 7
Layer 4 – Wildlife Condition	**Layer 4 Description**
GBCLH	Grizzly Bear Core and Lynx Habitat
GBCNLH	Grizzly Bear Core and no Lynx Habitat
GBNCL	Grizzly Bear Non-core and Lynx Habitat (note: there is no land where it is Grizzly Bear non-core habitat and not lynx habitat)

Layer	Description
BGWR	Whitetail Deer Winter Range
Other	Other
Layer 5 – Cover Type	**Layer 5 Description**
IMX-WM	Intolerant mix – warm moist (DF, WL, PP)
IMX-WD	Intolerant mix – warm dry (DF, PP, WL)
IMX-CM	Intolerant mix – cool moist (WL, DF)
LP	Lodgepole pine
TMX-WM	Tolerant mix – warm moist (GF/C)
TMX-CM	Tolerant mix – cool moist (AF/ES)
Other	Other – nonforest
Layer 6 – Size Class	**Layer 6 Description**
Seedsp	Seedling/Sapling (0 to 5 in.)
Small	Small (5 – 10 in.)
Medium	Medium (10 – 15 in.)
Large	Large (15 in.+)
Other	Other – nonforest

Management actions and outputs

The treatments in the model were developed to reflect management areas, standards, and guidelines in the Forest Plan. Silvicultural prescriptions (treatments), timing choices, and constraints defined in the model are for modeling purposes only and do not create standards or guidelines for Plan implementation.

Silvicultural prescriptions were defined by cover type and other resource conditions. Table 2-3 describes the silvicultural prescriptions by cover type. These defined the analysis area management prescriptions. Silvicultural prescriptions were developed to manage vegetation towards desired condition. See the report *Construction of Vegetative Yield Profiles for Forest Plan Revision,*[15] for further information on the silvicultural prescriptions.

Table 2-3. Silvicultural prescriptions by landbase/cover type

SPECTRUM Silvicultural Prescription	Application
Stand Replacement Fire (unplanned ignitions)	Everywhere based on cover type and size class from SIMPPLLE modeling (see below description of stand replacement fire)
Planned Ignitions (under-burn and stand-replacing)	Everywhere except in designated wilderness and not in TMX-WM. IMX-WM and IMX-WD are under-burns at 30 year intervals. LP, IMX-CM, and TMX-CM are single burns that are stand-replacing 1.
Group Selection (GS) (Uneven-aged Mgmt)	MAG 2, 3, 4, 5; not in LP
Clearcut/Seed Tree (CC/ST) with reserves (with or without commercial thinning) 2.	MAG 3, 4, 5
Shelterwood (SW)	MAG 3, 4, 5
Commercial Thinning (CT)	Imbedded in CC/ST/SW based on stand age

[15] Vandendriesche, D. 2005. USDA Forest Service. Forest Management Service Center. September.

SPECTRUM Silvicultural Prescription	Application
Precommercial Thinning (PCT)	Imbedded in CC/ST/SW based on stand age. No PCT in lynx habitat
No Management	Everywhere

1. There is no prescribed burning in cover type TGCH because prescribed burn occurs only with timber harvest in this type.
2. Large size class does not have commercial thinning. All other size classes for the existing stand allow with or without commercial thinning.

Several timing choices were also applied to the silvicultural prescriptions. Timing choices are defined by specifying (within the model) the range of ages in which an existing stand and a regenerated stand may be treated. The earliest point at which a stand could be regeneration harvested was based on culmination of mean annual increment (CMAI). The age at which the culmination of mean annual increment is attained was determined by the Forest Vegetation Simulator. Existing stands containing medium or large size classes have met the culmination of mean annual increment and are ready to harvest at the beginning of the planning horizon. Based on varying constraints and the specified management goals or objectives, the SPECTRUM model determines the management prescription to apply to an analysis area as well as the timing of the implementation.

Yield tables included the following outputs:

- Merchantable mcf (thousand cubic feet)
- Merchantable mbf (thousand board feet)
- Diameter of removals and residual volume
- Fire risk
- Snags – Delineated by diameter classes of 10 to 20 inches and 20+ inches
- Insect risk (composite rating of insect risk).

Costs for management activities

Costs were developed for sale preparation and sale administration (combined) reforestation, timber stand improvement, prescribed burning, and road construction and reconstruction. Table 2-4 describes the activity, units, cost, and production coefficient (relationship for incurring the cost based on a particular activity).

Table 2-4. Costs for the SPECTRUM model

Activity	Costs	Production Coefficient	Timing
NEPA, Sale prep and admin	$640/mcf	1/mcf harvested	With harvest
Reforestation (includes site prep for natural regeneration and planting)	$600/ac	0.1/ac CC/ST, SW 0.02/ac GS 0 all others	With harvest
TSI (PCT)	$310/ac	0.35/acre CC/ST 0.2/ac GS 0 all others	2 decades after harvest
Road Reconstruction	0 Purchaser cost, No appropriated funds (just tracking number of miles)	0.01 miles/ac	With harvest; not inventoried roadless area

Activity	Costs	Production Coefficient	Timing
Road pre-const/recons admin	$8,597/mi	0.01 miles/ac	With harvest
Prescribed burn (rx)	$125/ac	1/ac	With rx burn

All costs except prescribed burning are part of the budget constraint (see section on management constraints). To reflect higher unit costs within inventoried roadless areas, all activity costs within an inventoried roadless area or helicopter logging area (layer 1 code of “IRA”), except road construction and reconstruction, were increased by 20 percent. This increase was to reflect the increased access and analysis costs for these areas.

Timber values

Stumpage values for timber were developed by the regional timber program budget manager for the Northern Region, USDA Forest Service, with a residual value calculation Residual value means that stumpage value is calculated as the difference between the delivered log price at a mill and the estimated harvest and delivery costs incurred by a buyer who purchases the timber. Delivered log values were based on the average delivered log price by species for 2004 to 2014 (through quarter 2). Logging system costs, estimated transportation costs, and profit and risk to the purchaser were then subtracted to determine average stumpage price by species. Stumpage value by species was then cross-walked to SPECTRUM species groups. Values for different logging systems were averaged for the amount that has occurred on the Forest over the past several years. Table 2-5 displays the average stumpage value for the model.

Table 2-5. Stumpage value by species

SPECTRUM Species Strata	Sawtimber Value ($/MBF)
IMX-WM (DFW)	$99.37
IMX-CM (IMXSW)	$94.76
IMX-WD (IMXSD)	$98.86
LP	$104.35
TMX-WM (TGCH)	$65.90
TMX-CM (TASH)	$73.94

Transition pathways

Pathways were developed to indicate how species and size class would be expected to change over time, given the silvicultural prescription. Pathways for species are displayed in table 2-6 and pathways for size classes in table 2-7. These pathways were used to model movement towards vegetation desired condition. The treatment designation of “Natural Growth” is the silvicultural prescription equivalent of no management, “Even-aged Harvest” is the silvicultural prescription equivalent of regeneration, and “Uneven-aged Management” is the individual tree and group selection silvicultural prescriptions. Pathways were developed by the silviculturist on the interdisciplinary team.

Table 2-6. SPECTRUM species transition changes

Treatment	SPECTRUM Cover Type	Age	Percent (%) Species
Natural Growth and Stand-replacing Fire	IMX-WM	0-180	40% DF, 45% WL, 15% PP
		180+	20%DF,25%WL, 55% TGCH
	IMX-WD	0-180	70% DF,10% WL, 20% PP
		180+	80% DF,10% WL, 10% PP

Treatment	SPECTRUM Cover Type	Age	Percent (%) Species
	IMX-CM	0-160	50% WL, 50% DF
		160+	20%WL, 10%DF, 70% TASH
	LPP	0-90	100% LP
		90-120	50% LP, 50% TASH
		120+	100% TASH
	TMX-CM	All ages	100% TASH
	TMX-WM	All ages	100% TGCH
Even-aged Harvest	IMX-WM	At PCT/CT	50% WL, 35% DF, 15% PP
		At regen	50% WL, 20% DF, 20% WP, 10% PP
	IMX-WD	At PCT	50% DF, 40% PP, 10% WL
		At CT	25% DF, 60% PP, 15% WL
		At regen	20% DF, 65% PP, 15% WL
	IMX-CM	After first treatment	40% WL, 30% DF, 20% TASH, 10% WP
	LP	After first treatment	70% LPP, 10% WL, 10%, DF, 10% TASH
	TMX-CM	At PCT or CT	20% WL, 20% DF, 60% TASH;
		At regen	40% WL, 30% DF, 20% TASH, 10% WP
	TMX-WM	At PCT or CT	20% WL, 20% DF, 60% TGCH
		At regen	50% WL, 20% DF, 20% WP, 10% PP
Uneven-aged Management	IMX-WM	1st and 2nd entry	40% WL, 45% DF, 5% PP, 10% WP
		3rd entry	40% WL, 30% DF, 5% PP, 15% WP, 10% TGCH
		4th entry+	45% WL, 25% DF, 5% PP, 15% WP, 10% TGCH
	IMX-WD	1st entry	80% DF, 17% PP, 3% WL
		2nd entry	70% DF, 25% PP, 5% WL
		3rd entry	55% DF, 35% PP, 10% WL
		4th entry+	40% DF, 45% PP, 15% WL
	IMX-CM	1st and 2nd entry	20% WL, 55% DF, 20% TASH, 5%WP
		3rd and 4th entry	25% WL, 30% DF, 35% TASH, 10% WP
		5th entry+	25% WL, 25% DF, 40% TASH, 10% WP
	LP	Not applicable	Not applicable
	TMX-WM	1st entry	10% WL, 5% DF, 5% WP, 80% TGCH
		2nd entry	15% WL, 10% DF, 10% WP, 65% TGCH

Treatment	SPECTRUM Cover Type	Age	Percent (%) Species
		3rd entry	20% WL, 20% DF, 5% PP, 10% WP, 45% TGCH
		4th entry	25% WL, 25% DF, 10% PP, 15% WP, 25% TGCH
		5th entry	30% WL, 30% DF, 10% PP, 20% WP, 10% TGCH
	TMX-CM	1st entry	15% WL, 15% DF, 65% TASH, 5% WP
		2nd entry	15% WL, 20% DF, 60% TASH, 5% WP
		3rd entry	15% WL, 20% DF, 55% TASH, 10% WP
		4th entry+	20% WL, 20% DF, 50% TASH, 10% WP
Prescribed burn	IMX-WD	0-30	75% DF, 20% PP, 5% WL
		31-60	45% DF, 45% PP, 10% WL
		60+	20% DF, 65% PP, 15% WL
	IMX-WM	0-30	20% WL, 60% DF, 15% PP, 5% WP
		31-60	40% WL, 40% DF, 15% PP, 5% WP
		60+	50% WL, 25% DF, 15% PP, 10% WP
	IMX-CM	All ages (1 burn)	40% WL, 30% DF, 20% LP, 10% TASH
	LP	All ages (1 burn)	90% LP, 5% WL, 5% DF
	TMX-CM	All ages (1 burn)	30% LP, 20% TASH, 30% WL, 20% DF
	TMX-WM	Not applicable	Not applicable

Table 2-7. SPECTRUM size class transition changes

Treatment	SPECTRUM Cover Type	Age	Size
Natural Growth	IMX-WM	0-30	SS
		31-60	Small
		61-110	Med
		111+	Large
	IMX-CM	0-30	SS
		31-90	Small
		91-120	Med
		121+	Large
	IMX-WD	0-30	SS
		31-90	Small
		91-130	Med
		131+	Large

Treatment	SPECTRUM Cover Type	Age	Size
	LP	0-30	SS
		31-90	Small
		91-140	Med
		141+	Large
	TMX-CM	0-30	SS
		31-90	Small
		91-120	Med
		121+	Large
	TMX-WM	0-30	SS
		31-60	Small
		61-110	Med
		111+	Large
Even-aged Mgmt	IMX-WD	0-30	SS
		31-70 (PCT)	Small
		71-100 (CT)	Med
		101+ until regen	Large
	IMX-WM and TMX-WM	0-30	SS
		31-60 (PCT)	Small
		61-90 (CT)	Med
		91+ until regen	Large
	LP	0-30	SS
		31-80 (PCT,CT)	Small
		81-130 (CT or regen)	Med
		131+ until regen	Large
	IMX-CM and TMX-CM	0-30	SS
		31-90 (PCT)	Small
		91-120 (CT or regen)	Med
		121+ until regen	Large
Uneven-aged Mgmt Group Selection	All Strata except LPP – Size L	Entry 1	5% SS, 10% Small, 5% Med, 80% Large
		Entry 2	10% SS, 20% Small, 10% Med, 60% Large
		Entry 3	10% SS, 30% Small, 20% Med, 40% Large
		Entry 4	10% SS, 20% Small, 20% Med, 50% Large,
		Entry 5	10% SS, 30% Small, 20% Med, 40% Large
	All Strata except LPP – Size M	Entry 1	10% SS, 10% Small, 80% Med
		Entry 2	5% SS, 10% Small, 5% Med, 80% Large

Treatment	SPECTRUM Cover Type	Age	Size
		Entry 3	10% SS, 20% Small, 10% Med, 60% Large
		Entry 4	10% SS, 30% Small, 20% Med, 40% Large
		Entry 5	10% SS, 20% Small, 20% Med, 50% Large,
		Entry 6	10% SS, 30% Small, 20% Med, 40% Large
	All Strata except LPP – Size S and SS	Entry 1	20% SS, 80% Small
		Entry 2	10% SS, 10% Small, 80% Med
		Entry 3	5% SS, 10% Small, 5% Med, 80% Large
		Entry 4	10% SS, 20% Small, 10% Med, 60% Large
		Entry 5	10% SS, 30% Small, 20% Med, 40% Large
		Entry 6	10% SS, 20% Small, 20% Med, 50% Large,
		Entry 7	10% SS, 30% Small, 20% Med, 40% Large
Prescribed Burn	LP	One Entry	100% SS
	TMX-CM and IMX-CM	One Entry	100% SS
	All Species – except LP, TMX-CM, and IMX-CM - Small, SS	Entry 1, 2	20% SS, 60% Small, 20% Med
		Entry 3, 4	10% SS, 20% Small, 50% Med, 20% Large
		Entry 5+	40% Med, 60% Large
	All Species – except LP, TMX-CM, and IMX-CM - Medium	Entry 1, 2	20% SS, 80% Med
		Entry 3, 4	10% SS, 10% Small, 40% Med, 40% Large
		Entry 5+	10% SS, 10% Small, 20% Med, 60% Large
	All Species – except LP, TMX-CM, and IMX-CM - Large	Entry 1, 2	20% SS, 80% Large
		Entry 3, 4	10% SS, 10% Small, 20% Med, 60% Large
		Entry 5+	10% SS, 10% Small, 10% Med, 70% Large

Management constraints

Constraints describe limitations on management that must be considered when scheduling treatments. The following discussion provides a description of the various constraints that were incorporated into the SPECTRUM model in response to Forest Plan direction, regulations, and as a means of improving the model's ability to simulate actual management of NFS lands. Constraints as defined in the model were for modeling purposes only and do not create limitations for Plan implementation.

Harvest policy

Harvest policy includes non-declining yield, long-term sustained-yield and ending inventory constraints. These constraints ensure that the timber yield is sustainable and will not decline in any decade.

Budget constraint

The model included a budget constraint in order to assess effects under current budget levels for timber management and reforestation activities. For the model's planning horizon, the annual budget constraint was $4,051,000 and included all timber sale activities (timber sale preparation, timber sale administrations, timber stand improvement, and reforestation) and construction/reconstruction engineering costs.

Snag retention

The silvicultural prescriptions for regeneration harvest provided retention of trees for snag recruitment. Reserves of trees were required and the snag quantities were tracked in the yield tables. Numbers of snags were reported for two diameter classes (10 to 19.9 inches and 20 inches or greater) for three densities shown in table 2-8.

Table 2-8. Snag density by diameter class

Diameter Class	Small Snag Density	Medium Snag Density	Large Snag Density
10 to 20-inch snags	0 to 5.9 snags/acre	6 to 9.9 snags/acre	≥10 snags/acre
20+ inch snags	0 to 0.9 snags/acre	1.0 to 3.9 snags/acre	≥4 snags/acre
Total Snags	0 to 5.9 snags/acre	6.0 to 9.9 snags/acre	≥10 snags/acre

No prescribed burning in designated wilderness

To prevent prescribed burning in designated wilderness, prescribed burning in MAG1 was limited to the area of MAG1 in each alternative that was not MA1a. The limits were no more than 334,925 acres in alternative B, no more than 546,935 acres in alternative C, and no more than 248,633 in alternative D.

Watershed objectives

Watershed objectives were met by limiting the amount of area that could be in an opening at one time. To protect watershed resources, the amount of area in openings is limited to not more than 25 percent by management area group. Management area group 1 is excluded from this constraint because openings in MAG1 are created exclusively by natural processes and is therefore not a management limitation. Openings were modeled as follows:

- For regeneration harvest, stand-replacing prescribed burn, or stand-replacing wildfire, one acre of opening is created for each acre harvest or burned.
- For group selection or underburned prescribed burn, 0.2 acres of opening is created for each acre harvest or burned.

An opening remains an opening 40 years, with a decay function over time, to reflect the gradual recruitment of trees and recovery of the opening. During the first decade of harvest or burning, the opening equals 1.0, diminishing to 0.75 in decade 2, 0.50 in decade 3, and 0.25 in decade 4.

Wildlife objectives

Grizzly bear: In grizzly bear habitat within MAG4 (MA 6b), timber harvest was limited to no more than 5 percent per decade in core and 10 percent per decade in non-core. In grizzly bear habitat within MAG3 (which includes MA 6a), timber harvest was limited to no more than 2.5 percent in core and 5 percent in non-core per decade. There was no limit in MAG2 for grizzly bear because of the already limited amount of acres that may be treated in those management areas.

Lynx: For lynx habitat, all stand-replacing fire and timber harvest was limited to no more than 15 percent over a decade by management area group (with MAG1 excluded) and lynx habitat was not precommercially thinned.

For multi-storied lynx habitat, timber harvest and prescribed burning was limited by management area group to no more than 60 percent of acres in cover types TMX-CM or IMX-CM within management area groups 3-5.

Whitetail deer (winter range): To manage for whitetail deer winter range, no more than 30 percent of the area (by MAG group) would be in an opening. Openings are defined as 1 acre opening for every 1 acre regeneration harvest or stand-replacing wildfire. An opening remains an opening 60 years, with a decay function over time. During the first decade of harvest or burning, the opening equals 1.0, diminishing to 0.85 in decade 2, 0.70 in decade 3, 0.50 in decade 4, 0.35 in decade 5, and 0.20 in decade 6. After that, the stand fully functions as thermal cover.

Silvicultural prescriptions

To meet the intent of management intensity by management area group, silvicultural prescriptions for timber harvest were allocated by Management Area Group as shown in table 2-9.

Table 2-9. Silvicultural harvest prescription by management area group

Management Area Group	Harvest Prescription
2	No limit; all available
3 or 4	At least 20% GS, remaining EA of all timber managed acres
5	At least 5% GS, remaining EA of all timber managed acres

GS = group selection (unevenaged management)
ST = clearcut/seedtree with reserve trees
SW = shelterwood with reserve trees

Because of silvicultural limitations and to better achieve forest plan desired conditions, the following silvicultural constraints were applied forestwide:

- Group selection was limited to no more than 5,000 acres per decade.
- Commercial thin was limited to no more than 10,000 acres per decade.

To further meet the intent of management intensity by management area group, acres treated by management area group were subject to the limitations shown in table 2-10.

Table 2-10. Limits to timber harvest by management area group

Management Area Group	Constraint
5	No Constraint
4	No Constraint

Management Area Group	Constraint
3	Limit to no more than 50% of all acres allocated to timber management
2	Limit to no more than 2,000 acres timber harvest per decade

Prescribed burning was limited to no more than 7,500 acres per year, because of operational and logistical limitations on the amount of burning the forest can accomplish.

Disturbance processes – stand-replacing wildfire

The amount of natural disturbance (stand-replacing fire) was determined using SIMPPLLE. Twenty simulations for five decades were made to estimate the amount of acres with fire disturbance. The resulting amount of stand-replacing fire was input into the SPECTRUM model by species and size class for each decade. Decades one through five used actual acres burned in the SIMPPLLE model, while decades six through 25 used an average of the first five decades. The acres reflect wildfire under the selected suppression scenario (50 percent suppression in wilderness, 80 percent in non-wilderness)

The acres shown in table 2-11and table 2-12 were themed to stand replacing fire over each decade. Acres vary by management area group, with 80 percent of disturbance occurring in management area groups 1-3 and 20 percent in management area groups 4-5.

Table 2-11. Natural disturbance (stand replacing wildfire) by cover type

SPECTRUM Cover Type (Level 5)	Decade 1	Decade 2	Decade 3	Decade 4	Decade 5	Decade >5 (Average)
IMX-WD	681	1,241	2,502	2,827	2,603	1,971
IMX-WM	474	702	1,234	959	930	860
IMX-CM	3,503	5,791	10,946	10,599	9,973	8,162
LP	11,048	14,194	16,666	14,372	11,497	13,555
TMX-WM	6	10	9	30	31	17
TMX-CM	11,373	14,110	21,290	23,418	22,532	18,545
Total	27,085	36,048	52,647	52,205	47,566	43,110

Table 2-12. Natural disturbance (stand replacing wildfire) by size class

Size Class (transition size)	Decade 1	Decade 2	Decad e 3	Decade 4	Decade 5	Decade >5 (Average)
SS	6,201	11,345	14,597	12,249	12,066	11,291
SMALL	9,524	5004	6,707	10,861	8,840	8,187
MED	8,861	15,426	20,997	15,812	11,422	14,504
LARGE	2,499	4,273	10,346	13,283	15,238	9,128
Total	27,085	36,048	52,647	52,205	47,566	43,110

Management objectives

Linear programming models, such as SPECTRUM, optimize an objective function subject to a set of constraints. An objective function is defined in terms of its type, discount rate (if applicable), duration, and contributing activities and outputs. The constraints in the model were described in the previous section. The following discussion provides a description of the objective functions that were used for solving the model.

Objective to move towards desired condition

For the action alternatives, the objective function for the model was to move towards the desired condition for vegetation, as defined in the revised forest plan. The desired condition was defined by cover type and size class and then goals were developed to achieve desired condition.

Table 2-13 and table 2-14 display the goals for species and size class, respectively, based on the desired condition ranges for vegetation in the revised forest plan. These goals did not vary by alternative. In the model, every acre that is not within the desired condition minimum and the desired condition maximum is assigned a “penalty point.” Penalty points can accrue in any time period in the model, but can become less as the forest moves toward desired conditions through time. The objective is to minimize total penalty points. Thus, alternatives with lower overall penalty points do a better job of moving vegetation towards desired conditions than those alternatives with higher penalty points.

Desired conditions were defined by cover type (forest dominance type) and size class. Goals were set to achieve desired conditions. Because of increased importance on certain species and size classes, penalty points were doubled on white pine and ponderosa pine and on medium size.

Table 2-13. Species composition — percent of all forested National Forest acres

Forest Dominance Type	Forestwide Percent to Maintain or Move Towards
Ponderosa pine	6%
Douglas-fir	18%
Western larch	18% (in order to improve the ability to find a solution, this goal was removed from the model, as it was easily achieved)
Lodgepole pine	15%
TASH (AF/S)	38 % (in order to improve the ability to find a solution, this goal was removed from the model, as it was easily achieved)
TGCH (GF/C)	2%
Western White Pine	3%

Table 2-14. Species composition — percent of all forested National Forest acres

Size Class	Forestwide Percent to Maintain or Move Towards
Seedling/Sapling (less than 5 in. d.b.h.)	24%
Small tree (5 to 9 in. d.b.h.)	20%
Medium tree (10 to 15 in. d.b.h.)	24%
Large tree (greater than 15 in. d.b.h.)	32%

d.b.h. – diameter breast height

Objective to maximize timber

For alternatives A and D, the model was run with an objective function to maximize timber output levels in the first decade. For alternative D, the results were then ‘rolled over’ (first decade harvest levels input as a constraint) and the model re-run with the objective to move towards vegetation desired condition.

Results of SPECTRUM Modeling

Table 2-15 displays the objective functions used to run each alternative and some key outputs: production of timber in both million board feet (mmbf) and million cubic feet (mmcf) in the first decade with a budget constraint; the number of acres managed for timber production over the planning horizon with a budget constraint; timber budget in the first decade; production of timber in both million board feet and million cubic feet in the first decade without a budget constraint; the number of acres managed for timber production over the planning horizon without a budget constraint; the unconstrained timber budget in the first decade, and the desired future condition (DFC) penalty scores with and without budget constraints.

Table 2-15. Timber harvest, acres managed, and budget by alternative

Item	Units	Timeframe	Alt A	Alt B	Alt C	Alt D
Objective Function	N/A	-	Max Timber	Desired Condition	Desired Condition	Max Timber/ Desired Condition
Sawtimber Meeting Utilization Standards with limited budget	MMBF	Decade 1	28.2	27.4	18	29.2
Sawtimber Meeting Utilization Standards with limited budget	MMCF	Decade 1	5.8	5.5	3.9	5.9
Budget (limited)	MM$	Decade 1	4.1	4.1	2.8	4.1
Acres Allocated to Timber Management with limited budget	Acres	Model Horizon (250 yrs)	463,773	365,837	312,426	334,990
Sawtimber Meeting Utilization Standards with unlimited budget	MMBF	Decade 1	52.4	38.4	18	63.5
Sawtimber Meeting Utilization Standards with unlimited budget	MMCF	Decade 1	10.8	7.7	3.9	13
Budget (unlimited)	MM$	Decade 1	7.6	5.6	2.8	9.1
Acres Allocated to Timber Management with unlimited budget	Acres	Model Horizon (250 yrs)	471,661	415,294	361,040	436,182
DFC Score with limited budget	Penalty Points	Model Horizon (250 yrs)	N/A	17,304,284	23,129,453	23,988,325
DFC Score with unlimited budget	Penalty Points	Model Horizon (250 yrs)	N/A	16,898,868	22,823,416	23,560,374

Table 2-15 indicates alternative B does the best job at achieving desired future condition of the action alternatives. Alternative D harvests the most timber of the alternatives, but has the worst desired future condition score of the action alternatives. The desired future condition penalty points was not calculated for alternative A as it was not run with this objective function.

Sensitivity analysis

Sensitivity analysis is conducted to examine the trade-offs caused by the constraints and determine if the SPECTRUM model is working correctly. For the sensitivity analysis, a total of 15 runs were made to test the major features and the effect of various constraints on the results. All sensitivity analysis runs used the acres and analysis units from alternative B. Results would be similar for all alternatives. All runs were made with the objective to move towards vegetation desired future condition.

A set of four calibration runs were made to test the major features of the model. A set of three baseline runs were then made to identify extreme solutions and establish comparison points for measuring the effects of tested constraints. Finally, a set of eight sensitivity runs were made to test the effect of individual or a set of constraints on the model results.

Table 2-16 displays a brief description of the runs that were made for the sensitivity analysis and the purpose for each run.

Table 2-16. Type, description, and purpose of sensitivity analysis modeling runs

Run Type	Run Description	Purpose of Run
Calibration Run 1 (CR 1)	No constraints; all management regimes allowed on all acres including (unlimited) wildfire	Calculates the "best" (lowest) desired future condition (DFC) score the model can derive, although unrealistic
Calibration Run 2 (CR 2)	No constraints; all management regimes on all acres but with no wildfire	Shows the best DFC score when wildfire is not part of the vegetation model
Calibration Run 3 (CR 3)	No constraints; all management regimes on all acres; wildfire constrained to projections	Shows the best DFC score when wildfire is part of the vegetation model
Calibration Run (CR 4)	Adds harvest policy constraints (NDY<=LTSY in perpetuity) to CR 3	Demonstrates the effect of harvest flow constraints on the vegetation model
Baseline Run 1 (BR 1)	DFC baseline with minimal constraints (harvest policy; silvicultural restrictions by MA group)	Calculates a baseline for comparing all Sensitivity Runs
Baseline Run 2 (BR 2)	No management baseline (no veg management and no wildfire)	Calculates a DFC score resulting from no vegetation management
Baseline Run 3 (BR 3)	Max volume baseline (BR 1 with max cubic ft volume all decades)	Calculates the highest sustainable harvest level for comparison to BR 1
Sensitivity Run 1 (SR 1)	Add watershed opening constraints to BR 1	Measure the effect of constraints on watershed openings
Sensitivity Run 2 (SR 2)	Add lynx constraints to BR 1	Measure the effect of constraints on lynx habitat
Sensitivity Run 3 (SR 3)	Add winter range constraints to BR 1	Measure the effect of constraints on big game winter range
Sensitivity Run 4 (SR 4)	Add grizzly bear constraints to BR 1	Measure the effect of constraints on core and non-core grizzly bear habitat
Sensitivity Run 5 (SR 5)	Add silvicultural limit constraints for group selection, commercial thin, and prescribed burning to BR 1	Measure the effect of silvicultural limits on the amount of group selection, commercial thinning, and prescribed burning
Sensitivity Run 6 (SR 6)	Add MA group level group selection treatment mix constraints to BR 1	Measure the effect of limits on unevenaged mgmt within MA groups
Sensitivity Run 7 (SR 7)	Add budget constraints to BR 1	Measure the effect of budget constraints

Table 2-17 displays the results for the sensitivity analysis for selected outputs. This table indicates the best desired future condition score is attained under first calibration run, with the most flexibility in management and no constraints. The desired future condition score is greatly affected by a lack of management, with the worst desired future condition score occurring under the second baseline run, no management. The analysis also indicates that the desired future condition is not greatly affected by any one set of constraints in the model, as shown in the results for each sensitivity run (i.e., SR 1 through SR 8).

Table 2-17 also indicates the timber harvest levels are most affected under sensitivity run 7, the budget constraint and sensitivity run 4, the grizzly bear constraints. These constraints have the largest impact on timber harvest.

Calibration run 4 demonstrates that the harvest policy constraints have an impact on the quantities of timber harvest for each decade, but without a large impact on the desired future condition score. Because the harvest policy constraints do not greatly affect the desired future condition score, there should be no need to consider a departure from these constraints in order to achieve desired future conditions quicker.

Table 2-17. Sensitivity analysis results – desired future condition score and other selected outputs for decades 1, 2, and 3

Run	DFC Score	Timber Harvest mmbf/yr			Commercial Thinning (acres/year)			Regen Harves (acres/year)t			Group Selection (acres/year)			Prescribed Burning (acres/year)			Budget (million dollars/yr)		
		Dec. 1	Dec. 2	Dec. 3	Dec. 1	Dec. 2	Dec. 3	Dec. 1	Dec. 2	Dec. 3	Dec. 1	Dec. 2	Dec. 3	Dec. 1	Dec. 2	Dec. 3	Dec. 1	Dec. 2	Dec. 3
CR 1	7,113,318	100.8	0.0	20.7	29,059	-	-	-	-	-	26,887	-	7,726	905	-	-	43.6	0.3	11.1
CR 2	14,009,659	96.0	0.4	11.4	24,011	-	-	817	1,503	323	25,845	-	1,077	582	-	-	41.8	2.8	2.0
CR 3	12,758,944	68.7	0.0	0.0	26,803	-	-	-	-	-	22,082	-	-	905	-	-	35.9	0.2	0.0
CR 4	12,843,184	31.5	29.9	29.9	18,608	-	-	-	-	-	19,323	3,387	2,950	905	-	-	29.2	5.5	5.1
BR 1	14,920,756	56.1	57.0	57.4	2,376	1,213	950	-	1,602	1,604	5,970	2,272	2,369	4,510	-	2,252	8.7	8.4	8.4
BR 2	54,215,332	0.0	0.0	0.0	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0.0
BR 3	43,976,926	89.3	89.5	94.6	156	156	3,277	44	44	4,016	7,664	7,048	2,755	-	-	-	13.3	13.5	13.7
SR 1	14,920,924	56.2	57.2	57.7	2,376	1,239	923	-	1,600	1,704	5,983	2,278	2,251	4,510	-	2,247	8.7	8.6	8.3
SR 2	15,769,562	41.7	42.8	43.2	7,707	2,012	200	-	2,050	3,718	1,731	304	-	4,219	-	2,466	6.6	6.2	6.3
SR 3	14,922,346	55.7	56.7	56.9	2,376	1,121	1,041	-	1,604	1,408	5,946	2,272	2,587	4,510	-	2,262	8.6	8.4	8.4
SR 4	15,428,139	33.7	33.9	34.8	6,250	2,286	1,124	-	1,088	1,898	1,600	1,303	-	5,518	-	2,390	5.4	5.2	5.0
SR 5	15,538,861	56.5	56.5	57.2	1,000	1,000	1,000	2,591	2,759	3,418	500	500	500	-	3,163	3,706	8.1	8.1	8.2
SR 6	14,972,802	56.7	56.1	62.3	4,649	200	200	1,039	721	3,724	4,613	3,209	-	4,510	-	2,623	8.8	8.3	8.9
SR 7	15,563,233	24.7	26.1	27.9	8,740	3,650	33	-	426	2,436	-	1,134	-	6,840	-	2,858	4.1	4.1	4.1
SR 8	16,878,588	27.7	27.7	27.9	1,000	1,000	1,000	1,378	1,623	1,924	-	-	-	492	3,834	4,995	4.1	4.1	4.1

DFC – desired future condition

SIMPPLLE Modeling Results of Vegetation Change over Time

This section of the appendix displays outputs for the vegetation characteristics as modeled with SIMPPLLE. For projection of vegetation conditions into the future, multiple simulations were run with the same natural ecological processes and disturbances as done for the natural range of variation analysis, but assuming a fire suppression logic similar to current practice, and adding in the projected harvest and prescribed burn treatment outputs from the SPECTRUM model. Vegetation conditions were projected out through five timesteps (5 decades), with the first two timesteps under a “normal” climate scenario and the last three timesteps under a “dryer” climate scenario. Thirty iterations of the model were run to capture the variability and inherent uncertainties that would occur with timing and location of disturbance events (such as fire). This variability is reflected as a range in the vegetation characteristics that result by the fifth decade.

Fire, insects, disease, and timber harvest are the disturbances that impact vegetation change in the model, interacting with climate and vegetative succession, over the five decade modeling period. As discussed earlier, though best available science and professional knowledge are used to develop the model, we cannot know with certainty the location, timing or pattern of fire and insect/disease events. Similarly, exact locations and timing of anticipated harvest treatments cannot be predicted with certainty. Model projections portray a possible outcome based on our best efforts, and are most useful to provide comparative rather than absolute values. Figure 2-3 displays the average acres per decade affected by the individual disturbance type as modeled over the five decade modeling period for each alternative. Information on the modeling aspects for each of the disturbance types is briefly discussed below. Additional information on disturbances and treatments can be found in chapter 3 of the draft environmental impact statement, under the summary of ecosystem processes (section 3.3.2).

Since desired conditions in the plan for vegetation components are provided both at the forest wide scale and by biophysical setting (depending on the particular attribute), the future vegetation conditions were analyzed at these two scales to allow for comparison. Refer to appendix D of the plan for information on the biophysical settings.

Wildfire

In figures 2-2 and 2-3, the acres of wildfire are unplanned ignitions that include both fires that will be allowed to burn to achieve desired vegetation conditions (wildland fire use), and fires that will be actively suppressed, but have a probability of growing to moderate or large size under certain climatic and vegetation conditions. The average wildfire acres displayed in the figure do not imply an “even flow” of acres burned over time. The acres burned vary by decade between the thirty simulations, from a low of about 43,000 acres to a high of nearly 380,000 acres within a decade (see figure 2-3). Most (nearly 90 percent) are stand-replacement fires; about 10 percent are mixed (moderate) severity fires; less than 1 percent is estimated to be low severity fire. The model simulations reflect the reasonable assumption that under warmer climate periods drier conditions would also occur, and a higher amount of fire could be expected across the landscape when compared to normal climatic periods.

Insect and Diseases

As seen in figure 2-3, the model suggests that insects and disease, and particularly the bark beetles, will play a major role in affecting vegetation over the next five decades. Douglas-fir and spruce beetle increase dramatically and remain at a high level over most of the model period. As with fire, these are modeled estimates, based on our best available information, but associated with a high level of uncertainty. Though it is reasonable to assume some increase in these insects over the model period, the acres and length of infestation are believed to be substantially overestimated.[16] This factor should be considered when interpreting the model results, because these bark beetles would affect Douglas-fir and spruce trees, in particular by removal of the large and very large trees that are most susceptible to beetle mortality, and reducing forest size class. Forest impacted by beetles may also show a decrease in forest density and shift in species composition.

Acres affected by root disease and western spruce budworm are believed to be representative of what might be expected over the next five decades. Root disease primarily impacts Douglas-fir, grand fir and subalpine fir dominated forests, potentially decreasing forest densities and shifting species composition. Western spruce budworm primarily impacts these same species, as well as spruce.

Prescribed Fire

This is a management treatment, projected by the SPECTRUM model, that would occur across all areas of the forest except within designated wilderness areas or within the grand fir/cedar dominance type on the warm moist biophysical setting. The model estimates that low severity underburns across about one-quarter of the acres, which occur in the warm moist and warm dry biophysical settings where early successional fire resistant species occur. The remainder are moderate to high severity burns applied in the cool moist-moderately dry biophysical settings. No prescribed fire is modeled to occur in alternative A, because the existing plan has no specific objectives or direction related to implementation of prescribed fire. However, in reality prescribed fire is and will be used as a tool to achieve desired vegetation and fuel conditions under the current plan, similarly as might occur under the action alternatives.

Currently the forest conducts prescribed burns on about 2,500 acres per year on average (i.e., 25,000 acres per decade). The model estimates substantially more acres of prescribed burning over the next five decades. However, this is very likely an overestimation of the amount of acres that would actually be reasonably implemented, mainly due to the restrictions on treatment in multi-story winter showshoe hare habitat in mapped lynx habitat. Refer to appendix F of the plan for lynx direction, and to the Vegetation section of the draft environmental impact statement for additional information on this effect.

Timber Harvest

Harvest as modeled in SPECTRUM is of three general types: regeneration, commercial thin and group selection (see table 2-18 and figure 2-3). Commercial thin and group selection are combined into “non-regeneration harvest” in figure 2-3). As evident in figure 2-3, the acres affected by timber harvest are a relatively small proportion compared to natural disturbances. Regeneration harvest removes most existing trees, altering forest size classes and in some cases forest densities and species composition. Subsequent reforestation (planting or natural regeneration) occurs in regeneration harvested stands. Commercial thinning removes a portion of the existing trees, mainly resulting in reduced forest density, but may also increase size class and change forest composition. Group selection harvest would reduce stand densities, and tends to maintain or increase the shade tolerant tree species (e.g., grand fir, subalpine fir) as compared to shade intolerant species, because of the small openings and denser forest canopy conditions.

Quantitative Results and Comparison

Figures 2-2 and 2-3 and table 2-18 provide a comparison of the average acres per decade forestwide affected by fire, insects, disease and harvest by alternative, as modeled over a five decade period into the future. Figures 2-4 through 2-23 provide a summary of the quantitative results of the analysis of change in

[16] Personal communication. 2016. N. Sturdevant. Forest Service entomologist. USDA, Forest Service. Northern Region. Missoula, Montana. January.

vegetation as modeled with SIMPPLLE, using treatments projected in the SPECTRUM model. The results are displayed as a range in proportion of area at timestep five (fifth decade) for each alternative. The desired condition (or natural range of variation, in the case of forest canopy cover class) and existing condition are displayed in these figures for comparison. Graphs displaying the vegetation conditions by decade as they change across the five decade model period are located in the planning record. Taken together, the figures and graphs provide the detailed output results that were used to inform the effects analysis and comparison of alternatives disclosed in the Vegetation section of the environmental impact statement (sections 3.3.4, 3.3.5, 3.3.6, and 3.3.10).

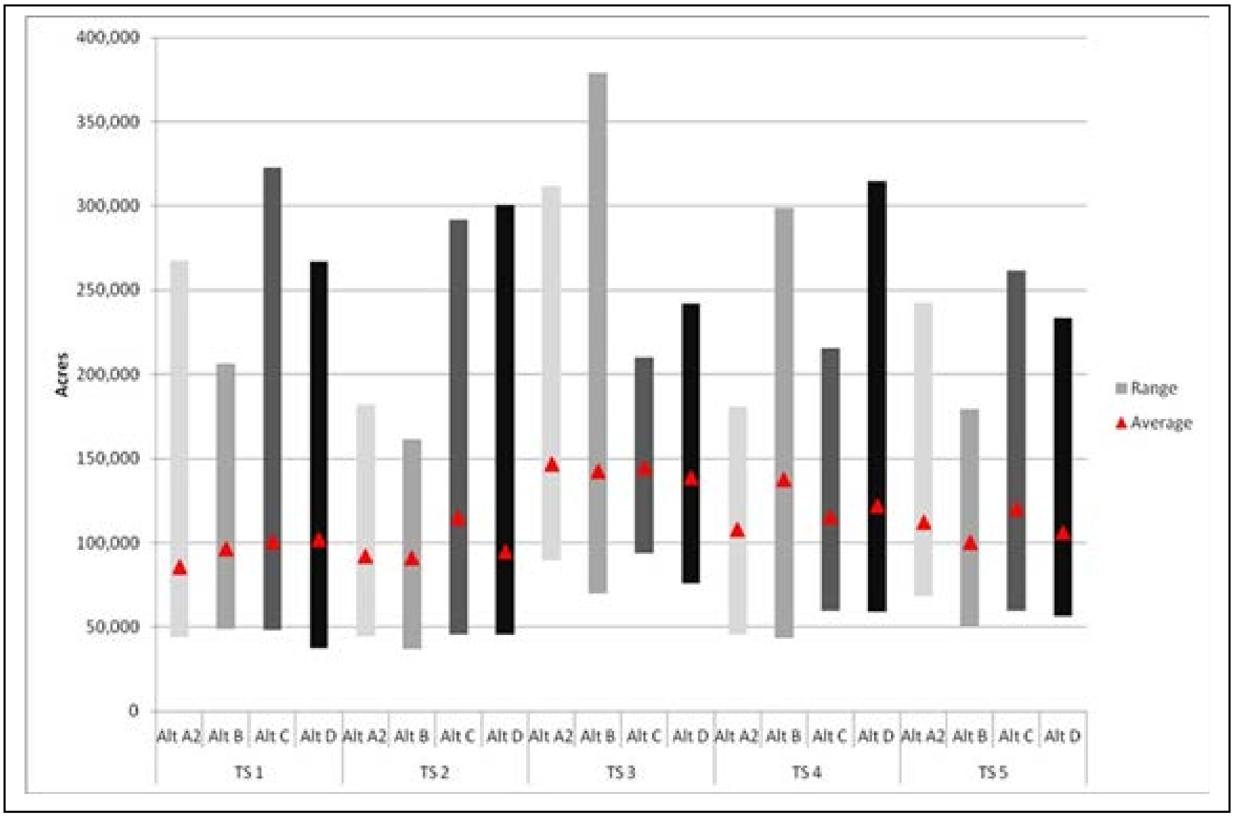

Figure 2-2. SIMPPLLE model outputs for wildfire acres burned by decade and alternative, across the five decade model period

Table 2-18. Acres per decade by alternative, as averaged across the five decade modeling period for each timber harvest type. Source: SPECTRUM model

Alternative	Regeneration harvest (acres)	Commercial thin (acres)	Group selection harvest (acres)	Total harvest average per decad (acres)e
A	13,625	0	5,068	18,693
B	14,202	31,454	0	45,656
C	5,263	25,554	8,089	38,906
D	14,568	13,774	2,998	31,340

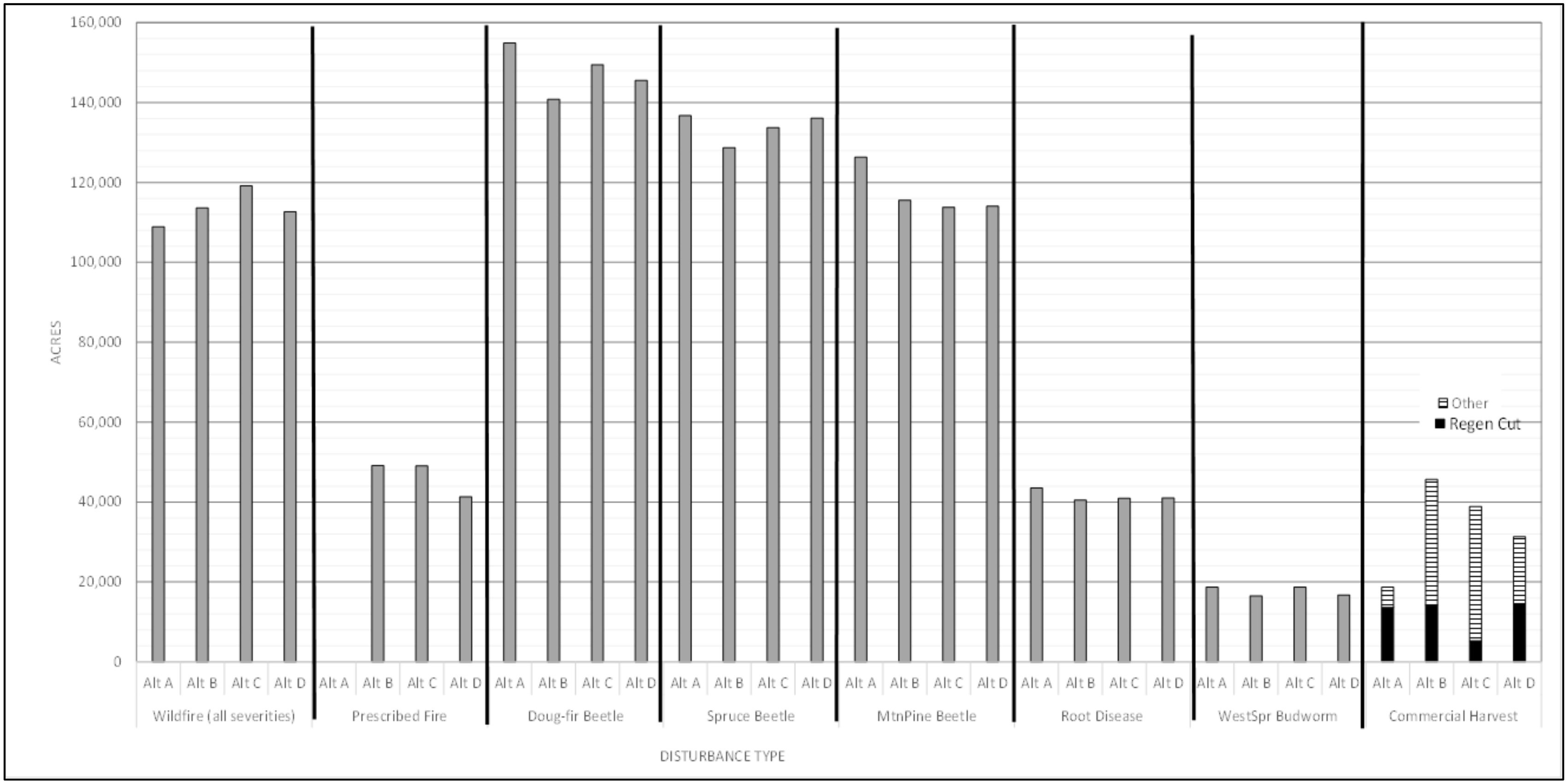

Figure 2-3. Average acres per decade forestwide affected by fire, insects, disease and harvest by alternative, as modeled over a five decade period into the future. Source: SPECTRUM model (for amount of harvest acres and prescribed fire, assuming a constrained budget) and SIMPPLLE model (for wildfire, insects and disease disturbances)

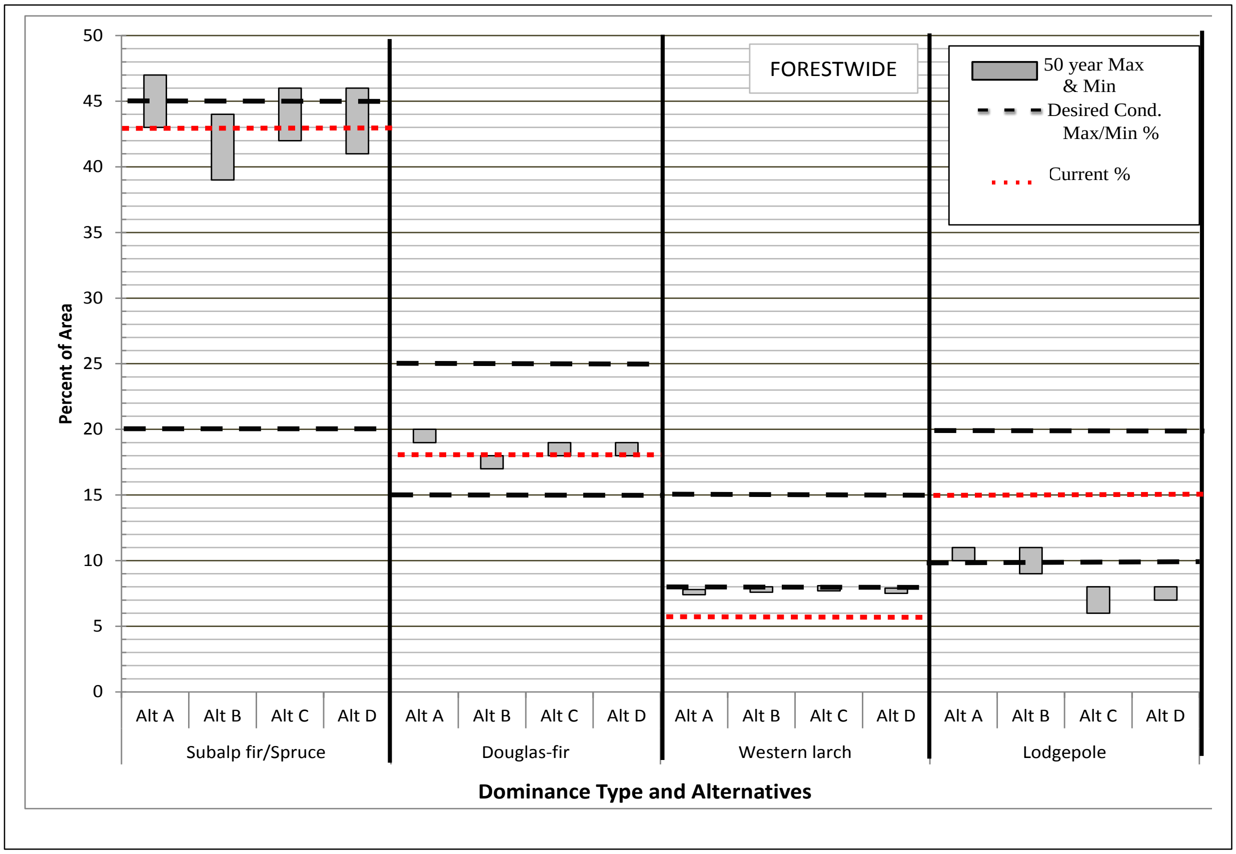

Figure 2-4. Vegetation dominance types (major species) Forestwide at decade 5 (SIMPPLLE model)

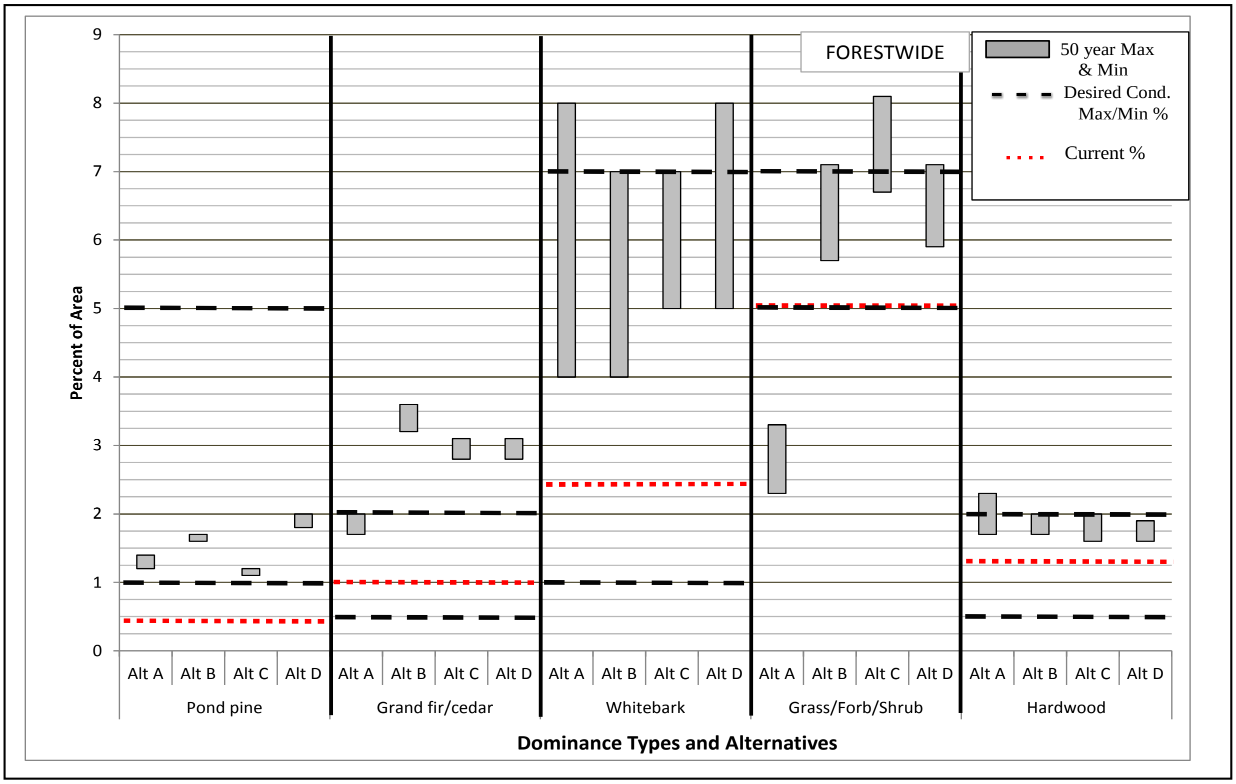

Figure 2-5. Vegetation dominance types (minor species) Forestwide at decade 5 (SIMPPLLE model)

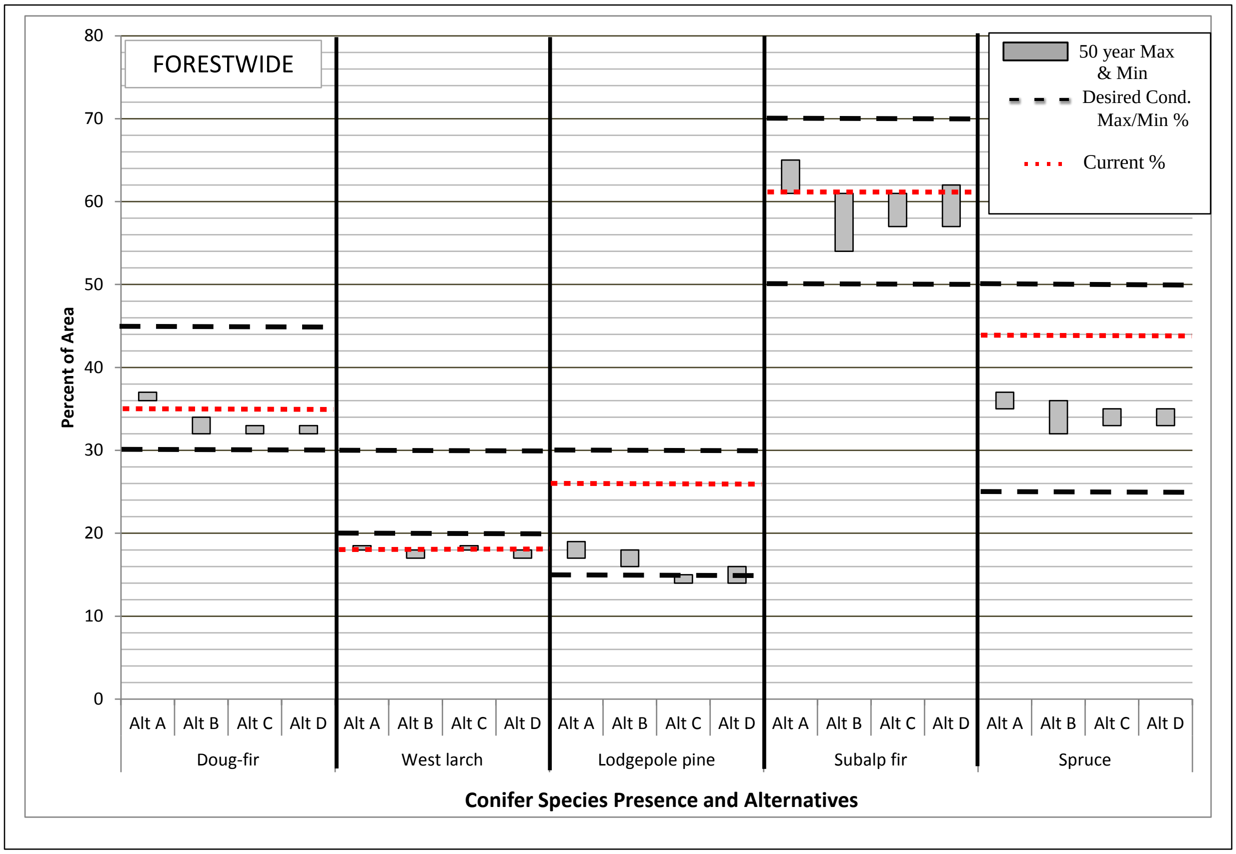

Figure 2-6. Conifer species presence (major species) Forestwide at decade 5 (SIMPPLLE model)

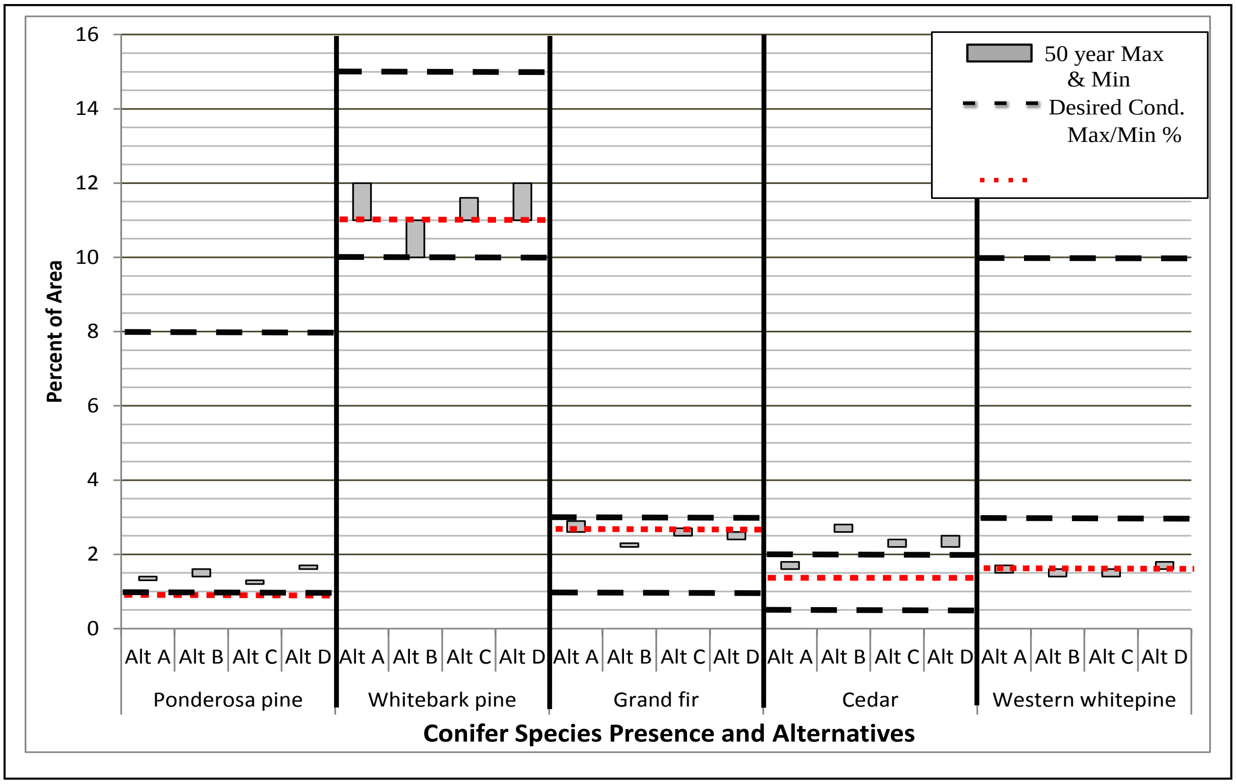

Figure 2-7. Conifer species presence (minor species) Forestwide at decade 5 (SIMPPLLE model)

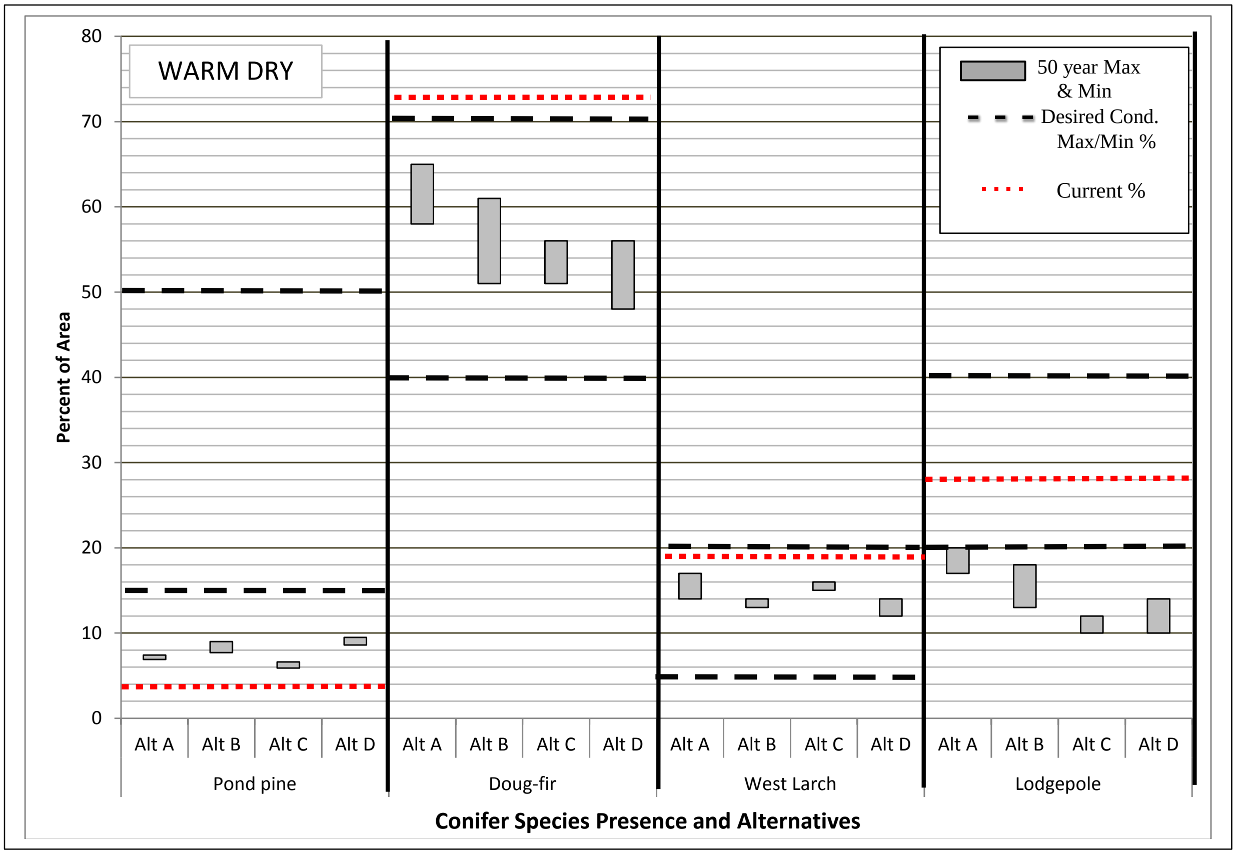

Figure 2-8. Conifer species presence in the Warm Dry BioSetting at decade 5 (SIMPPLLE model)

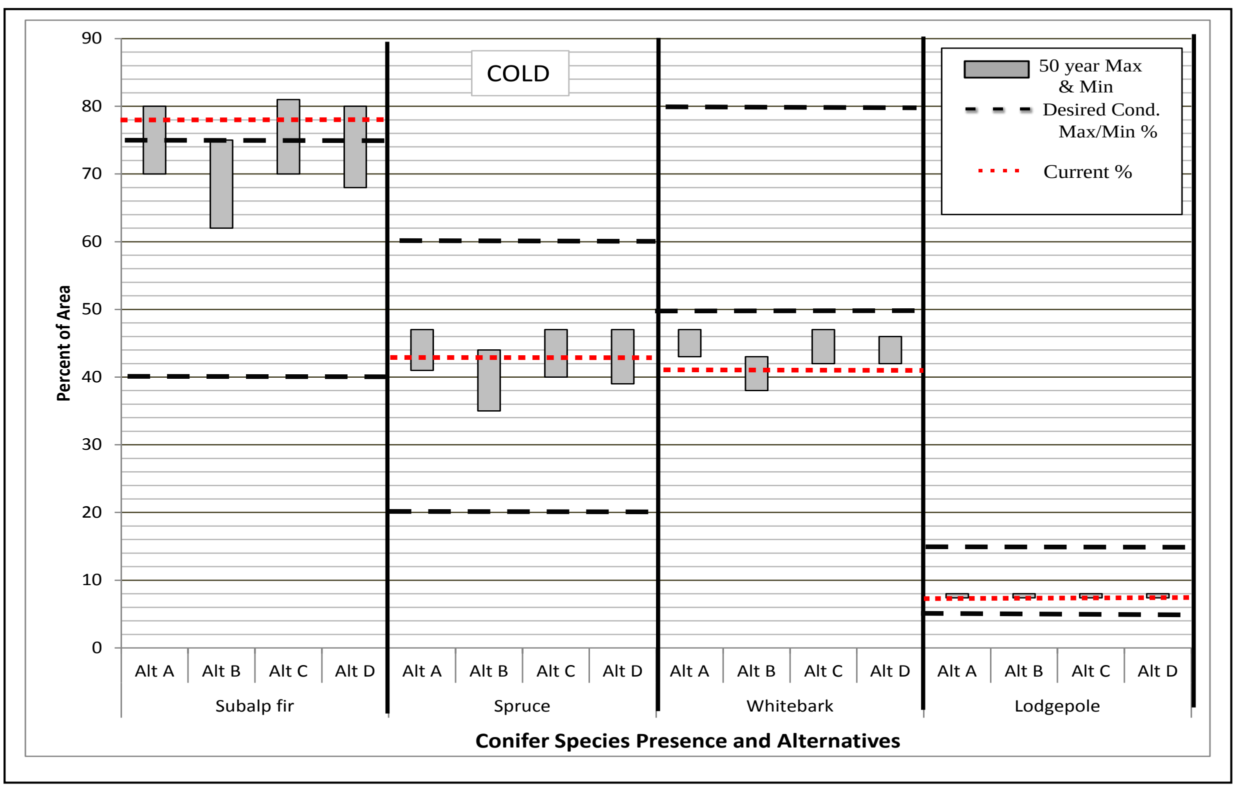

Figure 2-9. Conifer species presence in the Cold BioSetting at decade 5 (SIMPPLLE model)

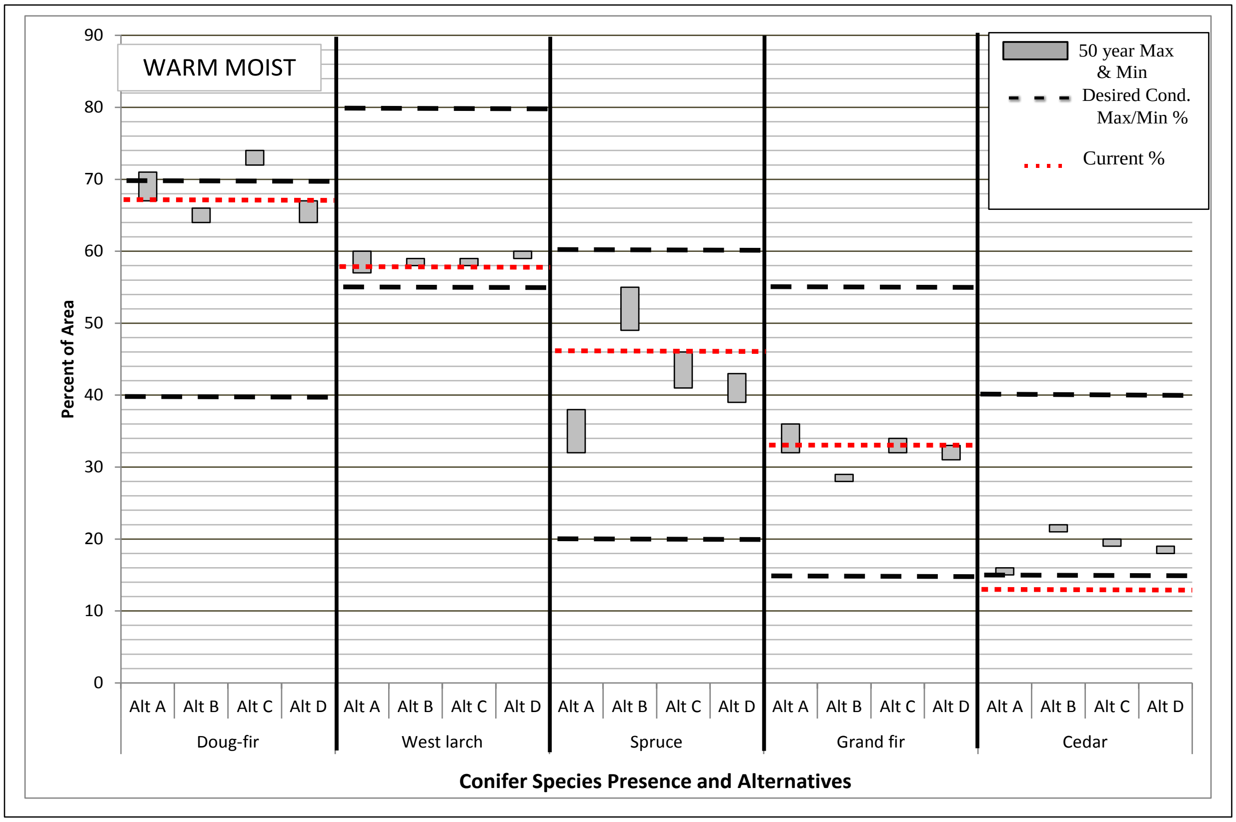

Figure 2-10. Conifer species presence (major species) in the Warm Moist BioSetting at decade 5 (SIMPPLLE model)

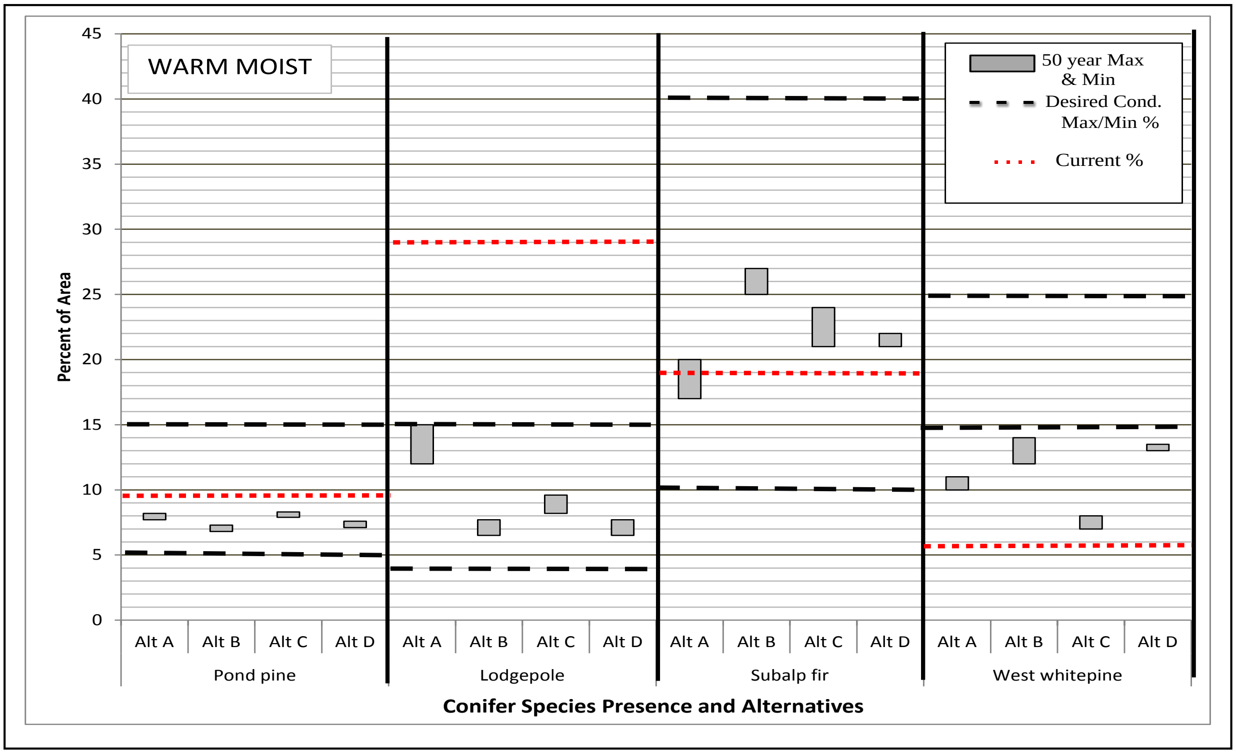

Figure 2-11. Conifer species presence (minor species) in the Warm Moist BioSetting at decade 5 (SIMPPLLE model)

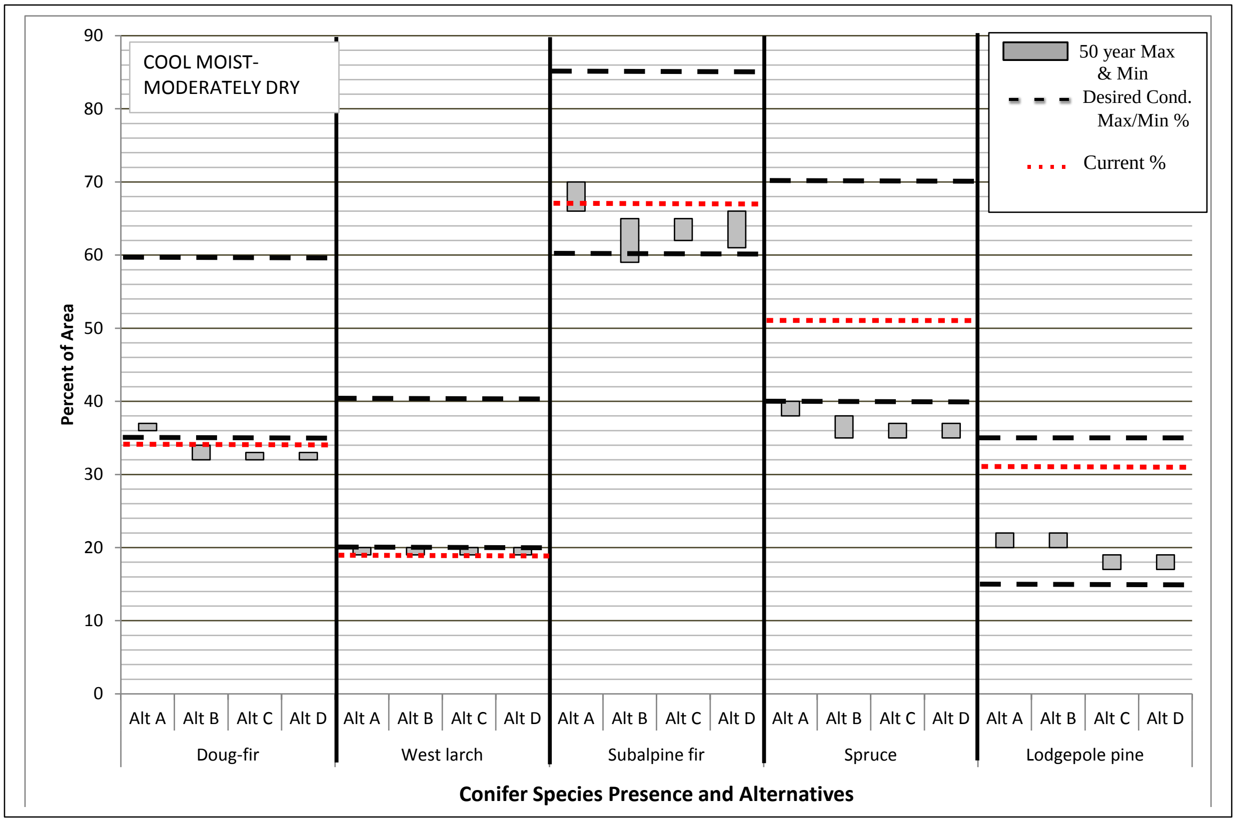

Figure 2-12. Conifer species presence (major species) in the Cool Moist-Mod Dry BioSetting at decade 5 (SIMPPLLE model)

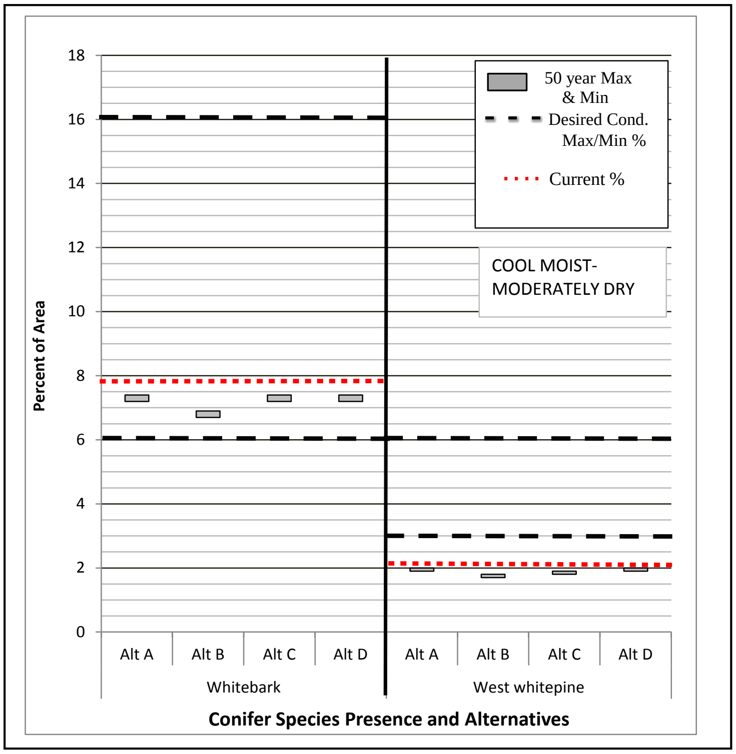

Figure 2-13. Conifer species presence (minor species) in the Cool Moist-Mod Dry BioSetting at decade 5 (SIMPPLLE model)

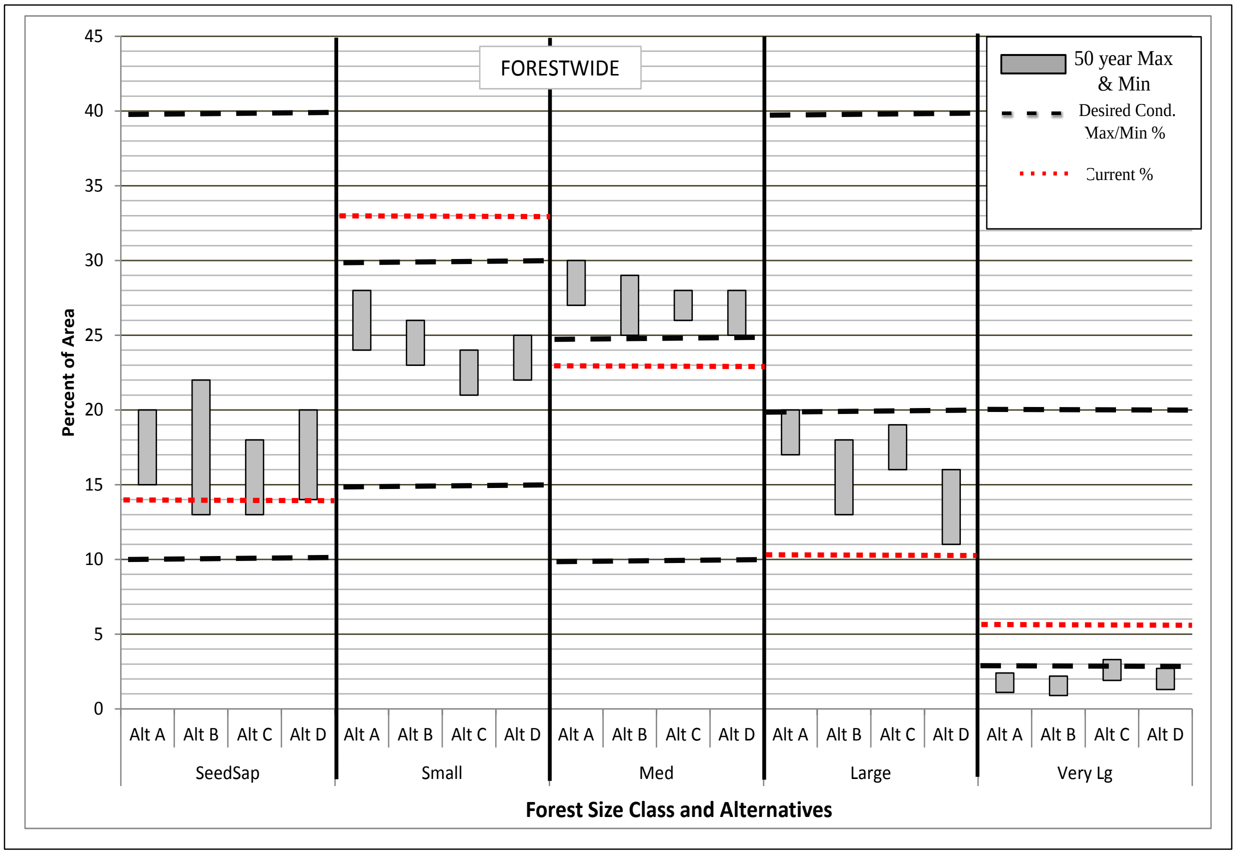

Figure 2-14. Forest size class, Forestwide, at decade 5 (SIMPPLLE model)

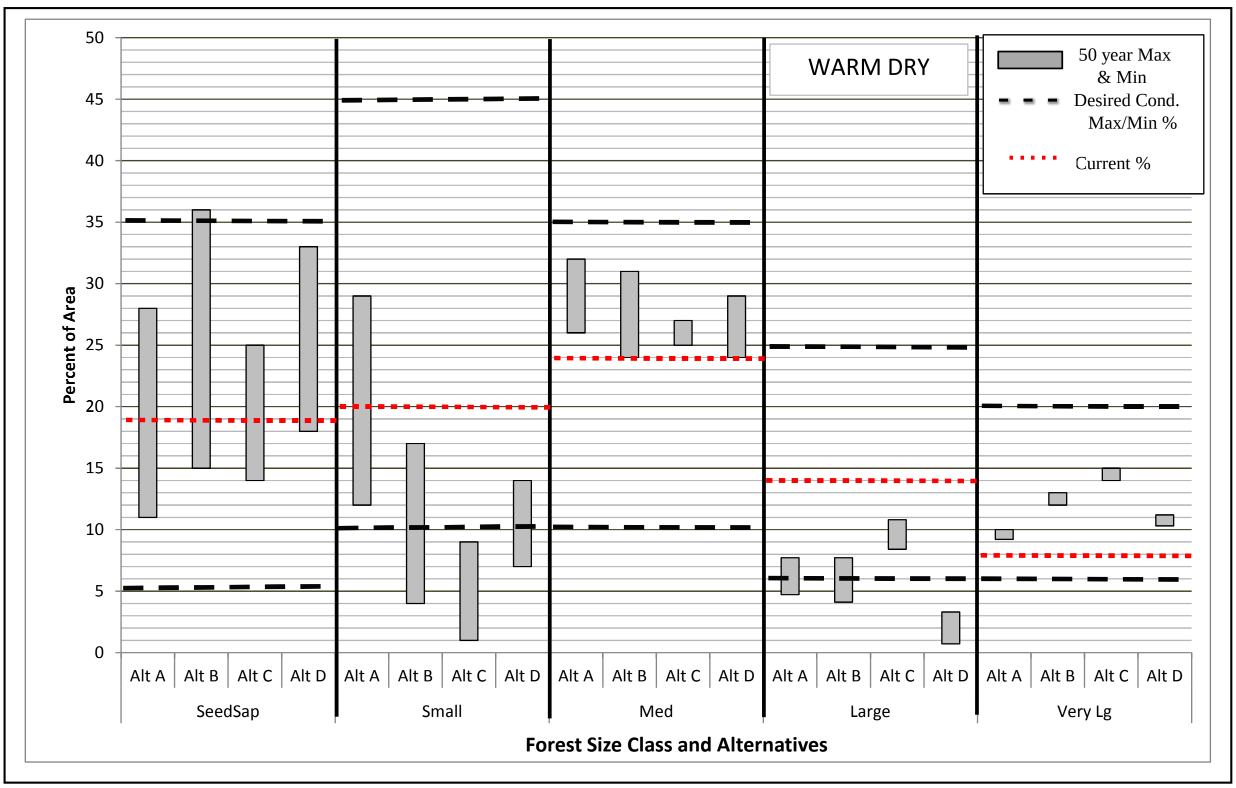

Figure 2-15. Forest size class in the Warm Dry BioSetting at decade 5 (SIMPPLLE model)

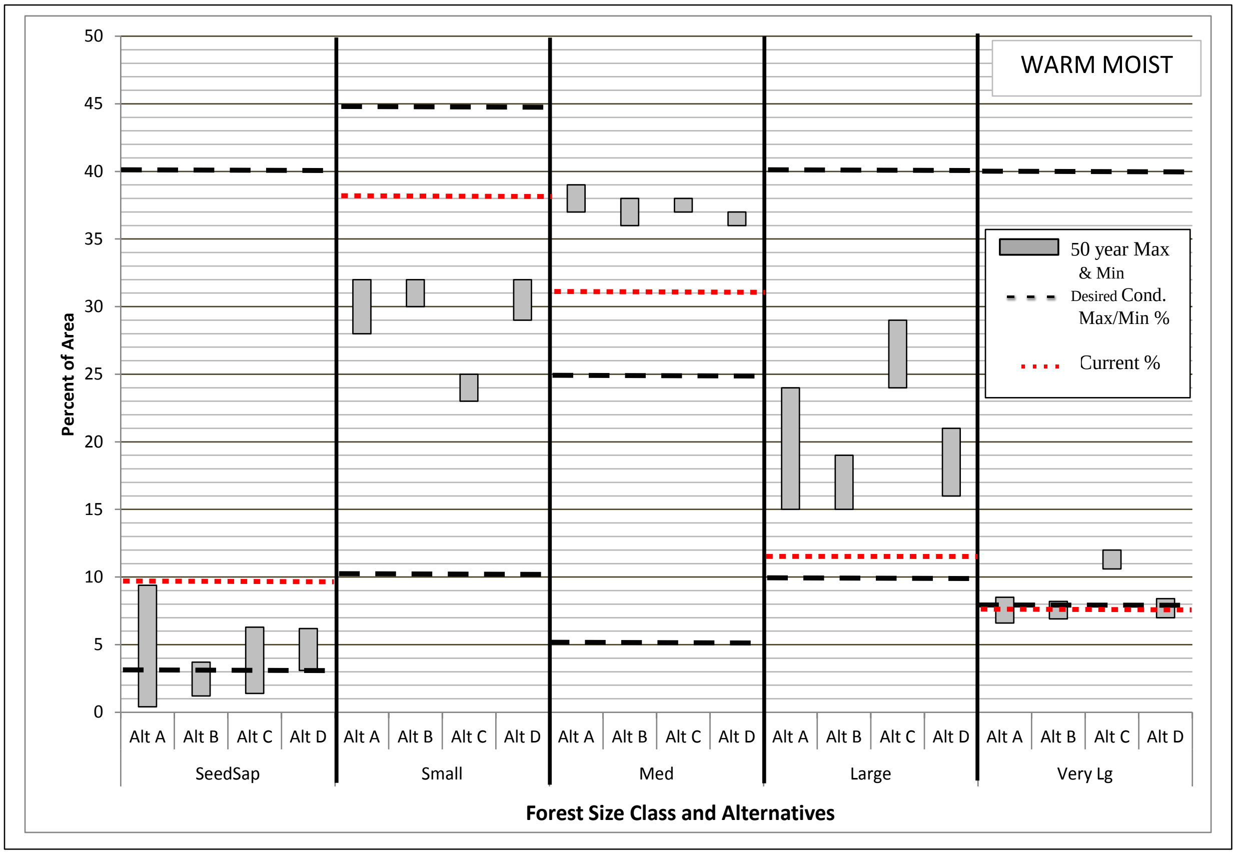

Figure 2-16. Forest size class in the Warm Moist BioSetting at decade 5 (SIMPPLLE model)

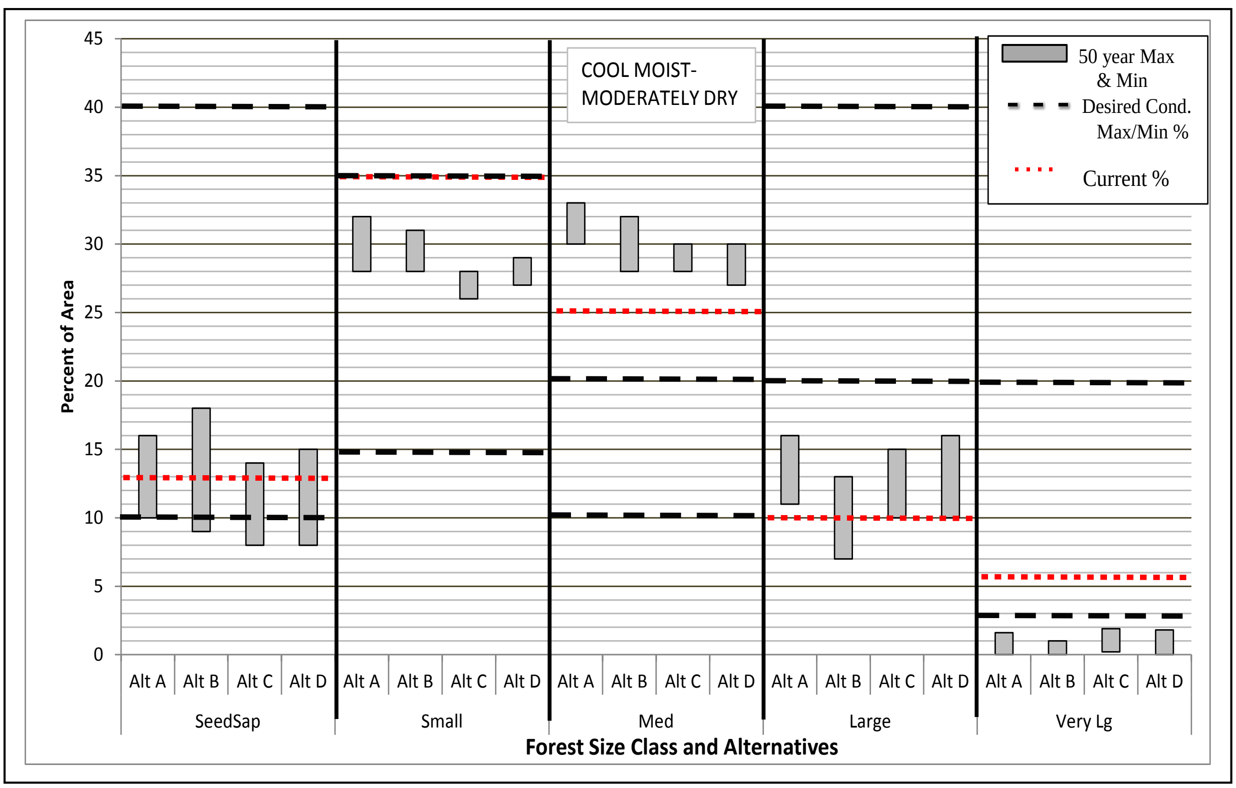

Figure 2-17. Forest size class in the Cool Moist-Mod Dry BioSetting at decade 5 (SIMPPLLE model)

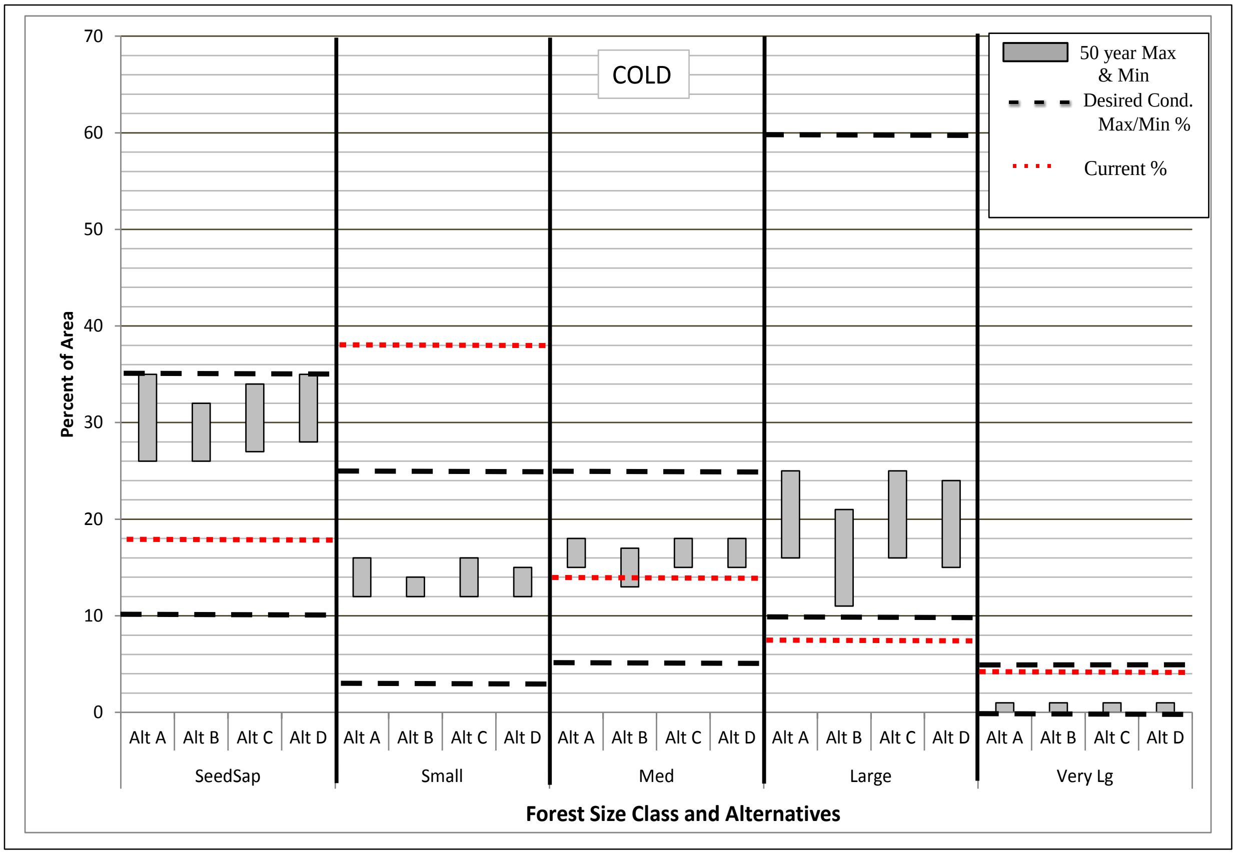

Figure 2-18. Forest size class in the Cold BioSetting at decade 5 (SIMPPLLE model)

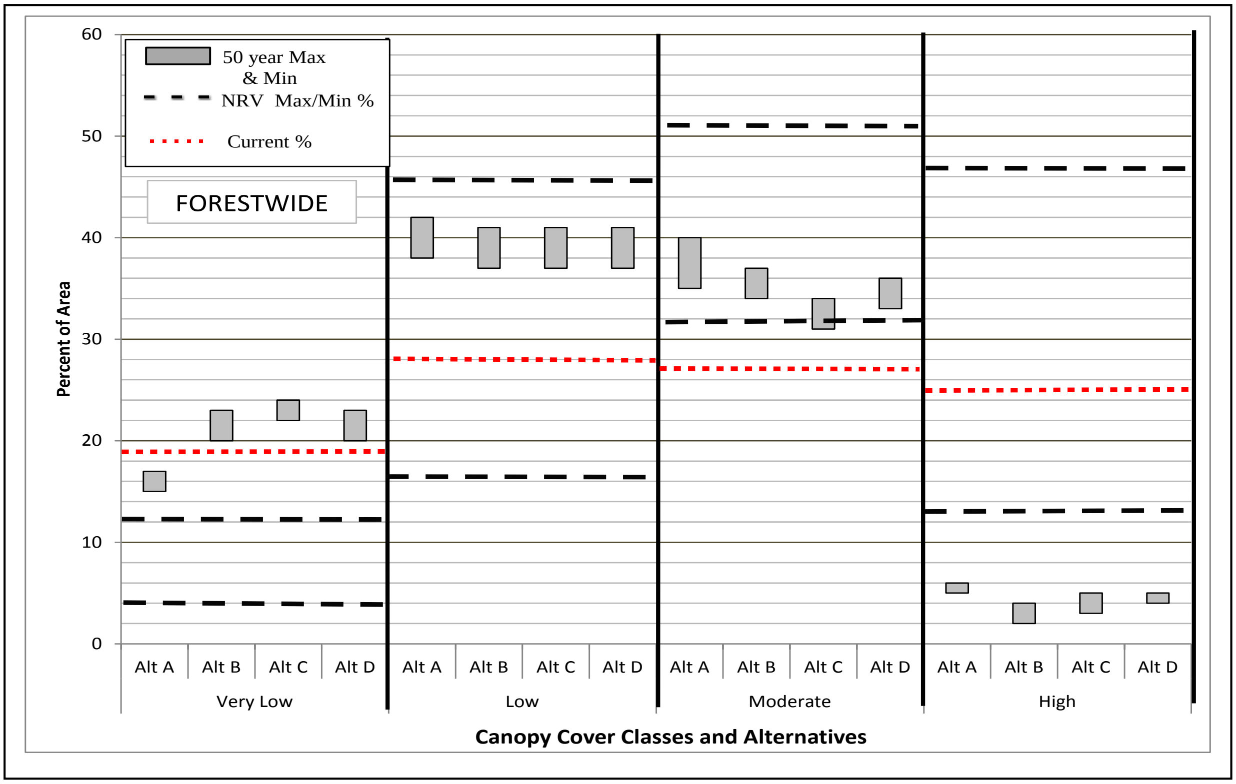

Figure 2-19. Forest canopy cover class, Forestwide, at decade 5 (SIMPPLLE model)

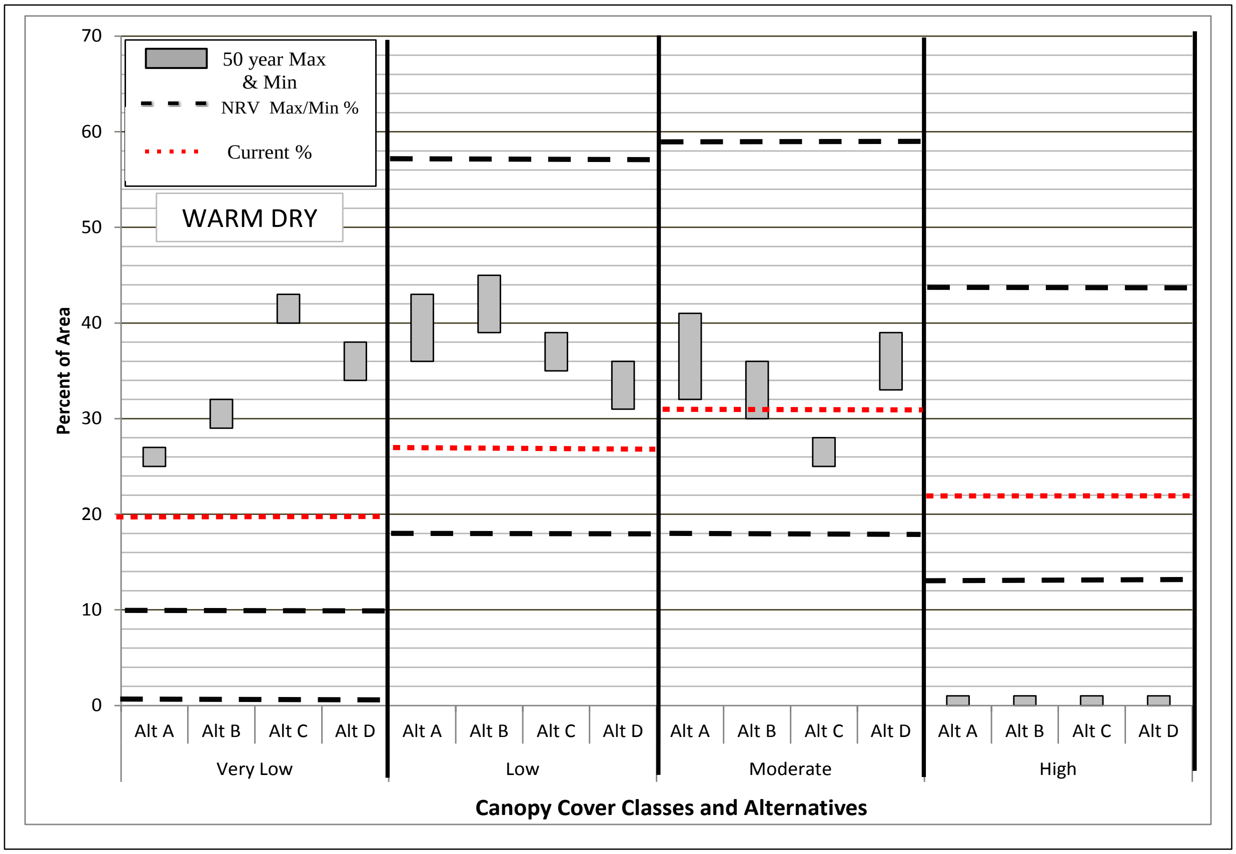

Figure 2-20. Forest canopy cover class in the Warm Dry BioSetting at decade 5 (SIMPPLLE model)

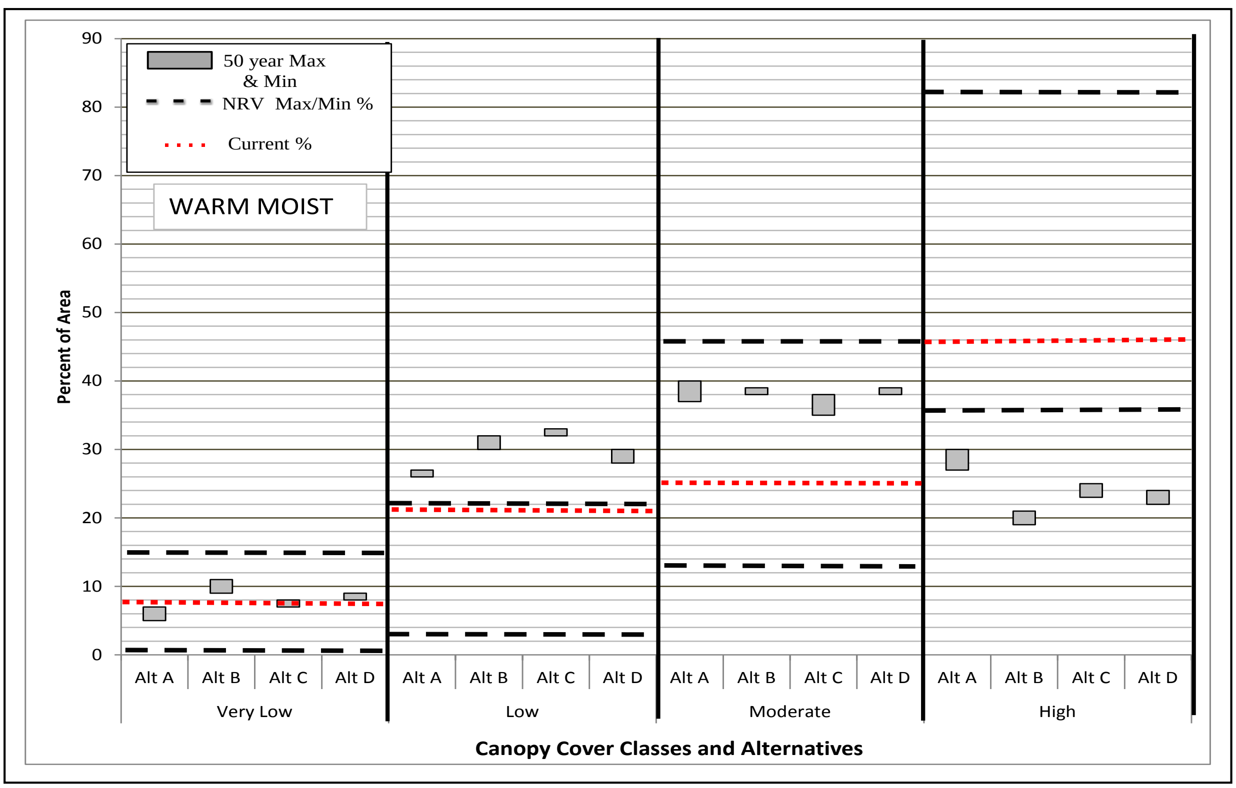

Figure 2-21. Forest canopy cover class in the Warm Moist BioSetting at decade 5 (SIMPPLLE model)

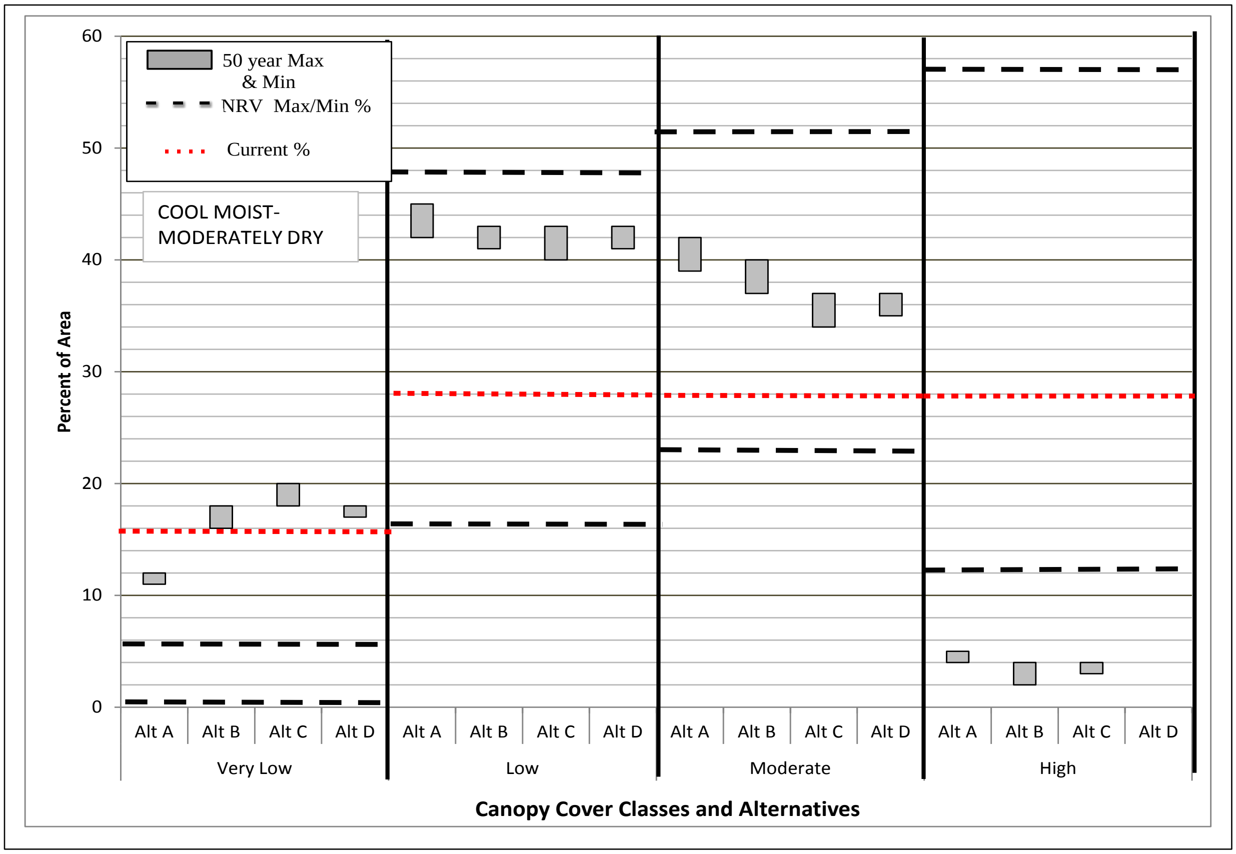

Figure 2-22. Forest canopy cover class in the Cool Moist-Mod Dry BioSetting at decade 5 (SIMPPLLE model)

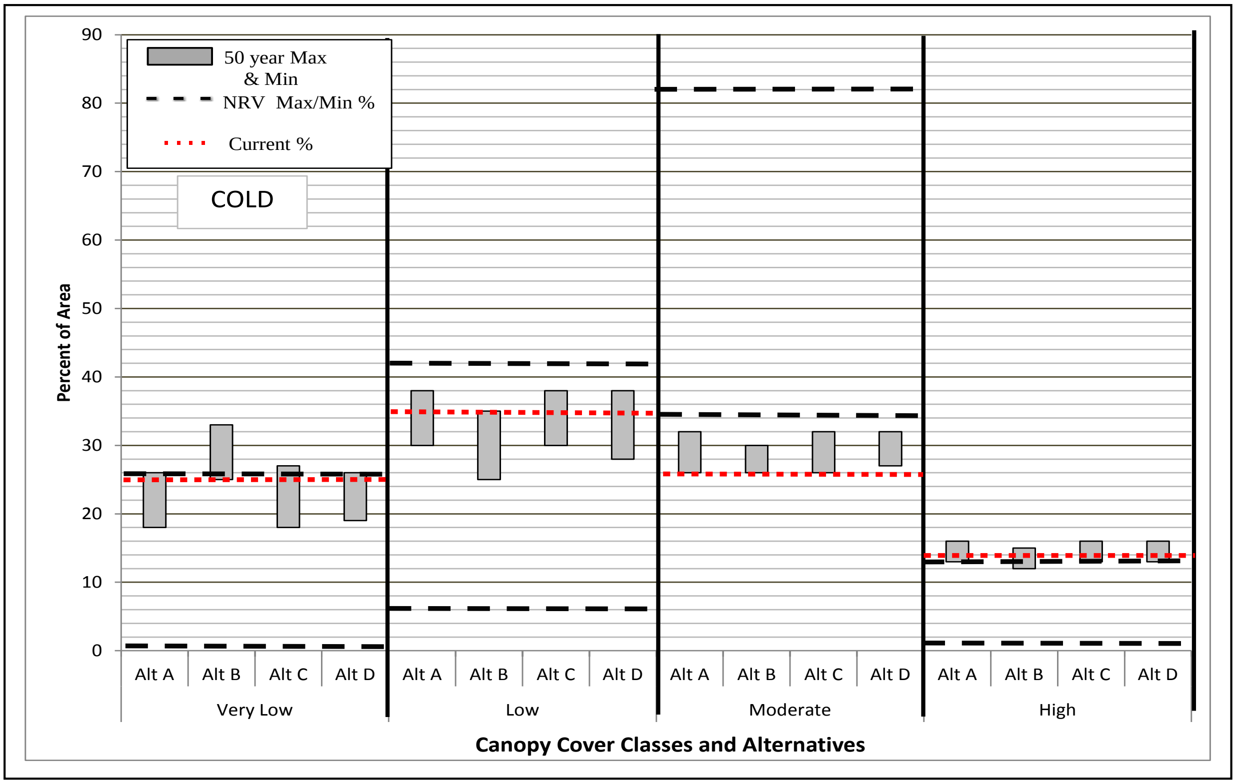

Figure 2-23. Forest size class in the Cold BioSetting at decade 5 (SIMPPLLE model)