Appendix H. Terrestrial Vegetation, Wildlife, and Timber Methodologies and Results

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Introduction

This appendix includes the background information, methodologies, and model results for all components of the terrestrial vegetation, old growth, snags and downed wood, and timber analyses, as well as specific wildlife habitat conditions that were included in the vegetation model.

Alternatives B and C are identical in terms of vegetation and timber plan components, and other elements that substantially influence vegetation. Therefore, they are analyzed together as “alternatives B/C”.

See appendix J for additional information regarding how climate change was incorporated in the analysis; and appendix I for a detailed summary of the natural range of variation (NRV) analysis.

Methodology overview

Terrestrial vegetation

The terrestrial vegetation section documents the coarse filter analysis of the terrestrial ecosystems. The analysis area includes all lands administered by the HLC NF. Information is summarized at several scales:

1. Forestwide, to provide information on the broad scale context;
2. Broad potential vegetation type (PVT), because indicators vary by site capability;
3. Geographic area (GA) because the unique disturbance history and human uses of each area has and will continue to influence vegetation;
4. Managed landscapes versus unmanaged landscapes (defined as designated wilderness, recommended wilderness - RWA, wilderness study act areas, and inventoried roadless areas - IRAs); and
5. Wildland urban interface (WUI) areas versus non-WUI areas. For the HLC NF analysis, the WUI is mapped based on County Wildland Protection Plans (CWPPs) where available, and standard Hazardous Fuels Reduction Act (HFRA) definitions where CWPP maps are unavailable. The WUI will change over time as human developments and land use change.

The analysis area for cumulative effects also includes lands of other ownership within and adjacent to the HLC NF. The terrestrial vegetation analysis is based on large part upon desired future conditions. These conditions are enumerated in detail in the “*Desired conditions and vegetation metrics*” section below. A NRV analysis was conducted to assess ecological integrity and to provide the basis for desired vegetation conditions (appendix I). The SIMPPLLE model was used to estimate the NRV; the calibrations applied to this model are described in the “*Vegetation models*” section below.

Old growth, snags, and downed wood

Three scales of analysis are used; all NFS lands are considered within these boundaries:

1. Forestwide - to provide information on the broad scale abundance of old growth.
2. Broad PVT - because old growth types and conditions vary by site capability.
3. GA - because the unique disturbance and human use history of each area influences the abundance and type of old growth.

The desired condition for old growth in the 2020 Forest Plan (alternatives B, C, D, E, and F) applies forestwide and by each broad PVT. Smaller scales, such as individual watersheds or drainages, or even the smallest GAs, would not necessarily be appropriate to encompass the disturbances that affect old growth or the array of natural vegetation conditions (such as nonforested plant communities) where old growth desired conditions would not be applicable.

Forest Inventory and Analysis (FIA) field procedures collect the data required to provide a statistically sound estimate of the amount of old growth present across the landscape at mid to broad scales. Confidence intervals around estimates vary based on the size of the sample and the variability of vegetation. Two datasets are used. "Hybrid 2011", is used for forestwide and broad PVT estimates because it represents all NFS lands across the plan area. "F12_F15_Partial_IntGrid_4X_Hybrid_2016COMBINED", is used for estimates on all GAs except the Rocky Mountain Range, because these areas have had an intensified plot grid installed.

Old growth cannot be estimated into the past or the future with available models, because the spatial data avilable (R1-VMap) cannot reliably derive attributes such as stand age. However, the large-tree structure attribute estimated from FIA at the mid to broad scale shows a correlation to old growth and is used as an analysis indicator. An unknown subset of these areas may be old growth and therefore the expected trend may be similar.

The analysis area for snags is forestwide by snag analysis group. Snag analysis groups are consistent with broad PVTs, except that areas dominated by lodgepole pine are addressed separately. This is important for the snag analysis because lodgepole pine is relatively short lived, generally smaller in diameter than other species, and subject to stand replacing disturbances which result in unique snag conditions and dynamics.

Downed woody debris is analyzed using broad PVTs to be consistent with the best available information to inform the desired condition.

Timber and other forest products

Timber suitability was mapped using the best available geospatial information. Lands that may be suitable for timber production were determined based on the factors required by NFMA and the 2012 planning rule and are the same for all alternatives. Of those lands that may be suitable, the lands that are suitable for timber production vary by alternative based on management objectives.

Timber harvest outputs (projected wood sale quantity, projected timber sale quantity, harvest by decade, and sustained yield limit) were modeled using PRISM, a software modeling system designed to assist decision makers in exploring and evaluating multiple resource management choices and objectives. Models constructed with PRISM apply management actions to landscapes through a time horizon and display outcomes. Management actions are selected to achieve desired goals while complying with identified objectives and constraints. PRISM outputs are used to display tradeoffs between alternatives and to predict sustainable timber harvest levels over time. The existing condition of vegetation is based on data sources which accurately reflect conditions on the landscape, including the impacts of recent fires, bark beetles, and management, as described in the *Data sources* section. The timber model incorporates detailed yield tables built using local data and prescriptions, as described in the *PRISM model design* section. Future projections include potential disturbances, climate conditions, and applicable constraints from plan components including fire suppression.

The analysis area for timber suitability, timber supply, timber harvest, and other forest products includes all NFS lands on the HLC NF. The analysis area for timber demand consists of sixteen counties that contain infrastructure and/or communities that utilize timber from the HLC NF (Table 1).

Table 1. Counties affected by HLC NF timber outputs

County group	Counties
North	Glacier, Pondera, Teton
Central	Cascade, Choteau
East	Fergus, Judith Basin, Meagher, Wheatland
West	Broadwater, Jefferson, Lewis and Clark, Powell
Secondary	Deer Lodge, Gallatin, Park

Data sources

A variety of well-researched and documented datasets and tools are used which collectively make up the best available science for quantifying vegetation. This determination is made based upon the following:

- Systematic field inventories using National and Regional field sampling protocols provide statistically based, consistent methodologies for quantifying vegetation characteristics and a high level of known accuracy. FIA plot data meets these criteria and are used to quantify the existing condition of vegetation. FIA intensified grid plots provide a larger and more recently sampled dataset for most of the HLC NF; these plots were re-measured following the recent mountain pine beetle outbreak and therefore reliably depict current vegetation conditions.
- Vegetation mapping derived from National and Regional remote sensing protocols provide consistent methodologies for classifying and mapping vegetation characteristics, and are assessed for accuracy so that their level of uncertainty is quantifiable. This information is inherently less accurate and detailed than systematic plot sampling, but provides valuable complementary information and allows for an analysis of the spatial distribution of vegetation. The R1 VMap used (version 2014) is based on imagery from 2011, and therefore incorporates most of the impacts of the recent mountain pine beetle outbreak. The product is also updated to incorporate more recent wildfires and management activities to ensure it accurately depicts current vegetation conditions.
- Other databases and map sources are used where appropriate, with a clear understanding of their purpose, accuracy, and limitations. As needed, professional judgment and interpretation are provided to frame the information found in all data sources.

The analysis also draws upon the best available literature citations relevant to the ecosystems on the HLC NF. Sources that were the most recent; peer-reviewed; and local in scope or directly applicable to the local ecosystem were selected. Uncertainty is acknowledged and interpreted. Local studies and anecdotal information that are not peer-reviewed is included where appropriate. New studies and literature are continually becoming available and may be incorporated throughout the forest plan revision process.

Forest inventory and analysis (FIA)

FIA data comes from measurements taken at a set of points established on a systematic grid across the U.S. (Renate Bush, Berglund, Leach, Lundberg, & Zeiler, 2006). Data collection standards are strictly controlled and the sample design and collection methods are scientifically designed, repeatable, and publicly disclosed. These plots are spatially balanced and statistically reliable for providing unbiased estimates at broad scales. A multitude of vegetation attributes are recorded, including but not limited to species, height, diameters, habitat type, age, physical defects, insect and disease, ground cover, fuel loading, understory species and ground cover. Plots are re-measured on a 10-year cycle, meaning that 10% are re-read each year, allowing evaluation of trends in forest conditions over time.

FIA plots are used for many aspects of the analysis, including: estimating the existing condition; validating the reliability of spatial datasets and/or build logic to update those datasets; seeding spatial datasets with the information required by vegetation models; and providing the tree lists needed for yield table development. Plots that have changed due to harvest or fire are excluded from analysis.

FIA base grid

The FIA program maintains a national grid of plots that are referred to as the “base grid”. The sample was designed to measure forested plots; non-forest plots are established but no data are recorded. Each plot represents about 5,000 acres. There are 150 base FIA plots on the Helena NF; 3 on the Beaverhead-Deerlodge NF portion of the Elkhorns; and 306 on the Lewis and Clark NF; for a total of 459 plots.

Starting with annual plots collected in 2006, the Northern Region has contracted with the FIA program to collect the “All Condition Inventory” (Renate Bush & Reyes, 2014). This inventory measures plots and portions thereof that do not meet the definition of “forested”. However, at this time, only a subset of the base grid plots has information collected on nonforested plots.

The base grid is used to summarize conditions for the entire plan area, and to represent GAs that do not have a grid intensification completed. The most recent plot measurement dates range from 1996 to 2011, with about half being measured prior to the mountain pine beetle outbreak that began in 2006.

FIA intensified grid

To enhance analyses at multiple scales, the FIA base grid has been intensified by four times (4x) across the HLC NF. This dataset is designed to capitalize on the statistical design of the base grid and allows for more accurate estimates at smaller scales. The grid intensification uses data collection protocols established for the Northern Region that are compatible with national protocols (Renate Bush & Reyes, 2014). This dataset is referred to as “intensified grid”, or “4x grid”. Plots are established across all NFS, regardless of whether they are forested.

The initial installation of intensified plots began in 2006 and is complete for all GAs except the Rocky Mountain Range (Table 2). There are no intensified plots on the portion of the Elkhorns GA that lies on the Beaverhead-Deerlodge NF. On GAs where the intensification is complete, 4x grid plots are added to base grid plots to create an analysis dataset.

Table 2. FIA and FIA 4x Intensified grid sample status by GA, as of 2016

Geographic Area	Base FIA Plots	4x Grid Installation Date	4x Plots Installed	4x Plots Yet to Install	Plots in 4x Dataset	Plots with live/dead re-measurement	Plots with full re-measurement
Big Belts	49	2006-08	191	0	240	82 (2008-10)	78 (2016)
Castles	10	2010	44	0	54	35 (2012)	0
Crazies	10	2010	32	0	42	0	0
Divide	35	2007-08	145	0	180	96 (2012)	142 (2012-15)
Elkhorns[1]	181	2006-07	72	0	87	24 (2009-10)	72 (2012)
Highwoods	7	2010	28	0	35	0	0
Little Belts	137	2009-10	588	0	725	365 (2012)	0
Rocky Mountain[2]	1222	2012-today	297	217	368	0	0
Snowies	20	2010-14	81	0	101	0	0
Upper Blackfoot	51	2007-08	228	0	279	101 (2009-10)	156 (2014-15)
Total	**459**		**1,706**	**217**	**2,111**	**703**	**448**

1 Only 15 of the 18 base FIA plots in the Elkhorns are included in the 4x dataset because the remaining 3 lie on the Beaverhead-Deerlodge NF, outside the 4x sample area. All 18 plots are included in the Hybrid 2011 dataset.
2 Only 71 of the 122 base FIA plots in the Rocky Mountain Range are included in the 4x dataset, because those plots are within the area where the 4x inventory is completed. The remaining 51 base FIA plots would be included when the 4x inventory is complete. All 122 plots are included in the Hybrid 2011 dataset.

The intensified plots are on a 10-year re-measurement cycle. However, starting in 2006 the HLC NF experienced wide-spread mortality caused by mountain pine beetle which created a short term need for rapid re-measurements. Plots on western GAs that had at least 20 square feet basal area per acre of pine trees were re-visited to determine changes in status (live/dead). In addition, full re-measurements have been conducted according to the regular schedule. The analysis datasets used to make estimates contain a “hybrid” of the most recent measurement of all plots.

The benefits of the intensified grid dataset include improved accuracy due to a large sample size; recent measurements reflect current conditions caused by the mountain pine beetle outbreak and some fires; and nonforested plot data. The weakness is that it is not complete on the Rocky Mountain Range GA. Plots are only installed on NFS lands; therefore, the geographic extent of plots is less than the total administrative boundary area which includes inholdings of other ownerships.

R1 summary database and estimator tool

The R1 Summary Database is developed by the Northern Region Inventory and Analysis staff to summarize plot data (Renate Bush & Reyes, 2014). This database includes statistical reporting functions and derived attributes or classifications consistent with the Region 1 Classification System (Barber, Bush, & Berglund, 2011). FIA and intensified grid plots are summarized using this tool. Based on the measured data, a suite of standardized classification algorithms populate attributes of interest (Barber et al., 2011; Renate Bush & Reyes, 2014). The database structure includes:

- Oracle tables reside at a data center that warehouse inventory data in the FSVeg database. The Oracle tables contain attributes collected at the site; derived attributes such as the R1 Existing Vegetation Classifications, R1 Wildlife habitat models, old growth; and spatial datasets.
- Access databases house a subset of the data in the Oracle Tables for a specified set of inventory data called *analysis datasets*. This database contains queries and reports built off of the Oracle Tables. The analysis datasets used include:
    - F12_F15Partial_IntGrid_4x_Hybrid_2016COMBINED, which includes the latest measurements of the intensified grid and base plots in those areas.
    - R1 Hybrid 2011, which includes the most recent available measurements of base plots, and the sample covers the entire HLC NF plan area.
- The R1 Estimator Form is a stand-alone program that derives estimates and confidence intervals for data in the access database that is selected (Renate Bush & Reyes, 2014). Reports were generated which include the mean, standard error, and 90% confidence intervals. For all attributes other than potential vegetation, estimates were made excluding plots that had changed since fire or harvest. Potential vegetation is estimated including all plots, because fire or harvest would not change this attribute. All reports are available in the planning record.

Region 1 vegetation map (VMap)

The Region 1 Vegetation Map (VMap) is a spatially explicit map product that contains information about the extent, composition and structure of vegetation. Satellite and airborne acquired imagery are used, and refined through field sampling and verification. This geospatial dataset includes all watershed areas that intersect with NFS lands on the HLC NF; private lands in these watersheds are included, so the map provides “wall to wall” coverage. The information is grouped into vegetation that is alike and organized into polygons. Each polygon has a life form, canopy cover, dominance type, and size class assigned consistent with the Region 1 Existing Vegetation Classification System (Barber et al., 2011). Additional information is attached using a digital elevation model (elevation, slope, and aspect); as well as continuous variables for tree size and canopy cover; probabilities of species occurrence; and additional attributes estimated by associating map classes to inventory plots.

The VMap was designed to allow consistent, continuous applications between regional inventory and map products across all land ownerships that is of sufficient accuracy and precision. VMap attributes have been assessed for accuracy through a process outlined for Region 1 (S. R. Brown, Jr, 2014; Vanderzanden, Brown, Ahl, & Barber, 2010). This accuracy assessment includes the results in Table 3 (S. R. Brown, Jr, 2014), which are within national mapping standards.

Table 3. Accuracy of VMap 2014 attributes for the HLC NF

Attribute	Accuracy
Lifeform	91%
Dominance Type (Dom40)	70%
Tree Canopy Cover	79%
Tree Size Class	69%

Relationships between VMap and FIA existing conditions

Both FIA plots and VMap are used to depict existing vegetation. While the grid plots provide the most statistically reliable estimates, the VMap provides the spatial depiction needed for modeling. The vegetation model input file for SIMPPLLE, which is also used for PRISM, is based on VMap with additional attributes inferred from FIA plots. As part of this process, the input file was adjusted to be as similar to FIA estimates of species, size class, and density class as possible. However, inconsistencies remain due to the inherent differences in the products, such as data collection methods and timing. However, the estimates from plots and the map should be similar, to ensure that the comparison between the existing condition and the NRV are valid as a cornerstone for the development of desired conditions. The following information discloses the level of similarity between the two data sources.

- Forestwide, VMap and the FIA plots correlate well for cover type. While the map shows slightly less ponderosa pine and more mixed mesic conifer, the trends compared to the desired condition are consistent. In the warm dry PVT and cool moist PVT the map and plots closely agree. In the cold PVT, VMap closely agrees with FIA for most cover types, except that the map shows lower amounts of lodgepole pine and higher amounts of spruce/fir.
- Forestwide, the mapped values are nearly within the plot confidence interval for all size classes except medium. Both sources indicate a need to decrease this class relative to the desired condition. In the warm dry PVT the biggest discrepancy between plots and the map is in the medium class, with VMap indicating that more is present. All other classes are similar. VMap closely agrees with FIA plots in all cases for the cool moist PVT. In the cold PVT, VMap shows slightly higher amounts of small and medium size classes, and slightly less grass/shrub. However, the data sources agree that a decrease in small and medium with an increase in large is warranted relative to desired conditions.
- Forestwide, VMap is nearly within the FIA estimate confidence interval for all canopy cover (density) classes except 60%+. The map and plots indicate a desired decrease in the 60%+, although the magnitude of the desired change varies. In the warm dry PVT, VMap is generally within the confidence interval for plot estimates except the 60%+ is slightly high. The sources agree that a decrease in this class is warranted to achieve the desired condition. Similar to the forestwide scale, in the cool moist PVT, VMap indicates that more 60%+ is present than the FIA plots. Both sources indicate a reduction is warranted to achieve the desired condition. In the cold PVT, VMap shows

less of the nonforested/<10% tree canopy than FIA, and more of the 60%+. The sources agree on a desired trend of decreasing the 60%+, while the 40-59% class is at the low end of the desired range.

To provide disclosure of the variability caused by utilizing these data sources, all charts in the *SIMPPLLE Model Results* section include the FIA existing condition and the modeling input file starting condition (based on VMap). The FIA existing condition is used for most desired condition components of the 2020 Forest Plan, because it is determined to be the most accurate. The exception is density class; for this attribute, the classification of remotely sensed imagery is more accurate than the algorithm used to estimate canopy cover from FIA plots. Therefore, for density class, the model input file starting condition is used as the existing condition in the 2020 Forest Plan. The EIS discusses in detail instances where the disparity between existing condition estimates are problematic for the interpretation of model results.

HLC NF geographic information system (GIS)

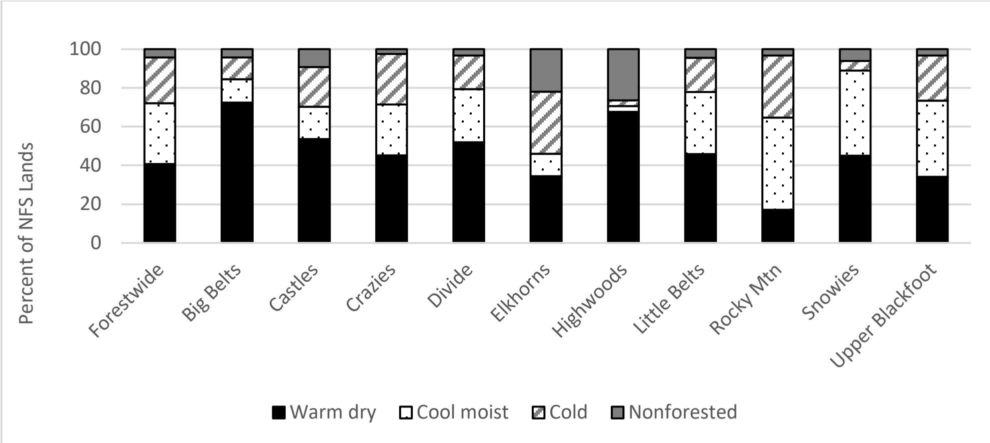
The HLC NF has a library of geographic information system (GIS) data. The library includes a large number of mapped data layers, with associated metadata, including fire history, insect and disease surveys, grizzly bear habitat, lynx habitat layers, roads, topographical features, and administrative-related boundary layers. Many summaries and assessments of vegetation condition were developed using GIS, which is both an analysis tool and a display technology. This tool was also used to map timber suitability; to build analysis units needed for PRISM; and compile the spatial data used for the SIMPPLLE model.

Potential vegetation types

Terrestrial vegetation characteristics are stratified by broad PVT, which identify sites of similar environmental conditions. Broad PVTs are groupings of habitat types and mid-level PVTs. The hierarchical classification for broad PVT is as follows:

- Habitat type is a fine-scale site classification based on physical and environmental similarities, which result in similar potential plant communities and ecological processes. The designation of habitat types is based on the potential climax plant community (Pfister, Kovalchik, Amo, & Presby, 1977). Climax conditions represent the culmination of the plant community that would occur through natural succession in the absence of stand replacing disturbances. Though the general characteristics of the climax plant community may be the same on sites of the same habitat type, at any one point in time existing plant communities could be very different due to factors unique to each site, such as disturbance history, pattern and frequency.
- Mid-level PVTs group habitat types into areas of similar climate, slope, soils, and other biophysical characteristics. A map layer was developed in 2004 (Jones, 2004) to depict PVT, which is the only available layer that provides a consistently derived and contiguous map of PVT across the Region.
- Broad PVTs are more coarse groupings for purposes of broad level analysis and monitoring. Region 1 produced a description of these groups and how PVTs and habitat types are nested (Milburn, Bollenbacher, Manning, & Bush, 2015). These groups serve as the basis for description and analysis of ecological conditions at the forestwide scale. Areas within each of the groups would have similarities in patterns of potential natural plant communities, potential productivity, natural biodiversity, and ecological processes.

Figure 1 displays the proportion of each broad PVT; see appendix D of the 2020 Forest Plan for more detailed descriptions, and appendix A of the FEIS for a map.



R1 Summary Database (Hybrid 2011 and F12_F15Partial_IntGrid_4X_Hyrbrid_2016). Only the HLC NF portion of the Elkhorns is displayed. Plots affected by fire and harvest are included.

Figure 1. Percent of each broad PVT on NFS lands

The warm dry PVT occupies the warmest and driest sites on the HLC NF that support forests. These sites support ponderosa pine and dry Douglas-fir habitat types. This group occurs at lower elevations, on warm southerly aspects, and/or on droughty soils. Forests are often dominated by Douglas-fir, ponderosa pine, or limber pine. Open forest savannas may occur on this group, where grasses or shrubs are dominant and trees are widely scattered due to repeated frequent fires.

The cool moist PVT comprises the most productive forest sites on the HLC NF. Moist Douglas-fir habitat types are in this group, along with lower subalpine fir and spruce habitat types. This setting occurs on mid to high elevation sites across all aspects. Lodgepole pine and Douglas-fir are the most common dominant species, with Engelmann spruce and subalpine fir common as well.

The cold broad PVT occupies the highest elevation areas that support forests. Some sites are cold, moist subalpine fir habitat types that support moderately dense forest cover. Remaining areas are cold, drier subalpine fir and whitebark pine types where growing conditions are harsher and tree density more open. Subalpine fir, Engelmann spruce, and whitebark pine are the most common species.

Nonforest PVTs consist of the persistent nonforested vegetation climax types. They occur on sites where establishment and growth of conifers is impeded, for example in areas of shallow or very droughty soils; very wet soils and high water tables; or very frequent disturbance. Persistent nonforested areas include alpine meadows, dry grasslands and shrublands, mesic grasslands and shrublands, and riparian areas. There are also areas on the forest that are non-vegetated, where very sparse or no vegetation grows, such as scree or barren areas. These are excluded from the analysis.

R1 broad PVTs are included in the R1 Summary Database, based on field classified habitat type. For modeling, it was also necessary to map them. The PVT map was developed by the Northern Region in the early 2000s (Jones, 2004). Sources of data included field plots and remote sensing. Lands with no field data were populated by extrapolation of plot data and the use of models that integrated site factors influencing vegetation, such as precipitation, slope and elevation. This layer, referred to as *R1 Potential Vegetation Types* or *R1-PVT*, is the best available PVT layer, although its level of accuracy is unknown. It is the only map of potential vegetation that covers the plan area.

To have both potential vegetation and existing vegetation attributes applied to polygons for analysis, the R1-PVT map was joined to VMap. VMap polygons are the best delineations for vegetation; therefore, a single R1-PVT label was applied to each VMap polygon based on the majority type. Because R1-PVT is raster-based and the VMap is polygon-based, illogical combinations of potential and existing vegetation were inevitable. It was necessary to refine the attributes in a logical fashion to improve accuracy. An analysis was done to compare the R1-PVT to VMap as well FIA plots. Because it has a known level of accuracy and is based on the most current data available, VMap was assumed to be correct. Using this data, logic was written to correct illogical combinations between potential and existing vegetation.

Most desired conditions are displayed by PVT. Several PVTs are not included. “Urban” is excluded because it would not have existed in the NRV. Although known to occur, “alpine” is not represented in SIMPPLLE or existing data. “Sparse” areas sometimes have cover types assigned in the R1 Summary Database but are assumed to be non-vegetated in the NRV and are therefore also excluded. About 5% of the Forest is Non-Vegetated (water or sparse) so percentages of PVTs do not equal 100%.

Nonforested vegetation, xeric ecotones, and forest savannas

Nonforested ecosystems are important components of the HLC. These areas are classified slightly differently depending on the attribute of interest. To avoid these inconsistencies, the abundance of nonforested vegetation conditions is tracked through cover type (dominant species) in the 2020 Forest Plan.

Areas are considered nonforested for cover type when they have less than 20 square feet of basal area per acre or 100 trees per acre. Conversely, areas are considered nonforested for density when there is less than 10% canopy cover of trees. This includes grass and shrublands with 0-5% canopy cover, open forest savannas with 5-10% canopy cover. There are more areas considered nonforested for density class than there are for cover type. That is, there are some forest cover types that do not have a density class – most likely, the differences between these classifications represent savannas. Based on FIA, the abundance of nonforested cover types is 14% forestwide, while the abundance of the nonforest/none density class is 22%, indicating that at least roughly 8% of the forest is in a very open forested condition. Additional savannas may also occur in areas with a nonforested cover type, to an unknown degree.

There are three categories classified as “nonforested” in FIA data and/or VMap.

1. *Nonforested communities (grass, shrub, forb) growing on nonforested PVTs*. Tree encroachment is usually limited on these types due to site conditions (moisture regime and soil type). To the extent that PVT mapping accurately captures these areas, the NRV modeling represents them by including pathways that maintain a nonforested community type through time.
2. *Xeric Ecotone (nonforested communities on forested PVTs whose dominance is maintained by disturbance)*. These are common systems on the HLC and consist of the driest forest habitat types where the past frequent disturbance regime served to limit the establishment of conifers, resulting in either maintaining the nonforested communities indefinitely or shifting between forested and nonforested communities. In latter scenario, the forest would tend to encroach during cool/moist periods, and then retract again in warm/dry periods when fire disturbance was more common. In addition, *forest savannas* could occur where scattered fire-resistant large trees are present, but the site remains dominated by grasses and shrubs. These types are the most difficult to classify and map because there may be a presence of trees currently. These types are also not well represented by the NRV modeling, because on forested PVTs the model efficiently establishes forest cover after disturbances and generally keeps them classified in a forested pathway, rather than allowing them to be maintained in a nonforested state. To account for this weakness, adjustments are made as necessary using other BASI.
3. *Recently disturbed forests on forested PVTs that have not yet regenerated may be classified as nonforested*. VMap generally captures these well and considers them “transitional”, and based on the PVT, the NRV modeling should regenerate them as forested areas. However, in the FIA plot data used for the existing condition, it is difficult to identify these areas versus the other nonforested types. Geographic context is used to help interpret this data. It is not possible in the

model to capture potential scenarios wherein some of these sites may not naturally regenerate due to drought or a changing climate.

Vegetation models

The vegetation management strategy for the HLC NF is to manage the landscape to maintain or trend towards vegetation desired condition. Modeling was done to define the NRV; inform the development of desired conditions and identification of lands suitable for timber production; provide estimates for vegetation treatments, acres, and timber outputs over time; and evaluate the degree to which each alternative moves towards desired conditions. Three vegetation models were used:

- Forest Vegetation Simulator
- PRISM (replaces the Spectrum model used in the DEIS)
- SIMulating Patterns and Processes at Landscape scaLEs (SIMPPLLE)

The models are used interactively to analyze vegetation as follows:

1. Yield tables for all potential vegetation management options and disturbance events are developed by running Forest Vegetation Simulator. Yield tables show timber volume and changes to vegetation through time associated with different management alternatives.
2. Expected future wildland fire and insect disturbances are modeled in SIMPPLLE.
3. The acres of expected disturbances and severities from SIMPPLLE are input into PRISM, which assigns the changes to vegetation in those areas based on yield tables.
4. The PRISM model is run to develop a schedule of future vegetation treatments and timber outputs that are designed to move the landscape toward desired conditions and other objective functions. The model uses the yield tables to assign post-treatment or disturbance conditions.
5. The projected treatment types, acres, and resulting vegetation changes from PRISM are input back into SIMPPLLE.
6. SIMPPLLE is run into the future to provide an analysis of expected vegetation conditions, based on a finer-scale integration of ecological processes and disturbances, and management activities.

Model simulations 5 decades into the future were conducted to analyze alternatives. Fifty years is a reasonable time period over which to model and capture vegetation trends, considering that some changes occur quickly while others are gradual. Fifty years is a relatively short time period to portray shifts that occur for long-lived conifers. However, there is an increasing level of uncertainty with ecological and social change the farther into the future you go, especially related to climate change.

Out of necessity, all models simplify complex and dynamic relationships between ecosystem processes and vegetation over time and space. The models use assumptions based on corroboration of data and review of scientific literature, as well as professional judgement. Although the best available information is used, uncertainty in the results remains because of the inability to accurately predict the timing, magnitude, and location of future disturbances. In addition, modeling potential treatments, accurately representing limitations, and integrating multiple ecological processes is very complex. The results from these models provide information useful for understanding vegetation change over time and the relative differences between alternatives. Models provide information of comparative value and are not intended to be predictive. Model outputs augment other information used for the analysis, including research and professional knowledge.

PRISM model design

PRISM (**P**lan-level fo**R**est act**I**vity **S**cheduling **M**odel) is a management scheduling tool used by the HLC NF to estimate treatment acres and harvest volume from the forest under different alternative considerations. The PRISM model formulation is designed to answer several management questions:

1. What vegetative treatments should they be scheduled to move us towards the desired conditions for vegetation, with and without budget limitations?
2. What is the PWSQ and PTSQ, with and without a budget limitation?
3. What amount of timber can be removed annually in perpetuity on a sustained-yield basis?

PRISM is designed to assist decision makers in evaluating resource management choices and objectives. Management actions are selected by the model to achieve desired goals (objectives) while complying with management objectives and limitations (constraints). PRISM makes it possible to display management actions to landscapes at multiple spatial and temporal scales. PRISM was used to model the alternatives with objectives based on achievement of desired conditions for forest composition and size classes. For example, a downward trend in the small size class and upward trend in the large size class are desired conditions, which the model may achieve with regeneration treatments, commercial thinning, and retaining stands to advance into larger tree size classes.

The key variables and assumptions used for PRISM modeling are summarized in this section. Please see the project record document *"Helena and Lewis & Clark National Forests Plan Revision: Construction of Vegetative Yield Profiles & PRISM Model Design"* for more detailed information. The assumptions used are designed to best approximate probable future management scenarios that are consistent with forest plan direction; these assumptions are not binding management constraints for implementation of the plan. Some key considerations include:

- Treatment prescriptions represent commonly used activities and schedules based on vegetation types, but actual site-specific prescriptions would be specifically tailored to each site.
- Actual budgets may vary and so too would the amount of vegetation management that occurs.
- Project costs as well as timber values could change in the future.
- There is a high level of uncertainty in the timing and location of future disturbance events.
- Project design and analysis may apply resource constraints differently based on a site-specific analysis that follows the most current law, regulation, and policy at the time of implementation.
- Implementation of the plan would consider many additional desired conditions, which may result in a treatment regime that differs relative to the type and timing of vegetation treatments.

The projected timber volumes, harvest acres, and prescribed burning acres depict possible management scenarios to provide for a comparison of alternatives. The model results also form the basis of the potential management actions described in appendix C of the 2020 Forest Plan and inform the objectives for vegetation treatments (FW-TIM-OBJ and FW-VEGT-OBJ). Actual implementation of the plan may vary based on the factors described above as well as other considerations such as litigation.

PRISM model changes between the Draft and Final

Between the DEIS and FEIS, PRISM replaced the Spectrum model. These models provide similar functionality. In addition, the modeling map was updated to: 1) correctly classify the cold and cool moist PVTs; 2) update vegetation type and structure to reflect disturbances and treatments up to 2018; and 3) adjust size, density, and vertical structure to be more similar to FIA data. Additional refinements include:

- The desired condition goals were updated to reflect the new desired conditions in the Plan.
- Future disturbances were updated based on new SIMPPLLE modeling of future fire.
- Disturbance acres were proportioned across the landscape based on the historical proportion on lands that are suitable versus unsuitable for timber production.

- Corrections were made to the “natural attrition” assumptions in lodgepole pine.
- The assumption of the required ratio of clearcut to shelterwood prescriptions was relaxed to allow the model more flexibility in choosing harvest type.
- The sustained yield limit for each proclaimed Forest was added as a top constraint to projected timber sale quantity.
- A non-declining even flow criteria was applied to the HLC NF as a whole to model the alternatives.
- RMZs were constrained to a low harvest level. Alternative A was calibrated to consider RMZs similarly to the action alternatives, to provide a consistent comparison and reflect the likely future management scenario if that alternative were implemented.
- Pre-commercial thinning activities were eliminated in lynx habitat; the potential for exemptions within the wildland urban interface (WUI) are not reflected in the model design.
- Updates to cost accounting were done to account for the budgets and treatments that occur on the Beaverhead-Deerlodge NF portion of the plan area.
- The updated lynx potential habitat layer for the HLC NF was incorporated.

Planning horizon

The planning horizon is a specified time frame broken down into periods of an equal number of years. The HLC NF PRISM model used 15 ten-year periods as the planning horizon. A long planning horizon helps ensure the sustainability of management options applied to long-lived vegetation. The results are shown for the first 50 years because results become more and more uncertain farther out into the future.

Yield tables and prescriptions

Growth and yield tables were developed using the Forest Vegetation Simulator. Since its development in 1973, it has become a system of highly integrated analytical tools based upon a body of scientific knowledge developed from decades of research. Available data from FIA and FIA intensified grid plots was stratified according to vegetation type and structure, and FVS was run to estimate key variables throughout the life of the plot under several management scenarios. PRISM uses yield table information to select management options to move towards the desired condition, and to show the outcomes of the harvest schedule over time. Yield tables included outputs such as stand age, basal area, diameter, trees per acre, culmination of mean annual increment, merchantable cubic feet board feet, diameter of removals and residual volume, fire risk, bark beetle risk and defoliator risk, and vegetation type and structure class.

Management actions consist of activities associated with a generalized silvicultural prescription. The prescriptions, timing choices, and constraints are for modeling purposes and do not constitute standards or guidelines for implementation. Silvicultural prescriptions were defined by vegetation type, structure, and other resource condition. Each prescription assigned a suite of activities designed to achieve desired conditions. Yield tables reflect the outcome of each activity in the prescription. The prescriptions and activities included in the yield tables are shown in Table 4 and Table 5. Detailed prescriptions can be found in the project record (“*HLC_Rxs_yieldtables20151116.xlsx*”).

Table 4. Silvicultural systems and activities used in yield tables

Prescription		Activities	
NG	natural growth - no disturbance	pct	Pre-commercial thin
SR	stand replacing wildfire	ct	commercial thin (or improve cut)
MS	mixed severity wildfire	ub	understory burn

Prescription		Activities	
BS	severe bark beetle	bb	broadcast burn
NA	natural attrition	sc	seed cut
CS	clearcut/seedtree	or	overstory removal
SW	shelterwood	gp	group selection opening
US	unevenaged Cut	ss	single tree selection
PB	Prescribed burn	wf	wildfire
		bs	severe bark beetle

Table 5. Applicable prescriptions by vegetation type in PRISM

Vegetation Type[1]	CS	SW	US	PB	SR	MS	BS	NA
C	X		X	X	X	X	X	
D		X	X	X	X	X	X	
E	X			X	X	X	X	X
F		X		X	X	X	X	
G	X			X	X	X	X	X
H	X			X	X	X		
I	X			X	X	X	X	

[1]see Table 12 for definition of vegetation types

Land stratification and analysis units

The plan area is subdivided into areas that facilitate analyzing land allocation and expected management. In PRISM, each stratum is a layer and a unique combination of layers results in an “analysis area.” There are six layers used in the model; the first four describe static landscape stratifications. The final two describe the vegetation type and structural characteristics of the site at the current time. The combination of classes in each layer creates a repeatable land unit with unique characteristics. Each analysis area may be scheduled to a different suite of management actions that yield a variety of outputs. A minimum map unit size of 20 acres is used. Only forested vegetation types were included; therefore, the results do not represent actions (e.g. prescribed fire) that occur on nonforested vegetation types.

Geographic area and wildland urban interface (WUI)

This PRISM layer is the combination of two static layers. Two geographic areas were identified, because the Blackfoot GA is primarily west of the Continental Divide and subject to maritime influences which result in differing productivity. The other area is comprised the rest of the forest’s “Island Ranges” on the east side of the Continental Divide. The wildland urban interface (WUI) is also depicted so that different costs of treatments can be applied, and for reporting purposes. Table 6 describes the combinations of geographic area and WUI used in PRISM. Each combination is labeled with a single-character unique identifier used to label the attribute. For the HLC NF analysis, the WUI is mapped based on County Wildland Protection Plans (CWPPs) where available, and standard Hazardous Fuels Reduction Act (HFRA) definitions where CWPP maps are unavailable. The WUI will change over time as human developments and land use change.

Table 6. Geographic area strata for PRISM

Group	Description	Identifier
Island Ranges WUI	All GA's except the Blackfoot, in the WUI	A
Island Ranges NonWUI	All GA's except the Blackfoot, not in the WUI	C
Blackfoot WUI	Blackfoot GA, in the WUI	B
Blackfoot Non-WUI	Blackfoot GA, not in the WUI	D

Management Area Groups (MAGs)

Prescription options and resource constraints are affected by land allocations and management emphasis. While the HLC NF plan does not include "management areas" as such, there are land classifications that direct management. These considerations are combined to create functional management area groups for modeling. These groups were developed to achieve the goal of different model runs and to reflect alternatives (Table 7). Management area groups are hierarchical, meaning that the most restrictive land allocations are identified first if more than one allocation applies to an area.

Table 7. Spatial attributes used in PRISM management area groups

Attribute	Acronym	Summary of plan components	Varies by alternative
Wilderness	W	No harvest. Some Rx fire allowed. (FW-WILD-DC-02; FW-WILD-SUIT-03)	No
Wilderness study areas	WSA	No harvest. Some Rx fire allowed. (FW-WSA-DC-01; FW-WSA-SUIT-01; FW-WSA-SUIT-03)	No
Research natural areas	RNA	Rare harvest allowed but assume none in model; limited Rx fire allowed (FW-RNA-DC-01; FW-RNA-GDL-01; FW-RNA-SUIT-01)	Yes
Recommended wilderness	RW	No harvest. Rx fire allowed. (FW-RECWILD-DC-02, FW-RECWILD-SUIT-02, FW-RECWILD-SUIT-04)	Yes
Inventoried roadless areas	IRA	Little harvest allowed. Rx fire allowed. (FW-IRA-DC-02, FW-IRA-SUIT-01, FW-IRA-SUIT-03)	No
Lands suitable for timber production	TS	More harvest occurs on suitable lands than on unsuitable. (FW-TIM-DC-01, FW-TIM-DC-05, FW-TIM-SUIT-01, FW-TIM-SUIT-02)	Yes
Recreation opportunity spectrum	ROS	More harvest occurs in roaded natural (RN) and rural (R) than in semi-primitive motorized (SPM), semi-primitive nonmotorized (SPNM), or primitive (P) (FW-ROS-DC and FW-ROS-GDL)	Yes

Sustained yield limit management area groups

The sustained yield limit is calculated for each Proclaimed NF individually from lands that may be suitable for timber production. Because the sustained yield limit is not subject to resource objectives or constraints, the management area groups for this model run only include two timber suitability allocations: not suitable for timber production and may be suitable for timber production, split by proclaimed forest. Acres on the Beaverhead-Deerlodge NF are not considered in the calculations.

Table 8. Management area groups for sustained yield limit calculation in PRISM

Group	Description	Identifier
May be suitable, LCNF	Lands identified as may be suitable on the LCNF	S
Not suitable, LCNF	Lands not suitable on the LCNF.	N
May be suitable, HNF	Lands identified as may be suitable on the HNF	H
Not suitable, HNF	Lands not suitable on the HNF.	F
May be suitable, B-D	Lands identified as may be suitable on the B-D	B
Not suitable, B-D	Lands not suitable on the B-D.	D

Action alternative management area groups

The following management area groups apply to the action alternatives, to reflect components in the 2020 Forest Plan. RMZs are in management area group 3, unless they were already included in more restrictive groups (1 or 2).

Table 9. Management area groups for action alternatives in PRISM

Suitability	Areas Included	Description	MAG
Unsuitable for timber production	W, RW, WSA, RNA, ROS = P	No harvest for model purposes. Limited Rx fire.	1
	IRA, or ROS = SPNM	Harvest very limited. Rx fire allowed.	2
	ROS = SPM; or RMZ	Low harvest. Rx fire allowed.	3
	All else	Moderate harvest and Rx fire.	4
Suitable for timber production	ROS = SPM	Suitable areas constrained by ROS.	5
	All else	Suitable area.	6

No-action alternative MAGs

Table 10 shows the management area groups for the No Action alternative. Because recreation opportunity spectrum classes were not included in the 1986 plan, these groups differ slightly from the action alternatives. The no-action groups include RMZs in a fashion similar to the action alternatives, to provide a consistent comparison, and to reflect the likely management scenario if alternative A was implemented.

Table 10. No action (alternative A) management area groups in PRISM

Timber suitability	Areas included *(hierarchical)*	Description	MAG
Unsuitable	W, RW (1986), WSA, RNA	No harvest. Some Rx fire.	1
	IRA	Harvest very limited. Rx fire allowed.	2
	RMZ	Low harvest. Rx fire allowed.	3
	All else	Harvest and Rx fire can occur.	4
Suitable	Suitable lands	Suitable areas	6
Unsuitable	SPNM and MAG3, MAG4, or MAG6 (or SPNM and RMZ)	Functions the same as MAG2	7
	RMZ and MAG4 or MAG6	Functions the same as MAG3	8

Wildlife habitat

Key wildlife habitats were used to identify where harvest constraints may apply; and/or to facilitate the analysis. Lynx constraints were developed and apply across potential lynx habitat, regardless of whether it is occupied or unoccupied. After initial test runs, no constraints were applied for grizzly bear, but it was useful to report model outputs for those habitat areas in the analysis.

Table 11. Wildlife habitat analysis groups for PRISM

Wildlife group	Description	Identifier
Potential lynx, NOT grizzly core	Potential lynx habitat DOES NOT overlap with grizzly bear core.	L
Potential lynx AND grizzly core	Potential lynx habitat that DOES overlap with grizzly bear core.	B
Not potential lynx, AND grizzly core	Grizzly core habitat that does not overlap potential lynx habitat	G
Other	Not as above (not grizzly and not potential lynx)	O

There was a technical change that occurred to the potential lynx habitat layer after the completion of the modeling, which resulted in 15,931 acres of potential habitat being added in the Big Belts, most of which occurred in MAGs 1 and 2. These acres were not included in the PRISM wildlife layers.

Stand Type

Vegetation Type

Combinations of cover type and PVT define vegetation type (Table 12). Some types are representative of the entire HLC NF, while some differ between geographic areas.

Table 12. Vegetation type strata used in PRISM

Area	PVT	Cover Type	Description	Identifier
Forestwide	Warm dry	Ponderosa pine	Dry PVTs dominated by ponderosa pine, limber pine, and/or juniper.	C
Split Blackfoot & island ranges	Warm dry	Douglas-fir	Dry PVTs dominated by Douglas-fir or western larch.	D
Forestwide	Warm dry	Lodgepole, Aspen/Hardwood	Dry PVTs dominated by lodgepole pine or hardwoods.	E
Split Blackfoot & island ranges	Cool moist	Ponderosa pine, Douglas-fir	Moist PVTS dominated by ponderosa pine, limber pine, juniper, Douglas-fir, and/or western larch.	F
Split Blackfoot & island ranges	Cool moist	Lodgepole, Aspen/Hardwood	Moist PVTs dominated by lodgepole pine or hardwoods.	G
Forestwide	All but cold	Spruce/Fir, whitebark pine	Dry or Moist PVTs dominated by Engelmann spruce, subalpine fir, and/or whitebark pine.	H
Forestwide	Cold	Any	Cold PVTs dominated by any species.	I

Structure class (size and density)

Structure classes are combinations of size and density class (Table 13). Size classes are based on basal area weighted diameter. The seedling class is grouped with the 0-4.9” class. The largest size class is 15” or greater diameter. Density classes are identified based on percent canopy cover of live trees.

Table 13. Structure class strata used in PRISM

Size Class	Canopy cover (density)	Description	Identifier
0-4.9”	10-39.9%	Seedling/sapling size class, low or low-moderate density	F
0-4.9”	>40%	Seedling/sapling size class, moderate-high or high density	G
5-9.9”	10-24.9%	Small size class, low density	H
5-9.9”	25-39.9%	Small size class, low-moderate density	I
5-9.9”	40-59.9%	Small size class, moderate-high density	J
5-9.9”	60%+	Small size class, high density	K
10-14.9”	10-24.9%	Medium size class, low density	L
10-14.9”	25-39.9%	Medium size class, low-moderate density	M
10-14.9”	40-59.9%	Medium size class, moderate-high density	N
10-14.9”	60%+	Medium size class, high density	O
15”+	10-24.9%	Large size class, low density	P
15”+	25-39.9%	Large size class, low-moderate density	Q
15”+	40-59.9%	Large size class, moderate-high density	R
15”+	60%+	Large size class, high density	S

PRISM goals, management options, and constraints

For each alternative, a treatment schedule is formulated to achieve the goal; namely, to move toward the desired vegetation condition. The number of acres by strata allocated to each activity renders a solution to the planning problem. Decision variables are combinations of strata, prescription, and timing option.

Desired vegetation condition goals

Forestwide desired condition ranges were defined for vegetation type and structure class. The ranges of the forest plan desired conditions were formulated to represent only forested acres included in PRISM vegetation types. For the FEIS, the desired condition goals in PRISM were updated based on desired condition updates. The desired conditions represent plan components FW-VEGT-DC-02, FW-VEGF-DC-02, and FW-VEGF-DC-03.

Objective functions

The objective function for the alternatives is to minimize the total deviation (above or below) the desired vegetation condition goals through time. Deviation from a goal is recognized as a single deviation point (1) per acre above or below the stated goal range in a given time period. For alternative E, a “rollover” run was done, where first harvest volume was maximized, and then achievement of desired conditions was applied while also imposing a constraint of achieving 95% of the maximum timber volume. This was done to capture the theme of the alternative, which is to emphasize timber outputs while meeting resource constraints. Alternatives A, B/C and D are run solely with an objective function to maximize achievement of the desired conditions. To blend these objectives, alternative F was set to achieve no less than 28 mmbf/year in the first decade under a constrained budget, or 35 mmbf with an unconstrained budget, which represents a volume level in between those achieved for alternatives B/C/D and E in the DEIS.

Prescription options

Based on constraints and the specified management goals or objectives, the PRISM model determines the management prescription to apply to an analysis area as well as the timing of the implementation. Not all prescriptions are permissible in each management area group (Table 14). Salvage after disturbance is not estimated, per the planning rule directives, because salvage sales are unpredictable. Natural disturbance activities are scheduled based on predicted levels from the SIMPPLLE model, as described below in the *disturbance processes* section.

Table 14. Allowable prescriptions/activities by PRISM management area group

PRISM prescription/activity	Management area group
Natural growth and natural attrition	Everywhere
Stand-replacing and mixed severity wildfire	Everywhere
Severe bark beetle	Everywhere
Clearcut/seed tree, shelterwood, uneven aged cut	MAG 2 through 6
Prescribed burn	Everywhere
Associated activities (thinning, burning, etc)	MAG 2 through 6

There has been a correction to "natural attrition" prescription assumption in lodgepole pine. In the DEIS, it was assumed that lodgepole dies at age 150. For the FEIS, it is assumed that 10% begin to die at age 40, 20% of what is left at age 150, and 50% of what is left at age 160. This rectified an age imbalance on the Lewis & Clark NF that resulted in available volume artificially dropping in later time periods. Another model improvement done for the FEIS was that the prescriptions for lodgepole pine in the cool moist PVT were applied to lodgepole pine in the cold PVT.

Minimum rotation ages and timing options

Prescriptions include different opportunities and timings for activities to move toward desired conditions. Timing choices specify the range of ages in which a stand may be treated. As required by FW-TIM-STD-06, minimum rotation age is set to be 95% culmination of mean annual increment estimated from previous analyses and professional judgement (Table 15). For regeneration stands (stands originating from anticipated future management), the model is given 5 decades of flexibility around the rotation age. The rotation for the existing stands has flexibility for the entire modeling period. The medium and large tree size classes are made available for harvesting the first period. In addition, it is assumed that at least 2 decades pass between a thin and a final cut.

Table 15. PRISM minimum rotation age

Vegetation type	Expected culmination	Minimum rotation age, existing stands[1]	Minimum rotation age, regenerated stands
C (warmdry PP)	120	90	140
D (warmdry DF/mix)	120	60	120
E (warmdry LP/AS)	120	60	120
F (coolmoist PP/DF/mix)	120	60	120
G (coolmoist LP/AS)	110	50	100
H (coolmoist/warmdry AF/WB)	100	50	120
I (cold)	150	100	150

1 Minimum rotation ages of existing stands are modified from CMAI to reflect estimates in initial age.

Costs, values, and budget constraints

Although the model is not used for economic optimization, costs and budget constraints are needed for effects analysis. Between the DEIS and FEIS, updates to the spatial layers and cost accounting were done to account for the budgets and treatments that occur on the Beaverhead-Deerlodge NF portion of the plan area. Treatments in this area are subject to the HLC NF Forest Plan and contribute to desired vegetation conditions, but do not contribute to the volume metrics for the HLC NF. It was assumed that the proportion of cost allocated to this area was the same as the proportion of those acres to HLC NF acres.

Budget constraint

The model included a budget constraint to reflect reasonably foreseeable budget levels. Each alternative was run with and without this constraint. The budget constraint is a 3-year average of actual budgets for fiscal years 2013, 2014, and 2015, at $5,322,000 per year. This budget supports NEPA teams, program management, sale admin and sale preparation, and the pre-construction and construction engineering costs as well as prescribed burning associated with timber harvest and ecosystem burning in forested areas, within and outside the WUI. The budget constraint includes “timber” funding, as well as fuels funding (adjusted to reflect forested areas). The budget is held constant. The three averages used are as follows:

- Non-WUI fuels $1,189,100 + WUI fuels $2,518,600 + timber $1,614,300

The following breakdown of budget was applied to the first 5 decades of the model period, to reflect where funds are required to be spent.

- Ensure that costs incurred in the WUI add up to at least $2,518,600.
- Ensure that costs incurred in non-WUI add up to at least $1,189,100.
- The remainder of funding can be applied anywhere in MAGS 1 through 6.

Management costs

Management costs associated with vegetation treatments are shown in Table 16. All costs are part of the constrained budget. The assumptions used to build these costs are described below the table.

Table 16. Management costs in PRISM

Activity	Prescription	MAG	Veg type	Period	Costs[1]	Production coefficient	Timing
Sale analysis, preparation, & administration	All harvest	All but MAG 1	All	All	$518 /mcf	1/mcf harvested	With harvest
Reforestation	Evenaged	All but MAG 1	All	All	$274/ac	0.5/ac	With harvest
	Unevenaged				$560/ac		
Pre-commercial thinning	All harvest & burning	All but MAG 1	C, D, E, F	All	$358/ac	0.6/ac	20 yrs after harvest or burn
			G, H, I			0.2/ac	
Road Re-construction	All harvest	All but MAG1 & 2	All	All	$7,060/ mi	0.01 miles/ac	With harvest
Prescribed Burning	All burning	WUI	All	All	$463/ac	1/ac	With burn
		Non-WUI			$162/ac		
Weed treatments	All harvest & burning	All but MAG 1	All	All	$141/ac	0.75/ac	With harvest or burn

Activity	Prescription	MAG	Veg type	Period	Costs[1]	Production coefficient	Timing
Dead/downed material surcharge	All harvest & burning	All but MAG1	All	First 3	+$200/ ac	0.75/ac	With harvest or burn
Whitebark pine surcharge	All harvest & burning	All but MAG1	COLD	All	+$500/ ac	0.5/ac	With harvest or burn

[1] Costs do not include cost pools. For activities that only occur sometimes in a given regime, the activities and costs are adjusted to reflect the probabilities of the treatment occurring specified in the prescriptions.

- The cost for timber sale analysis, preparation, and administration are based on budget allocations which encompass the variability in project location, cost, complexity, and logging system. Unit cost data comes from a three year budget allocation average. The HLC is typically funded at the unconstrained budget request level for timber and fuels dollars.
- Reforestation costs are based on local costs in recent Knutsen-Vandenberg funding plans and include site preparation.
    - For clearcut/seedtree/shelterwood, 75% is assumed to be natural regeneration at $40/acre plus site preparation $180/acre which occurs 50% of the time (adjusted cost $130/ac). 25% is planting ($612/ac) plus site preparation burn $180/acre which occurs 50% of the time (adjusted cost $702/ac). The adjusted mix cost accounting for natural regeneration (75%) and planting (25%) is $274/acre.
    - For uneven-aged harvest, 75% is planting and 25% is natural with the same costs/proportions described above. The adjusted mix cost accounting is $560/ac.
    - The production coefficient accounts for the proportion of “KV” funding (outside the constrained budget and covers most reforestation for non-salvage). Reforestation occurs with regeneration harvest. However, areas outside suitable timber are not “KV required”, and may be reforested with constrained budget. The coefficient assumes that KV covers 90% of post-harvest reforestation in the suitable base (MAG 5 & 6) but 0% in the unsuitable lands where harvest can occur (MAGs 2 through 4).
- Pre-commercial thinning costs are based on local costs. KV can cover this but is non-essential and therefore not assumed. The production coefficient is based on history by vegetation type of how often these treatments actually occur on the ground, as documented in prescriptions.
- Road reconstruction/admin reflect local costs for road work associated with timber or fuels projects that are counted against the constrained budget. Purchaser-related road work, including new construction and de-commissioning of roads associated with projects, is assumed to be $0 against the constrained budget. Costs borne by the purchaser are inherently included in log values. New road construction is done minimally on the HLC.
- Prescribed burning reflects all costs for preparation and burning (excluding site-prep), including intermediate entries as part of a harvest prescription and ecosystem burns. While burning (of non-activity fuels) can be eligible for KV, it is non-essential and therefore not assumed. The 3-year average of treatment unit costs applied for WUI ($463/ac) and non-WUI ($162/ac).
- Weeds treatment costs reflect work done pre and/or post-harvest. While this can be eligible for KV funding, it is non-essential and therefore is not assumed. The cost assumes an average of treatment types based on the contract documentation ($49/ac for roadside; $74 for off-road; $225 for

backpack), plus $25/acre for the cost of herbicide for a total $141/ac. Production coefficient reflects that weed treatments accompany harvest or burning 75% of the time.

- The dead/downed material surcharge reflects the increased treatment costs that are expected over the next 3 decades due to the buildup of down/dead fuels as a result of the recent mountain pine beetle outbreak. This material results in lower productivity. It is assumed that this material will be present for about 3 decades in about 75% of the places that the Forest prioritizes to treat.
- The whitebark pine surcharge is designed to encompass all elements unique to whitebark systems that are more expensive than the costs reflected elsewhere (protection of leave trees, inaccessibility, more expensive reforestation and timber stand improvement, labor for site preparation, etc). The production coefficient assumes that whitebark is present in the cold treated sites 50% of the time.

Forest product values and volume assumptions

Forest product values were developed for each vegetation type (Table 17). Because the model was not used to conduct economic analysis, these values were not utilized except to calculate additional nonsaw volume as appropriate. The following assumptions were used:

- The prices reflect a Regional analysis of 10-year average stumpage prices by species, subtracting logging and hauling costs, and adjusting for inflation to 2015 dollars.
- Values were based on proportions of tractor (60%), cable (30%), cut-to-length (5%), and helicopter (5%) logging systems reflecting the typical mix on the HLC NF.
- The sawtimber prices are developed based on the proportions of each wood type that is typical for each vegetation type. Lodgepole pine pricing ($108.68/MBF) is used for “whitewoods” (lodgepole pine, Engelmann spruce, and subalpine fir). Douglas-fir is valued at $114.66/MBF. Typically ponderosa pine “is sold as “nonsaw” for $0.50/MBF.
- Nonsaw material (4” to 7” diameter) is not represented in sawlog volumes in yield tables. This material adds approximately 15% more volume to all types with a value of $1/CCF. Volume estimates are adjusted accordingly to calculate the projected wood sale quantity.
- In addition, outside of the model an additional 1.35 mmcf of firewood is added to the projected wood sale quantity to reflect the Forest’s typical firewood sale program.

Table 17. Forest product values by vegetation type for PRISM

Vegetation Type	Species assumptions	Sawtimber ($/MBF)	Nonsaw (CCF)	Nonsaw ($/CCF)
C	80% Bull pine; 20% Douglas-fir	$71.68		
D	80% Douglas-fir; 20% Bull pine	$103.92		
F	80% Douglas-fir; 20% Whitewood	$113.47	(+) 15%	$1
E, G	80% Whitewood; 20% Douglas-fir	$109.87		
H, I	100% Whitewoods	108.68		

Other management requirements

Harvest policy

Non-declining even flow, or non-declining yield, means that the volume from a certain area is steady or increasing into the future. The sustained yield calculation did not include a non-declining even flow constraint for the first 50 years, in order to get the Forest into an age-balanced state, but this constraint was applied in later decades to ensure sustainable harvest over time. This differs from how modeling was done for the 1986 plans under the 1982 planning rule, which required that each decade conform to a non-declining even flow (219.16(a)1). No such requirement is included in the 2012 rule. Although not required, the PRISM formulation for the projected timber sale quantity (PTSQ) does include an objective to achieve non-declining even flow, applied across the Forest as a whole, for all alternatives. In addition, the sustained yield limit is used as a maximum constraint on PTSQ for all alternatives.

Dispersion of openings

To distribute treatments across the landscape, this constraint limits the amount of area that can be in an opening at one time. The amount of area in openings is limited to < 30% by management area group, excluding group 1. Openings were modeled by entry as shown in Table 18; and they recover over time as shown in Table 19.

Table 18. Openings modeled in PRISM by treatment type

Treatment	Size of opening
Prescribed fire or low/mixed severity burn entry	0.45 ac opening for each ac burned
Stand replacing wildfire	0.85 ac opening for each ac burned
Mixed severity wildfire	0.65 opening for each ac burned
Severe bark beetle	0.30 opening for each ac infested
Group/single tree select	0.30 ac opening for each ac harvested
Clearcut/seedtree or shelterwood harvest	0.95 ac opening for each ac harvested
Existing seedling/sapling stands	0.75 opening for each ac

Table 19. Recovery of openings over time in PRISM

Decade after harvest	Percent effective opening
1	100 %
2	75 %
3	50 %
4	25 %
5	0% (fully recovered)

Wildlife

It was determined that a constraint for grizzly bear is not needed due to the small amount of grizzly bear habitat that is eligible to be selected for management. Most of these areas are in management area groups where little to no treatment can occur. Specific constraints in potential lynx habitat are applied to comply with the Northern Rockies Lynx Management Direction (NRLMD, appendix F of the 2020 Forest Plan), as shown in Table 20.

Table 20. Lynx constraints within potential lynx habitat in PRISM

Rx	MAG	Veg type	Period	Constraint	Rationale to meet NRLMD
Even-aged harvest or burning	All but MAG1	Any	Each decade	No more than 15% of each MAG harvested or with a final broadcast burn in an Rx burn regime.	Covers S1 by incorporating recovery period (30% total over 2 decades). De-facto covers S2, because no more than 15% can be impacted by

Rx	MAG	Veg type	Period	Constraint	Rationale to meet NRLMD
					regen harvest, and is more conservative by constraining fire.
Any	Any	G, H	Any	No pre-commercial thinning allowed.	Covers S5. Costs for thinning not incurred.
All harvest or burning	Any	Any	Any	No lynx multistory habitat can be treated.	Covers S6.

Harvest and prescription constraints

To meet the intent of management intensity by management area group and account for operational constraints, prescriptions and activities are allocated as shown in Table 21. In addition, the total acres of thinning is limited to 2,000 per year or less and uneven-aged harvest is limited to 500 acres per year or less, to reflect operational capacity. Finally, the model was calibrated so that both clearcut/seedtree and shelterwood prescriptions are represented in the regeneration harvest mix (within 25% of half of the acres each).

Table 21. Harvest and silviculture method constraints in PRISM by management area group

Management area group	Harvest and silviculture method constraints
MAG1	Only the Rx burning (PB) regime can be selected.
MAG2	At least 10,000 average acres per decade must be allocated to PB (not necessarily in each decade). 0-5% of the total planned harvest acres can occur here.
MAG3	1-10% of the total planned harvest acres can occur here. PB can occur as desired.
MAG4	No more than 25% of harvest acres should occur here.
MAG5 & 6	At least 65% of planned harvest acres should occur here.

Prescribed burning

Underburns, broadcast burns, and site prep burns across all management area groups and prescriptions are set to occur on between 2,000 to 10,000 acres per year. The maximum level is set because of considerations such as operational capacity, air quality standards, and weather window limitations. The minimum level is set to reflect that the Forest applies prescribed fire frequently.

Disturbance processes – wildfire and bark beetles

The expected amount of future natural disturbances (stand replacing fire, mixed severity fire, and severe bark beetle) was determined using the SIMPPLLE model. Disturbance levels were input into PRISM, requiring a certain number of acres to undergo disturbance every decade. For the FEIS, future disturbances were updated based on new SIMPPLLE modeling of future fire (see appendix H). The following assumptions were used in SIMPPLLE:

- The assumed future climate be consistent with the hot/dry NRV.
- Fire suppression was modeled by correlating the most 2000-2017 fire occurrence/size data (which resulted from current day suppression tactics) and modifying the weather ending event model logic to represent those results.

The projected disturbance acres from SIMPPLLE are applied to the acres being modeled in PRISM, based on vegetation type and structure class, using the following assumptions:

- For fire by vegetation type, the average from the first 5 decades is used for all 25 decades.
- Acres are not averaged for the size classes because the distribution of size classes might not accommodate the average values in a given timestep. Therefore, for fire acres by size class, there are minimum and maximum constraints on the sum of decades 1-5 at 90% of the total for each size class. For decades 6-25, the minimum is 90% of the average of decades 1-5.
- Disturbances are more likely to occur in management area groups 1 and 2, because a) these represent the bulk of the area on the HLC NF (roughly 70%); and b) management outside these areas lowers the potential impacts of disturbance.
- Disturbance acres were proportioned in PRISM management area groups that are suitable versus unsuitable for timber production, based on historical proportions (9% of wildfire from 1985-2016 and 34% of bark beetle infestations 2000-2015 occurred on lands suitable for timber production).
- Because the HLC NF recently underwent a mountain pine beetle outbreak, a constraint is set starting in decade 4 and then every 6 decades thereafter to capture the episodic nature of this insect.
- Minimum time periods must pass before a site is eligible to receive another disturbance of the same kind: 20 years for stand replacing and mixed severity fire; and 60 years for severe bark beetle.

SIMPPLLE model design

SIMulating **P**atterns and **P**rocesses at **L**andscape sca**LE**s (SIMPPLLE)(Chew, Moeller, & Stalling, 2012) is a model that simulates changes in vegetation on landscapes in response to natural disturbances and management activities, as they interact with climate. This model was used to: 1) calculate the NRV; and 2) project disturbances and vegetation conditions into the future, as affected by anticipated treatments, disturbances and climate. These results can be used to evaluate relative differences between alternatives.

The VMap was the base map used to develop the input map for SIMPPLLE, and it was calibrated with FIA plot data. Broad PVTs, GAs, ownership, and other features such as WUI areas were also integrated.

SIMPPLLE takes a landscape condition at the beginning of a simulation and uses logic to grow the landscape through time, while simulating processes (growth, fire, insects, management, etc.) that might occur and the effects of those processes. One timestep is 10 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, data from other models, and from initial model logic files that reflect a long history of trial-and-error and research that has been maintained and passed from forest to forest.

One of the main utilities of SIMPPLLE is its stochastic nature. The model is run for multiple iterations to allow the manager to see a variety of possible projections, look for patterns, and adjust management responses. Managers cannot know with precision the specific types, locations, and extents of disturbances that will occur on the landscape. Therefore, SIMPPLLE will randomly assign fire, insect, and disease processes on the landscape in a manner consistent with the nature and probability of these disturbances.

The other utility of SIMPPLLE its spatially interactive nature. A process occurring on one site is dependent, to an extent, on the processes that occur on adjacent sites. For example, SIMPPLLE simulates fire by assigning fire starts with a probability consistent with historic records for the area and climate. Each start is given the opportunity to grow. The direction, size, and the type of fire that spreads, is dependent on the surrounding vegetation, climate, elevational position, and wind direction. The fire process will stop according to the probability of a weather ending event, successful fire suppression, or natural barriers such as the treeline or water. SIMPPLLE will determine the effect of the fire by considering whether there are trees present capable of re-seeding/re-sprouting, whether the stand’s fuel conditions have been reduced, and/or if there has been a change in size and/or species on the site.

A number of updates of the logic files and assumptions in SIMPPLLE were conducted to reflect the ecosystems and processes on the HLC NF. There remains uncertainty due to the ecological complexities and lack of ability to predict the future. Please refer to the planning record document, *Helena-Lewis & Clark NF SIMPPLLE Modeling for Forest Plan Revision* for more detailed metadata.

Modeling extent and time periods

The modeling extent covers the HLC NF administrative boundary, including inholdings, and a buffer onto adjacent lands (Figure 2). This area excludes non-FS grasslands between the island ranges because processes on these lands did not materially impact results. The extent includes adjacent lands to avoid modeling artifacts (“edge effects”) which could artificially disrupted the behavior of disturbances.

For the NRV, the model was run for 30 iterations over 100 timesteps (1,000 years), using historic climate and disturbance data. It was important to create a range of random starting points, so that the analysis reflected conditions unaffected by modern influences. To accomplish this, each landscape was run for 50 periods. The output from that was then run for 119 periods. The 30 runs were done in 3 batches of 10, where for the first 19 periods there was a randomly selected climate, so there where 3 different climate streams. Only the results from the last 100 periods where used.

For the FEIS, the model was run for 30 iterations over 5 timesteps (50 years), using expected future climate, disturbance regimes, and projected management activities for each alternative. In addition, a timestep of zero was included, which reflected the disturbances for the 10 years prior to the date of the VMap data. Only 5 timesteps were run because that period captures several decades beyond the life of the forest plan, and uncertainty in results increases farther into the future. With the NRV analysis there was data to inform the climate scenario for each period, but into the future this calibration is more speculative.

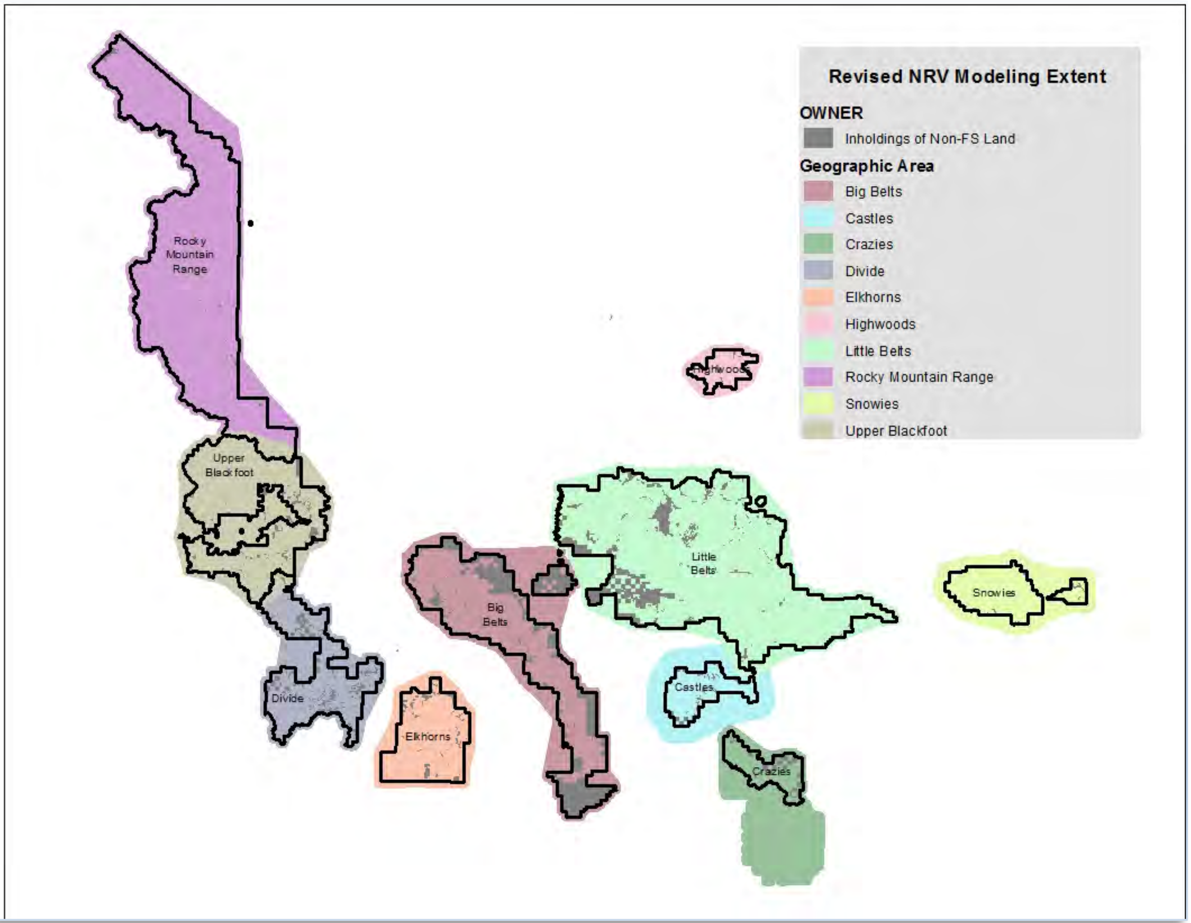


Figure 2. SIMPPLLE modeling extent

Vegetation classifications and crosswalks

The HLC NF uses consistent vegetation groupings based on the R1 Classification System. These classifications were crosswalked with SIMPPLLE attributes as part of input file compilation, post-processing of results, or both, as follows.

- Cover types were crosswalked into SIMPPLLE species labels and PRISM vegetation types. Cover type was applied at the post-processing phase of modeling. Assumptions were applied to assign species labels that were split across cover types based on PVT.
- Size class and density classes in the R1 Classification System are cross-walked directly to SIMPPLLE classifications. For SIMPPLLE, the VMap average diameter breaks were used to assign size class rather than the size class diameter breaks (e.g., the small size class was assigned to all polygons with less than 9” diameter, rather than those less than 9.9”). The diameter breaks for the size classes vary (by 1”) between the two classifications, but this difference is negligible. The R1 Classification system calculates size class based on the average basal area weighted diameter of the polygon. In SIMPPLLE, the class is determined based on successional pathways, and is more heavily influenced by the presence of large trees. This disparity is addressed in the analysis.
- Density class was assigned to match the R1 Classification System as closely as possible. The canopy cover breaks for density classes vary somewhat between the R1 Classification system and SIMPPLLE. The primary difference is that the low and medium tree cover classes are split apart in

the R1 Classification system, but must be combined in SIMPPLLE. The break between density class 3 and 4 is also slightly different than the breaks in the R1 Classification system, but for the relative trends for programmatic modeling this relationship is sufficient.

- Vertical structure is not included as an attribute in VMap; therefore, FIA intensified grid plots were queried to determine the vertical structure for each habitat type group, dominance group and size class. For groups that indicated there was a multiple story condition the assignment to two story or multi story was determined by the species code. A species code with 2 species received a two-storied label, while assigned species codes of three or four species received the multi-storied label.

Compilation of the SIMPPLLE input layer

SIMPPLLE requires more detailed vegetation information than is provided by VMap; it is necessary to use a reasoned method to populate VMap polygons with data derived from FIA and FIA intensified grid plots, as well as other geospatial information.

- The VMap layer was transformed into a grid layer required by SIMPPLLE. The VMap polygon with the largest area intersecting the square polygon is used to assign attributes.
- Digital elevation model data was overlain to determine elevation for each pixel.
- Additional layers were overlain to provide attributes necessary for modeling and/or reporting, including GAs, ownership, fire occurrence zones, and WUI. For the HLC NF analysis, the WUI is mapped based on County Wildland Protection Plans (CWPPs) where available, and standard Hazardous Fuels Reduction Act (HFRA) definitions where CWPP maps are unavailable. The WUI will change over time as human developments and land use change.
- PVT was assigned to each polygon based on a detailed process to associate the R1 PVT layer to VMap, including the resolution of illogical combinations and adjustments to improve accuracy.
- Species, size class, and density were assigned based on VMap. Adjustments were made to improve the similarity of the SIMPPLLE landscape with the abundance of species and size classes measured on FIA plots.
- Rulesets were applied to ensure the model did not allow species to occur outside of their native geographic ranges.
- Vegetation changes resulting from management activities and wildfires that occurred after the VMap product was acquired were incorporated.
- The prevailing wind direction for all GAs was set to “west”.
- The model was calibrated so that results could be grouped by decade, ownership, GA, management area group, and broad PVT.

SIMPPLLE model calibration

Once the data was prepared and formatted for use in SIMPPLLE, a multitude of calibrations and assumptions were applied, as documented in “knowledge system files”. The knowledge system file initially imported for the HLC NF was taken from work done primarily west of the continental divide, and then calibrations and pathways done for previous east-side efforts were incorporated. After iterative reviews of test runs, additional calibrations were applied as follows:

Climate

- For the NRV analysis, it was necessary to depict climate conditions over the past 1000 years. The appropriate indicator of past climate for this application is the Palmer Drought Severity Index

(PDSI). PDSI has been used as an indicator for historic climate in other historical vegetation reconstructions (McGarigal & Romme, 2012). Data for the PDSI is for a set of gridded points covering the continental U.S. PDSI is presented as an annual value that has to be generalized to a decadal average for simulations in SIMPPLLE. Each decade was classified as dry, normal or wet based on the annual value with the majority of occurrences.

- Future climate was modeled using assuming that all future time periods would experience a warmer/drier climate scenario. It was desirable to encompass the uncertainty associated with climate change. However, SIMPPLLE does not have the model structure to incorporate specific climate parameters that could be aligned with climate change scenarios. However, one of the primary manifestations of climate scenarios would be the extent of wildfire disturbances. Therefore, to encompass a range of possible outcomes that would be driven by climate scenarios, the model was formulated to project different magnitudes of wildfire, as described in the fire section below.

Successional pathways

- There were some species combinations on the HLC NF that were not represented in the SIMPPLLE model. For these, new pathways were developed using expert opinion from vegetation specialists.
- One of the initial model runs showed that limber pine was not trending in a believable manner; regeneration processes were modified to better capture its successional role. Seed production logic is updated to include all limber pine species mixes.
- Modifications to nonforested pathways were made. Altered grasses were not allowed to occur in the NRV, as they would not have been present prior to European settlement. Adjustments were made concerning the potential encroachment of conifers occurring on nonforested PVTs.
- Low severity fire is assumed to maintain it low density where it occurs; and light/moderate severity fire will decrease in density. Further, regeneration for certain species are set to low density in warmer climate periods.
- To avoid an unrealistic decline in spruce and fir on some PVTs, pathways were modified to allow shifts to spruce and fir based on seeding logic.
- To avoid an unrealistic decline in whitebark pine, producing seed logic was modified to include all species mixes with a whitebark component.
- To avoid an unrealistic decline in juniper on hot/dry sites, all pathways with Douglas-fir were modified to include a potential juniper component (pole size).
- To avoid an unrealistic decline in aspen in some PVTs, aspen pathways were modified to include conifer encroachment but not a complete shift to conifers.
- The geographic range of species was reviewed and updated based on data and local knowledge, including that aspen may occur in all GAs; no subalpine fir, whitebark, or lodgepole in the Little Snowies; cottonwood should occur in most GAs, especially the Snowies, Crazies, and Rocky Mountain Range; there should be little ponderosa pine on the Rocky Mountain Front; and there should be no whitebark pine in the Highwoods.
- The pathways for some specific species combinations on the cool moist PVT were reviewed to see what mechanisms lodgepole pine had to re-seed an area after fire. Adjustments were made to ensure that lodgepole pine had the opportunity to re-seed a burned area if a live seed source was present nearby or was present in the pixel prior to burning (serotinous seed source).
- The pathways for whitebark pine species combinations were checked for the ability of whitebark to re-seed after fire. Adjustments were made to ensure that whitebark pine has the opportunity to seed

in after a fire as long as a live seed source was present somewhere on the landscape (to reflect potential seed caching by Clark's nutcracker).

Fire

- A detailed fire size analysis was conducted. Historic records of fire starts were analyzed to identify areas where ignitions are more likely to occur. The data was used to spatially determine the probability of starts, as well as the number and placement of ignitions. Historic fire occurrence and size data used for calibrating fire probabilities in SIMPPLLE were derived from three sources:
    - Fire occurrence data from the FIRESTAT database was used for ignition points;
    - Large fire polygons where obtained from HLC NF spatial records and the Forest Activity Tracking System database;
    - The National Fire History Database was queried for fire occurrence and fire size on other land ownership and as a comparison to Forest records.
- The probability of weather-ending events was calibrated based on the fire history database. The model uses probabilities that fires of a given size will be extinguished before progressing into a larger size. Historic fire references, to the extent available, were used to evaluate NRV fire outputs.
- New fire spread logic developed by Keane and others was incorporated for the revised NRV and the FEIS, which better reflects the size and shape of how fire moves across the landscape.
- Fire suppression was modeled by correlating the most 2000-2017 fire occurrence/size data (which resulted from current day suppression tactics) and modifying the weather ending event model logic to represent those results.
- It is desirable to reflect a range of potential scenarios in the future modeling that reflect the likely effects and levels of uncertainty from a warming climate. However, SIMPPLLE addresses climate periods in general terms (i.e., warm/dry versus cool/moist), and associated process or pathway changes. Fire is one of the processes most sensitive to climate change, and the disturbance which results in the most rapid and substantial changes to vegetation. As a proxy for more detailed climate variables, it is the best available calibration available to better reflect the uncertainty in future conditions. A reasonable level of future fire to expect is two times (2x) the acres that have burned under the current fire regime, based on expert input and BASI; this information is summarized in the project record document, "*180823_FutureFireNRVConsiderations.docx*". It is appropriate to model fire at two levels (a minimum of 1x and 2x current levels) to get a range of variation. 15 runs were conducted with each scenario, analyzed together to depict a range of variation over 30 runs. To provide the baseline condition of "current fire regimes", the Monitoring Trends in Burn Severity (MTBS) initiative data was reviewed, as the most consistent and corporately available fire information. Based on this, the target decadal burn acres for all ownerships was a lower level of 179,000 acres (scenario 1); and a higher level of 357,000 acres (scenario 2).

Insects and Disease

- The model was calibrated to only allow insect and disease processes in applicable species groups. Mountain pine beetle pathways were added for limber pine, consistent with whitebark pine.
- Literature for historic insect and disease disturbances was reviewed to assist with the calibration of the NRV analysis, although the available sources were limited.
- The probability of a polygon having an insect outbreak was adjusted based on the latest available science for insect hazard ratings (Randall, Steed, & Bush, 2011). The best available science describing the expected mortality from mountain pine beetle (Randall, 2010) was used to help evaluate successional pathways for this insect and the validity of model results.

- Root disease was manually removed from illogical species types.
- Numerous adjustments were made to western spruce budworm logic.

Future treatments

The planned vegetation treatments modeled by PRISM are integrated into the SIMPPLLE modeling of future conditions by alternative.

- The planned acres for overstory removal after shelterwood harvest is manually adjusted to be 25% of the acres shown in PRISM, based on the typical management regime on the HLC NF.
- For lodgepole pine vegetation types, the size class had to be small (pole) or larger to be eligible to receive a harvest treatment. For all other vegetation types, the size class had to be medium or larger.
- Assumptions of the resulting condition (type/size/density) were developed for each activity. These same assumptions were used to modify SIMPPLLE following past and recent activities.

Patch analysis

A patch analysis was done in SIMPPLLE to describe early successional forests. Nonforested PVTs were not included in the analysis. Results were generated to show the average size for patches greater than 5 acres in size. By imposing the size minimum of 5 acres, the analysis effectively resulted in a 10 acre minimum patch size due to pixel size. The analysis was done in two ways: first, a patch was counted as a patch until it progressed out of the seedling/sapling size class. Second, the analysis was run based on patches only remaining for 1 time period after creation (10 years). In both cases, early successional forests were included in the calculation regardless of the cause of whether they were created by natural disturbances or forest management activities (such as harvest and/or prescribed burning). In the NRV analysis, all patches would have been created by natural disturbances.

Wildlife habitat

Biologists from the HLC, Lolo, and Flathead NFs developed a list of species for which it might be useful to model the NRV for their habitats; and for which SIMPPLLE was appropriate to use. The species' habitats that were modelled and the rationale for their selection are shown in Table 22.

Table 22. Terrestrial wildlife habitats modelled with SIMPPLLE

Species	Rationale/Utility for Modelling
Canada Lynx	Lynx are listed as threatened under the federal Endangered Species Act. Lynx are highly dependent on snowshoe hare, which in turn are dependent on certain seral stages of boreal (primarily spruce-fir) forest. The historic distribution of lynx across the HLC NF is not well understood but it appears that they have occupied only portions of the HLC NF, with some island ranges occupied only intermittently and others not at all. Understanding the NRV for these habitats may provide reference ranges of lynx habitat that the various GAs on the HLC NF are capable of maintaining.
Flammulated owl	Flammulated owls are identified as a Species of Conservation Concern (SCC) for the HLC NF, and are known to occur in four of the ten GAs. They are highly dependent on large diameter, open ponderosa pine forests, which may be less prevalent than they were historically. Although modelling of the ponderosa pine cover type provides some information about potential habitat, the specific combination of cover type, tree size, and canopy cover queried from the model better approximates the estimated NRV of habitat for this species and for others that may require or use similar habitat.

Species	Rationale/Utility for Modelling
Lewis's woodpecker	Lewis's woodpeckers are identified as a Species of Conservation Concern (SCC) for the HLC NF, and are known to occur in three of the ten GAs on the HLC NF. There are historic observations on three additional GAs. Similar to flammulated owls, Lewis's woodpeckers use mature, open, large-diameter Ponderosa pine with a significant snag component. Additionally, Lewis's woodpeckers may use large, old cottonwoods in riparian areas.
Elk	Management of elk habitat, and elk distribution on NF and adjoining lands have been issues of public interest for decades. Management and public attention have often focused on both security (distance from open roads) and hiding cover. There has been some question as to the impact that hiding cover on NFS lands may have on overall elk distribution, particularly during hunting season. Modelling the NRV may provide context for understanding whether there might be appropriate levels of hiding cover to manage for on NFS lands.

In the assessment phase, the northern goshawk was also identified as a species to model. Northern goshawks were identified in the 1986 Forest Plans as a Management Indicator Species for old growth, and they have been the focus of public concerns regarding habitat quality and availability. Information has become increasingly available, however, indicating that goshawks are not dependent on growth (Brewer, Bush, Canfield, & Dohmen, 2009; Clough, 2000; USFWS, 1998), and that they and their habitat may be more widespread and available than previously thought (Renate Bush & Lundberg, 2008; Samson, 2006). Initial model results indicated that the existing amount of goshawk nesting habitat on the HLC NF, and in all but one GA (Rocky Mountain Range) appear to be at or near the maximum estimated NRV. Based on consideration of this information we concluded that the northern goshawk does not require a fine-filter approach in forest planning, but is addressed through the coarse filter analysis of key ecosystem characteristics that include cover type, canopy, tree size and density, and others. We did not include northern goshawk nesting habitat in updated NRV modeling or in the FEIS.

There was agreement among biologists that, to the extent possible, consistency was desired across NFs and analysis processes given that the HLC NF, Lolo, and Flathead NFs have adjoining boundaries and that each is undergoing either forest plan revision or is part of a large landscape analysis process. However, there was also agreement that the species chosen for modelling and the specific habitat parameters used in queries on each NF might differ due to different vegetation conditions and habitat use. This may be particularly true of the HLC NF, the majority of which is east of the Continental Divide.

The HLC NF was a participant in developing the Eastside Assessment, which was an effort to improve habitat and vegetation models and analysis using information specific to NFs east of the Continental Divide. The assessment was intended to help specialists and decision-makers answer comprehensive management questions. The Eastside Assessment group envisioned using SIMPPLLE to predict species' habitat over time, under a variety of possible vegetation management scenarios. The Eastside Assessment group used data specific to, and gathered from, east-side forests, and incorporated the best available, most current science relevant to the entire HLC NF plan area to develop the parameter sets for modelling wildlife habitats. For the HLC NF forest planning effort, therefore, we used SIMPPLLE queries based on parameters developed for the Eastside Assessment where possible. For species not considered in that effort, parameters were based on those discussed by the HLC, Lolo, and Flathead NF biologists and adjusted, where appropriate, to reflect vegetation conditions on the HLC NF.

In 2016 and early 2017 the Regional Office began working on improving consistency in how lynx habitat is mapped across the Region, and incorporating recent science into mapping considerations. As a result, the HLC NF has adjusted the parameters used to model lynx habitat, which now differ slightly from those used in the Eastside Assessment and the lynx habitat queries used in the SIMPPLLE model.

Some information is provided here, in the form of references, regarding the BASI used to develop queries for wildlife habitat models. Also refer to the Helena and Lewis & Clark NF Forest Plan Assessment (U.S. Department of Agriculture, Forest Service, Northern Region, 2015) for information and best available science regarding species' habitats.

Canada Lynx

There are four habitat elements modeled for Canada lynx: *potential habitat, stand initiation hare habitat, early stand initiation hare habitat, mature multistory habitat*, and *other habitat*. The analysis results include all ownerships in the administrative boundary of the HLC NF. After the initial NRV and DEIS, errors in model queries were discovered and corrected for the final NRV and FEIS analyses.

Potential habitat

Potential lynx habitat is a static layer depicting the areas on the landscape that have the potential to support habitat conditions used by lynx and their prey. The potential lynx habitat layer is based on habitat types, and was derived from VMap (2014 version) and Jones' PVT (Jones, 2004). Model outputs for each of the habitat categories were displayed as proportions of the total potential lynx habitat area. Updated potential lynx habitat mapping was conducted by the HLC NF between the DEIS and FEIS. This map was incorporated directly into the modeling for the FEIS.

Stand initiation hare habitat

Recent research (Cheng, Hodges, & Mills, 2015) has shown that forests in a small-diameter structural stage can produce high densities of snowshoe hares. The Northern Rockies Lynx Management Direction (U.S. Department of Agriculture, Forest Service, 2007) describes high and low density winter snowshoe hare habitat by trees per acre. High density regenerating forests are 5000+ trees per acre, with high density undergrowth in multistoried forests at 2500 + small trees per acre. Low density regenerating forest is 2500-5000 trees per acre and low density undergrowth in multi-storied forests is 1000-2500 small trees per acre. Young forests with fewer than 1000 trees per acre may not provide enough cover for snowshoe hares (ibid). The only measure available in SIMPPLLE to reflect trees per acre and horizontal cover is density class (canopy cover). A plot analysis was conducted to help define stand initiation habitat. FIA intensified grid plots across the HLC NF provided the following information:

- All the seed/sap plots (<5" dbh) in the cool moist PVT across the HLC NF were summarized (72 plots), to see which canopy cover classes best aligned with more than 5,000 trees per acre.
    - 30 plots had a density >60% CC. 100% of these had more than 1000 trees per acre. 50% had more than 5000. This condition is reasonable to include as stand initiation habitat.
    - 15 plots had 40-59% CC. All but 2 had more than 1000 trees per acre, and 50% had more than 5000. This condition is also reasonable to include as stand initiation habitat.
    - 27 plots that had 0-39.9% CC. 56% of these plots had more than 1000 trees per acre, but only 19% had more than 5000. This condition should be excluded.

Based on this information, a threshold of 40% canopy cover was set to describe stand initiation hare habitat and mature multistory habitat (Table 23). Canopy cover is a proxy for horizontal cover; if trees are dense, then canopy is dense, and at this seral stage that likely means horizontal cover is also dense.

Table 23. Stand initiation hare habitat SIMPPLLE query

Habitat type group	Elevation	Canopy	Size class	Other query parameters
See potential lynx habitat	See potential lynx habitat	≥40%	0-5” (seedsap/pole)	Also include pixels between 21 and 50 years post-stand replacing fire or even-aged regeneration harvest.

Early stand initiation hare habitat

Early stand initiation habitat, which consists of seedling/sapling and pole forests that are not dense enough to meet the requirements for stand initiation habitat, and that are not tall enough for trees to protrude above the snow in winter may provide summer snowshoe hare habitat but is used much less, if at all, by hares in winter (Interagency Lynx Biology Team, 2013; U.S. Department of Agriculture, Forest Service, 2007). The SIMPPLLE model was queried as shown in Table 24 to estimate this condition.

Table 24. Early stand initiation hare habitat SIMPPLLE query

Habitat type group	Elevation	Canopy	Size Class	Other query parameters
See potential lynx habitat	See potential lynx habitat	<40%	0-5” (seed/sap, pole)	Also include pixels that are less than 20 years post-stand replacing fire or post-even-aged regeneration harvest.

Mature multistory lynx habitat

Multi-story habitat is optimal winter habitat for snowshoe hares, and therefore provides optimal habitat for lynx in the winter (ILBT, 2013; Kosterman, 2014; Squires, Decesare, Kolbe, & Ruggiero, 2010; U.S. Department of Agriculture, Forest Service, 2007). A plot analysis was conducted to assist with defining multistory habitat, based on the information from the NRLMD. All multistory plots (10” and greater size class; vertical structure 2, 3, or C) in the cool moist PVT on the HLC NF were summarized (104 plots).

- 51 plots had >60% CC. Of these, 84% had more than 1000 trees per acre and 61% had more than 2500. This condition is reasonable to include as multistory habitat.
- 47 plots had >40% CC. Of these, 72% had more than 1000 trees per acre but only 49% had more than 2500. Still reasonable to include, based on a 1000 trees per acre threshold.
- 6 plots that had <40% CC. Of these, 50% had more than 1000 trees per acre, and those same 50% had more than 2500.

Based on this data, a threshold of 40% canopy cover was set for mature multistory habitat (Table 25).

Table 25. Mature multistory habitat SIMPPLLE query

Habitat type group	Species Groups	Elevation	Stories	Canopy	Size class	Other query parameters
See potential lynx habitat	All except lodgepole pine (LP)	See potential lynx habitat	≥2	≥40%	≥10”	None

Other lynx habitat

Other habitat represents the matrix around the other lynx habitat categories, and other conifer habitat, including stem-exclusion stage, that does not currently provide hare habitat, but may be used by lynx for movement and foraging for alternate prey. It represents the remainder of the potential lynx habitat area that does not meet one of the other habitat definitions.

Flammulated owl

Flammulated owls are associated with open, mature and old growth xeric ponderosa pine and mixed ponderosa pine/Douglas-fir (Renate Bush & Lundberg, 2008; Cilimburg, 2006; Nelson, Johnson, Linkhart, & Miles, 2009; Samson, 2006). Based on a comparison of the outputs with the habitat estimated from FIA plots, we determined that only ponderosa pine dominated forests adequately represent flammulated owl nesting habitat. The model was queried as shown in Table 26.

Table 26. Flammulated owl nesting habitat SIMPPLLE query

Habitat type group	Species groups	Stories	Canopy	Size class	Other query parameters
A1, A2, B1, B2	PP, PP-DF, PP-DF-JUSC, PP-DF-PF, PP-PF	1-2	15-60%	≥15”	Species groups that at climax are going to have large, old, open ponderosa pine were selected.

Lewis’s woodpecker

Lewis’s woodpeckers are closely associated with open ponderosa pine forest, old-growth or large-tree stands that have been maintained by fire (MNHP-MTFWP). They may also rely on large, old cottonwood stands in riparian areas. Nesting habitat was queried from SIMPPLLE as shown in Table 27.

Table 27. Lewis’s woodpecker nesting habitat SIMPPLLE query

Habitat type group	Species groups	Canopy	Size glass	Notes and other query parameters
A1, A2, B1, B2, B3	DF, DF-ES, DF-JUSC, DF-LP, DF-LP-AF, DF-PF, DF-PF-ES, DF-PF-JUSC, DF-PF-LP, DF-PP-LP, PP, PP-DF, PP-DF-JUSC, PP-DF-PF, PP-PF, QA-DF, QA-DF-LP, CW, CW-ES-AF, L-DF, L-DF-AF, L-DF-ES, L-DF-LP, L-DF-PP	15-40%	>15”	Also include areas with low-moderate severity (non-lethal) fire in the past 20 years

Elk

Management of elk habitat on the HLC NF has included consideration of elk security, which is a concept that addresses vulnerability of elk to disturbance and to mortality specifically during elk hunting seasons. Hiding cover is one of several potential components of elk security. Hiding cover is defined in general as “vegetation capable of hiding 90 percent of a standing adult elk from the view of a human at a distance equal to or less than 200 feet” (Lyon & Christensen, 1992). Specific, functional definitions of hiding cover, using canopy as an indicator of horizontal cover, were included in the 1986 Forest Plans. Those definitions, along with analysis recommendations made in the Eastside Assessment process (U.S. Department of Agriculture, Forest Service, 2013) were used to inform the SIMPPLLE query (Table 28). Two types of elk hiding cover habitat were evaluated: spring/summer/fall, and winter. Results were reported forestwide and for the HLC NF lands within elk analysis units. For spring/summer/fall habitat, the assumption is made that canopy cover results in a certain trees per acre that provide horizontal cover.

Table 28. Elk hiding cover habitat SIMPPLLE query

Habitat type group	Species groups	Canopy	Notes and other query parameters
All forested types	AF, DF-PF-AF, QA-LP, CW-ES-AF, DF-PF-LP, QA-LP-ES-AF, DF, DF-PP-LP, WB-AF, DF-AF, ES-AF, WB-DF, DF-ES, LP, WB-DF-AF, DF-ES-AF, LP-AF, WB-DF-ES-AF, DF-JUSC, LP-ES, WB-DF-LP, DF-LP, LP-ES-AF, WB-LP, DF-LP-AF, LP-PF, WB-LP-ES-AF, DF-LP-ES, PF-LP-AF, L-DF, DF-LP-ES-AF, PP-DF, L-DF-AF, DF-LP-PF, QA-DF, L-DF-LP, DF-PF	SSF: 40-60% Winter: All	Spring/Summer/Fall:None Winter: Limit to areas mapped by MTDFWP as winter range.

Desired conditions

The 2012 planning rule requires that forest plan direction provide for ecological integrity while contributing to social and economic sustainability. To achieve this, desired conditions have been developed for key vegetation components. Though the 2020 Forest Plan provides direction for a relatively short period of time (15 years), desired conditions were developed with a long-term view due to the long-lived nature of tree species. To address the uncertainty in future conditions, desired conditions incorporate strategies that would maintain or improve the resilience of the ecosystem and promote the adaptability of vegetation. The desired conditions incorporate the survival strategies trees and other plant species.

Desired condition development and methodologies

This section discusses the factors and rationale applied in the development of desired conditions for vegetation in the HLC NF 2020 Forest Plan. Since the DEIS, changes have been made to desired conditions based on internal and public comment as well as an updated NRV analysis (appendix I of the EIS). The desired conditions are included as plan components and form the basis of the timber and vegetation future modeling to compare alternatives. Please see appendix D of the 2020 Forest Plan for detailed definitions of each attribute.

The NRV shows the mean percentage for the attribute, with ranges around the 5 and 95 percentile, rounded to the nearest percentage. Existing condition estimates are shown as the mean with ranges depicting the 90 confidence interval. The desired condition ranges are built based on the NRV ranges; however, rounding occurs to not place undue confidence on model precision. Generally the ranges span at least 5% for uncommon elements and 10% for more common elements. For example, if the NRV predicted a range of 6-8%, the desired condition range may be 5-10%. In addition, either the lower bound, upper bound, or both of the modeled NRV ranges are adjusted in specific cases to account for BASI regarding the historic condition or potential future condition of the attribute. When such adjustments are made, in most cases, the desired condition ranges overlap either the high or low end of the NRV range. Specific literature used to support adjusted desired conditions is cited in each attribute section.

Some attributes cannot be modeled with SIMPPLLE (i.e., snags, old growth, large live trees, etc). For these elements, other resources are used to inform plan components.

NRV as a basis for desired conditions

An analysis of the NRV was a primary element that informed desired conditions. The NRV provides a frame of reference for ecological integrity and resilience. It reflects the conditions that have sustained the current complement of wildlife and plant species and provides context for understanding the natural diversity of vegetation and the processes that sustain it. Since the mid-1800s human presence and activities have increased dramatically in the plan area. NRV estimates provide a reference to conditions that might have occurred prior to these impacts. The intent of using the NRV to inform desired conditions is not to return to conditions that occurred at a single point in time, but rather to encompass the full range of conditions that were supported prior to substantial human influence.

The future will not be the same as the past. The NRV does not provide insight into conditions that may vary in the future, or other considerations relative to social demands placed on the ecosystem. Further, the analysis includes inherent uncertainty and it is appropriate to utilize additional resources, including literature, to ensure the “envelope” of vegetation conditions described by desired conditions will meet future ecological and social needs. Therefore, the desired conditions are not always equal to the NRV, because additional factors were considered as noted in the detailed sections below.

The directives (2015) recognize there may be other factors (social, economic or ecological) that lead the responsible official to determine that the NRV may not be an appropriate desired condition for certain characteristics. These considerations include maintaining conditions that contribute to long-term resilience given uncertainties in future climate and disturbances; sustaining stand structures or species compositions that provide habitat for at-risk wildlife or plant species; conserving rare structures or components; existing or anticipated human use patterns; the effects changing climate may have; and ecosystem services expected from forest lands (such as reduction of fire hazard). The following factors are considered in the development of vegetation desired conditions: generally manage vegetation to be within the NRV; maintain conditions that would contribute to long-term ecosystem resilience and adaptation to uncertainties of future climate and disturbances; sustain important wildlife habitat conditions; and consider social and economic factors.

Research indicates there is potential for ecological transformations to occur in temperate ecosystems, based on the potential for interrelated drivers such as chronic and acute drought, wildfire, and insect outbreaks to push ecosystems beyond their thresholds for resilience (Golladay et al., 2016; Millar & Stephenson, 2015). In some cases management intervention might be able to ease the transition to new forest states and minimize losses of ecosystem services (Millar & Stephenson, 2015). We do not have the capability to predict such possible shifts at the local scale. By basing the desired conditions around the NRV, with a focus on maintaining the full suite of ecosystem diversity and components that enhance resilience to disturbance, the 2020 Forest Plan would guide management toward maintaining functioning ecosystems in the face of uncertainty.

Several recent studies have been conducted regarding the appropriateness of using the NRV to frame desired conditions (Hansen et al., 2018; Timberlake, Joyce, Schultz, & Lampman, 2018). In both cases, the authors found that using the NRV provided a solid and defensible base to inform future desired conditions.

- Hansen and others (2018) document the results of a workshop during which a variety of subject matter experts examined the ecosystems on the neighboring Custer-Gallatin NF and determined that “managing toward the NRV is a reasonable approach given the current relatively natural state of the forest ecosystem and projected future change.” The authors examined the vulnerability of ecosystems on the Custer-Gallatin NF to climate change and delineated potential adaptation strategies, which are consistent with the recent work of the Northern Rockies Adaptation Partnership, which is the BASI for climate change in Region 1. The HLC NF supports similar ecosystems and utilizes similar information to frame desired conditions.
- Timberlake and others (2018) allow that NRV may help inform the desired future condition, but propose a worksheet format to help forest planners systematically address ecosystem integrity in the face of climate change by evaluating dominant ecosystem characteristics. The factors in these

worksheets include an assessment of the NRV, climate change vulnerability, climate change information, and other stressors. Similar information has been summarized by the HLC NF in this document by incorporating information from BASI to frame and, in some cases, support desired condition ranges that are not the same as the NRV model outputs.

The issue of utilizing a historical range of variability in the context of climate change is addressed in *Climate Change Vulnerability and Adaptation in the Northern Rocky Mountains* (Halofsky et al., 2018b), as shown in Box 1. The HLC NF is consistent with the concepts presented, by considering the full range of NRV conditions to establish desired condition ranges (not precise targets) that are adjusted where need to reflect other BASI.

Box 1: From Halofsky et al 2018 Box 6.1 – Using Historic Range and Variability to Assess and Adapt to Climate Change

"To effectively implement ecosystem-based management, land managers often find it necessary to obtain a reference or benchmark to represent the conditions that describe fully functional ecosystems (Cissel et al. 1994; Laughlin et al. 2004). Contemporary conditions can be evaluated against this reference to determine status, trend, and magnitude of change, and to design treatments that provide society with valuable ecosystem services while returning declining ecosystems to a more sustainable condition (Hessburg et al. 1999; Swetnam et al. 1999). Reference conditions are assumed to represent the dynamic character of ecosystems and landscapes, varying across time and space (Swanson et al. 1994; Watt 1947).

The concept of historical range and variability (HRV) was introduced in the 1990s to describe past spatial and temporal variability of ecosystems (Landres et al. 1999), providing a spatial and temporal foundation for planning and management. HRV has sometimes been equated with "target" conditions (Harrod et al. 1999), although targets can be subjective and somewhat arbitrary; they may represent only one possible situation from a range of potential conditions (Keane et al. 2009). HRV encompasses a full range of conditions that have occurred across multiple spatiotemporal scales.

HRV represents a broad historical envelope of possible ecosystem conditions—burned area, vegetation cover type area, patch size distribution—that can provide a time series of reference conditions. This assumes that (1) ecosystems are dynamic, not static, and their responses to changing processes are represented by past variability; (2) ecosystems are complex and have a range of conditions within which they are self-sustaining, and beyond this range they make a transition to disequilibrium (Egan and Howell 2001); (3) historical conditions can serve as a proxy for ecosystem health; (4) the time and space d omains that define HRV are sufficient to quantify observed variation; and (5) the ecological characteristics being assessed for the ecosystem or landscapes match the management objective (Keane et al. 2009).

The use of HRV has been challenged because a warmer climate may permanently alter the environment of ecosystems beyond what was observed under historical conditions (Millar et al. 2007a). In particular, disturbance processes, plant species distribution, and hydrologic dynamics may be permanently changed (Notaro et al. 2007). However, a critical evaluation of possible alternatives suggests that HRV might still be the most viable approach in the near term because it has relatively low uncertainty.

An alternative to HRV is forecasting future variations of landscapes under changing climates by using complex empirical and mechanistic models. However, the range of projections for future climate from the commonly used global climate models may be greater than the variability of climate over the past three centuries (Stainforth et al. 2005). This uncertainty increases when we factor in projected responses to climate change through technological advances, behavioral adaptations, and population growth (Schneider et al. 2007). Moreover, the variability of climate extremes, not the gradual change of average climate, will drive most ecosystem response to climate mediated disturbance and plant dynamics (Smith 2011) that are difficult to project. Uncertainty will also increase as climate projections are extrapolated to the finer scales and longer time periods needed to quantify future range and variability (FRV) for landscapes (Araujo et al. 2005; Keane et al. 2009).

Given these cumulative uncertainties, time series of HRV may have lower uncertainty than simulated projections of future conditions, especially because large variations in past climates are already captured in the time series. It may be prudent to wait until simulation technology has improved enough to create credible FRV landscape pattern and composition, a process that may require decades. In the meantime, attaining HRV would be a significant improvement in the functionality of most ecosystems in the Northern Rockies, and would be unlikely to result in negative outcomes from a management perspective. As with any approach to reference conditions, HRV is useful as a guide, not a target, for restoration and other management activities.

There is literature that indicate a high likelihood of future scenarios wherein the suite of ecosystems present today and in the NRV are no longer resilient to change, and transform into novel ecosystems. In other words, conditions may shift outside of the NRV and ecosystem integrity may no longer be measured by that yardstick; and desired conditions built around NRV may not be achievable. The risks for species shift and loss of forest cover due to drought and disturbance are acknowledged; however, these scenarios are generally predicted to occur in the longer term (beyond the 15 year planning cycle), and are difficult if not impossible to quantify at the scale of a NF. The specific configuration of potentially new ecosystem conditions is not quantifiable due to the level of uncertainty associated with future climates, and any attempt to craft desired conditions to capture the suite of conditions that may be sustainable in 50+ years would be based on substantial guesswork and downscaling of larger modeling efforts.

The NRV for wildfire and insect activity places the analysis into context with historic regimes (see appendix I). Wildfire is, was, and will remain a dominant ecosystem driver. Given the importance of fire as a key ecosystem process, maintaining vegetation and forest diversity, sustaining fire adapted species and structures, and creating vegetation conditions that support and sustain native wildlife species in the short and long term are critical components of the Plan. Some GAs are still demonstrating the lack of fire that has occurred throughout the era of fire exclusion, and remain well below the NRV for acres burned; others are reflecting the trend of increasing fire activity with warming climates. It is likely that insect and disease occurrence may increase with continued warm/dry climates during the life of the plan. However, the recent mountain pine beetle outbreak may preclude many areas from infestation for several decades.

For the purposes of desired conditions that apply over the next planning cycle, using the NRV with adjustments as documented in this report provide the most supported picture of conditions that would provide for ecosystem integrity, while promoting resilience to future changes to the extent feasible.

Hierarchy and scale of desired conditions

Desired conditions are developed at a scale that represents the broad-scale planning unit and can be monitored through time, while also capturing the unique contribution and condition of each GA. Most of the vegetation desired conditions are displayed as numeric ranges in chapter 2 (forestwide) or chapter 3 (GAs) of the 2020 Forest Plan. Appendix C provides descriptions of management approaches and actions that are expected to be used to help achieve desired conditions. Desired conditions may be achieved through both natural processes and management activities. Those that are developed at the GA scale complement forestwide desired conditions and reflect the unique array of PVTs, disturbance history, and growth potential in each GA. Table 29 shows how vegetation conditions are addressed across scales.

Table 29. Organization of vegetation desired conditions in 2020 Forest Plan

Vegetation attribute	Chapter 2, forestwide	Chapter 3, GAs
Forested and nonforested cover types	X	X
Tree species distribution	X	X
Forest size class	X	X
Large-tree Structure	X	
Forest density class	X	X
Forest vertical structure	X	
Snags	X	
Downed woody debris	X	
Old growth	X	
Early successional patches	X	

Desired conditions for composition

Discussion/Summary

Cover types are assemblages of dominance groups that describe the dominant vegetation on a site (Milburn et al., 2015). *Tree species presence* is the percentage of the area that contains at least one live tree of the species.

The exclusion of fire since modern settlement has resulted in a higher proportion of late seral, shade tolerant species at the expense of shade-intolerant types. This is most evident in the warm dry broad PVT and in cover types where high frequency, low severity fires would have been common. Low elevation, dry forests have experienced the greatest magnitude of change in composition, structure and function because of fire suppression, forest management, and climate change (Hessburg & Agee, 2003; Hessburg, Agee, & Franklin, 2005; Westerling, Hidalgo, Cayan, & Swetnam, 2006). Still, even cover types adapted to long fire return intervals and stand-replacing severities such as lodgepole pine have changed because these forests also burned in low-to mixed-severity events historically which created variable age structures and patterns (Kashian, Turner, Romme, & Lorimer, 2005).

Table 30 below displays a matrix of the relationship between the existing condition and the desired condition ranges for species composition, for all cover types and associated tree species presence (or extent). These comparisons are made using the mean modeled values and do not account for the error bars around those means, which in some cases may extend into a different position relative to the desired range. Charts with error bars are available in the project file for all attributes for alternatives A and F.

The ponderosa pine cover type, and the presence of ponderosa pine, is consistently below the desired ranges, as is aspen; whereas the Douglas-fir cover type and presence is consistently above. When the desired trend of a cover type (where a certain species is dominant) varies from the extent or presence of the species, it indicates that there is a difference in the abundance of forests where the species dominates versus where it is present overall, potentially as a minor component. The variability in desired trends across the GAs underscores the importance of having forest plan components at multiple scales.

Based on the modeling, it would initially appear that nonforested or savanna areas may be similar or more prevalent today than historically; however, these types were more abundant during warm/dry climate periods. Therefore, a trend of maintaining or increasing nonforested types – and very low tree cover <10% on some forested types – is appropriate for the future desired condition. In one local example, this conclusion was demonstrated by a study in the Elkhorns GA which found that there has been a three-fold increase in the amount of closed-canopy forest at the expense of grass, shrub, and open tree stands compared to historical conditions (Barrett, 2005).

In the warm dry PVT, desired conditions would promote landscape patterns and large trees beneficial for wildlife, timber production, and seed sources. Open forest savannas should occur on the hottest, driest sites dominated by grass or shrubs with widely scattered trees (5 to 10% canopy cover). These areas blend into grass and shrublands and may be more prevalent in the future. Nonforested cover types will be promoted with future warm and dry climate. It is desirable to limit the encroachment of coniferous tree species onto nonforested PVTs. Increases or maintenance of ponderosa, limber, and aspen will be supported by future warm climate and fire. Ponderosa pine is highly drought tolerant, whereas Douglas-fir is likely to experience greater stress with drying conditions. The fact that the presence of Douglas-fir is within the desired range, but the Douglas-fir cover type is above the desired range, indicates that the dominance of dry forests should shift towards ponderosa pine, but Douglas-fir should remain a component of many forests where it currently occurs.

In cool moist, desired conditions would sustain multistory lynx habitat in spruce/fir cover types and provide the habitat diversity necessary for other wildlife species, and stand conditions more resilient to future disturbance and climate change. Infrequent, large fires characteristic of this setting will favor these species over those with low fire resistance. In the cold PVT, desired conditions are to maintain the whitebark pine cover type, and increase its overall extent focusing on sites best suited (e.g. open ridges and harsher aspects). On sites where whitebark pine is capable of surviving, there should be a decrease in subalpine fir. Subalpine fir and Engelmann spruce dominate northerly and easterly aspects, swales, moist basins, and riparian areas. Some lodgepole pine cover types are desired, mainly on warmer sites, for species diversity and responses to fire.

Table 30. Matrix of existing condition (FIA) compared to desired condition at multiple scales – species composition

	Forestwide	Warm Dry	Cool Moist	Cold	Big Belts	Castles	Crazies	Divide	Elkhorns	Highwoods	Little Belts	Rocky Mtn	Snowies	Upper Blackfoot
Nonforested cover type	W/B	W/A	W	W/A	W	W	W	W	W	W	W	A	W	W/A
Aspen/Hardwood cover type	B	B	B	N	B	W/B	B	B	B	W/B	B	W	B	B
Aspen/Cottonwood presence	W/B	B	W	N	B	W/B	B	W	W/B	W	B	W	B	B
Ponderosa pine cover type	B	B	W	N	B	B	B	B	B	B	B	W/B	W	B
Ponderosa pine presence	B	B	N	N	B	B	B	B	B	B	B	B	W	B
Limber pine presence	W	W	W	W/B	W/B	B	B	W/B	W/B	B	W	W/B	W/A	W
RM Juniper presence	W/A	W	W/B	N	A	W	B	W	W/A	B	W	W	W	W
Douglas-fir cover types	A	A	A	W/A	A	A	A	A	W/A	B	A	W	A	A
Douglas-fir presence	W/A	W	A	W	W/B	A	A	W	W	B	A	W	A	W
Lodgepole pine cover type	W/A	A	W/A	B	W	W	B	A	W	A	A	W/A	B	W
Lodgepole pine presence	A	A	A	W	W	W/A	W	A	W	A	A	A	B	A
Western larch cover type	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Western larch presence	N	N	N	N	N	N	N	N	N	N	N	N	N	B
Spruce/fir cover type	W	N	B	B	W/B	W/B	W	W	A	W/B	B	B	W	B
Engelmann spruce presence	W	W/A	A	W/B	W/B	W/B	B	W	A	N	A	W	A	W
Subalpine fir presence	W/A	N	W/B	A	W/A	W/A	A	A	A	W/B	W/A	W	W	A
Whitebark pine cover type	W	N	W/B	W	W	W	W/A	B	B	N	B	W/B	N	B
Whitebark pine presence	W/B	N	W	B	W	W	W	W	W	N	W	W	B	W

W = within the DC range; A = above the DC range; B = below the DC range; N = not present or no DC for that scale. When the existing condition is at the boundary of the DC range, it is noted as W/A (at the upper end of the range) or W/B (at the lower end of the range). Items shaded in the dark gray tones and white font indicate conditions at the upper bound or above the desired range. Items shaded in light gray tones indicate conditions at the lower bound or below the desired range. Cells with no shading are within the desired ranges, or are not present/applicable.

Cover type

Data and modeling considerations

The various nonforested cover types are not currently classified in the R1 Summary Database; therefore, they are lumped into one desired condition. In addition, the existing condition includes cover types labeled as "none", which include nonforested types and forested types that were recently disturbed.

Assumptions had to be made to translate SIMPPLLE species associations into cover types. This was done by comparing how the type corresponded to the dominance groups in VMap. For example, whitebark-spruce SIMPPLLE species ("WB-ES") occurred most often in spruce ("PIEN") dominance groups in VMap, so are classified into the Spruce-fir cover type. It's possible, however, that historically some WB-ES areas would have been dominated by whitebark (Whitebark Pine cover type). However, because SIMPPLLE does not track the abundance of each species, there is no way to know how much should be in each cover type. This classification method is problematic for species that have declined since NRV and are in low abundance or scattered in small patches and not well-represented by VMap. The result is that some unknown proportion of the indicated levels of Spruce Fir in the NRV include areas that should be classified into whitebark Pine cover type. While whitebark pine is one of the most prominent examples of this potential error, similar errors could occur in other types, such as the relationship between Douglas-fir and ponderosa pine; and between aspen and conifers. Recognizing this weakness highlights the importance of using other BASI and professional judgement to interpret model results.

On the HLC NF, the Mixed Mesic Conifer cover type represents Douglas-fir dominated forests on productive sites, and Dry Douglas-fir represents Douglas-fir on dry sites. For the FEIS these cover types are combined because they are both dominated by Douglas-fir (with the distinction being the moisture regime of the site); at the forest plan level this distinction is not necessary to inform desired conditions. The combination of these groups is termed "Douglas-fir".

Correlation to warm/dry climate periods and other considerations

Because future climates are expected to be warm and dry, historic warm/dry climate periods were compared to the trend of cover types. Aspen/Hardwood is at the higher end of its range during these periods, while ponderosa pine declines. Dry Douglas-fir increases during warm/dry periods, and Mixed Mesic Conifer appears to peak. Lodgepole pine is not particularly responsive to climate periods. Spruce/fir declines while whitebark pine increases. Dry nonforested cover types in particular increased in warm/dry periods. NRV indicates that forested cover types encroached into nonforested PVTs at times; however, this happened less during warm/dry periods. Ponderosa pine and limber pine are likely do better than Douglas-fir in drought. The lodgepole pine cover type is not expected to drastically change, but the whitebark pine cover type may see species dominance shifts (Halofsky et al., 2018b).

NRV compared to Existing Condition

The following tables display the existing condition versus NRV for cover type.

Table 31. Cover Type, NRV versus existing condition – forestwide

	NF	AS/HW	PP	DF	LP	SpFir	WBP
NRV	7-9	0.6-1	22-26	15-21	18-20	22-26	1-1.2
Existing	14 (11-16)	1 (0.4-2)	8 (6-10)	29 (25-35)	27 (24-30)	13 (10-15)	4 (2-5)

NF = nonforested; AS/HW = aspen/hardwood; PP = ponderosa pine; DF = Douglas-fir; LP = lodgepole pine; SpFir = spruce/fir; WBP = whitebark pine. Values are percentages of total NFS lands of the scale of interest, rounded to the nearest whole number unless the value is small enough to require showing decimal to the tenth place.

Table 32. Cover type, NRV versus existing condition – forestwide by PVT

PVT		NF	AS/HW	PP	DF	LP	SpFir	WBP
Warm dry	NRV	0.1-3	0.6-1	54-62	31-39	4-5	N/A	N/A
	Existing	13 (10 -17)	1 (0.3-2)	16 (12-20)	52 (42-61)	16 (12-21)	0.4 (0.4-1)	0
Cool moist	NRV	3-7	0.2-0.6	4-5	8-16	27-32	45-55	0-0.1
	Existing	10 (6-14)	2 (0.2-3)	2 (0.6-4)	23 (17-29)	35 (29-42)	19 (14-24)	2 (0.6-4)
Cold	NRV	0-0.3	0.1-0.4	0	2-5	42-47	43-48	5-7
	Existing	11 (7-16)	0	1 (1-2)	5 (2-8)	37 (29-44)	27 (21-34)	12 (7-16)

See footnote for Table 31.

Table 33. Cover type, NRV versus existing condition by GA

GA		NF	AS/HW	PP	DF	LP	SpFir	WBP
Big Belts	NRV	11-14	0.7-1.3	41-47	20-27	8-10	8-11	0.5-1
	Existing	21 (18-28)	0	9 (5-12)	41 (31-50)	8 (5-12)	5 (2-7)	3 (1-6)
Castles	NRV	10-11	0	31-35	9-14	34-39	5-9	2-3
	Existing	15 (6-23)	2 (2-6)	0	35 (19-56)	35 (23-46)	6 (1-12)	4 (4-8)
Crazies	NRV	10-13	0-0.1	16-18	5-8	25-35	18-27	2-5
	Existing	19 (9-32)	0	0	34 (14-55)	14 (5-24)	21 (10-34)	5 (5-12)
Divide	NRV	8-11	1-2.4	21-27	22-29	24-26	9-13	2.5-3
	Existing	8 (5-12)	1 (1-3)	0	40 (31-51)	37 (29-42)	10 (7-14)	1 (1-3)
Elkhorns	NRV	18-20	0.5-1.4	16-22	16-23	23-27	6-10	4-5
	Existing	23 (15-31)	1 (1-3)	1 (1-4)	19 (13-33)	23 (14-30)	17 (10-26)	4 (3.6-7)
Highwoods	NRV	17-20	4-6	35-45	19 -31	8-9	3-5	0
	Existing	37 (21-52)	3 (3-10)	0	12 (11-30)	31 (16-46)	3 (3 -10)	0
Little Belts	NRV	4-6	0.1-0.2	30-34	15-22	19-22	20-24	0.5-1
	Existing	8 (6-9)	0.4 (0.4-1)	9 (7-11)	39 (34-44)	29 (26-32)	11 (9-13)	1 (0.6-2)
RM Range	NRV	6-7	1-1.4	8-10	10-17	12-16	39-46	0.3-0.7
	Existing	21 (15-27)	3 (1-5)	2 (0.2-4)	15 (7-22)	20 (15-27)	22 (16-28)	5 (2-8)
Snowies	NRV	6-8	1-2	20-23	15-21	19-25	20-28	0.2-1
	Existing	9 (4-14)	1 (1-3)	22 (15-30)	37 (24-51)	10 (5-16)	20 (13-27)	0
Upper Blackfoot	NRV	4-8	0.2-0.4	19-25	16-25	23-28	20-26	1-2
	Existing	16 (12-20)	0.4 (0.4-1)	2 (0.6-4)	33 (26-42)	26 (20-30)	10 (7-14)	1 (0.7-2)
	In addition, there is 0% (0-0.1%) western larch mixed conifer existing. The NRV shows only 0.1% at 95th quartile.							

See footnote for Table 31.

Forestwide cover type desired conditions

The subsequent figures show the desired condition for cover type reflected in plan component FW-VEGT-DC-02. Only cover types with a desired range of at least 1% are included; other types may occur at incidental levels. Estimates are rounded to the nearest whole number unless the value is less than 1%, in which case it is rounded to the nearest 10th. The totals do not necessarily equal 100% due to non-vegetated areas (water or rock). The following adjustments from the NRV were applied:

- The desired conditions for the aspen cover type are slightly higher than the NRV, because this type is not as well represented in the data due to its scattered nature (often present in stringers overtopped by conifers), which makes it difficult to detect with plots or remote sensing. Literature sources indicate that aspen has decreased from the historic condition due to factors such as fire suppression (Bartos, 2001; Campbell & Bartos, 2000; Shepperd, 1996).
- Most nonforested cover types would occur on nonforested PVTs and on the warm dry PVT where they are created and maintained by natural disturbance. Nonforested cover types were most prevalent during the warm and dry climate periods in the NRV; therefore, management at the upper end of the natural range is appropriate given future climate. The ability of the model to depict historic grasslands is limited as the model recruits trees onto sites with a forested PVT, whereas anecdotal knowledge and literature would indicate that more areas may have been maintained in a nonforested in the past based on presence of species such as sagebrush. The upper range of the desired condition for nonforested cover types is higher than the NRV, based on BASI that indicates these types were more prevalent historically and likely to be promoted by a warming climate in the future (Halofsky et al., 2018a, 2018b, 2018c, in press; Heyerdahl, Miller, & Parsons, 2006; Means, 2011). These include savanna or ecotones with sparse trees and grass/shrublands. Forestwide ranges of nonforested cover types indicate that the existing condition is just below the desired range; however, for each of the forested PVTs, nonforested communities are generally within or at the upper end of the desired range. This indicates that the desired increases in nonforested types at the forestwide scale would primarily occur on nonforested PVTs, in addition to potentially moving higher within the desired range in the warm dry forested PVT.
- The bounds of the desired condition range for spruce/fir are adjusted down based on information that this type is more prevalent today than it was historically, and post-fire regeneration of this species will not be promoted by warmer and drier climates (Halofsky et al., 2018b; Urza, Sibold, & Gilliam, 2016). In addition, it is likely that some of this type should be classified as whitebark pine in the NRV due to limitations in classification for modeling.
- The whitebark pine ranges overlap but are slightly higher than the NRV ranges due to limitations in the classification (wherein some of this type is lumped into spruce/fir) as well as BASI indicating that this species was more prevalent historically (Halofsky et al., 2018b, in press; Keane et al., 2012; U.S. Department of the Interior, 2010; Wong & Daniels, 2016).
- The future modeling does not detect a measurable abundance of ponderosa pine on the cool moist PVT. However, a desired condition is included to encompass its known presence based on plot data, and to allow for potential movement onto these sites as a result of warm and dry climate conditions.

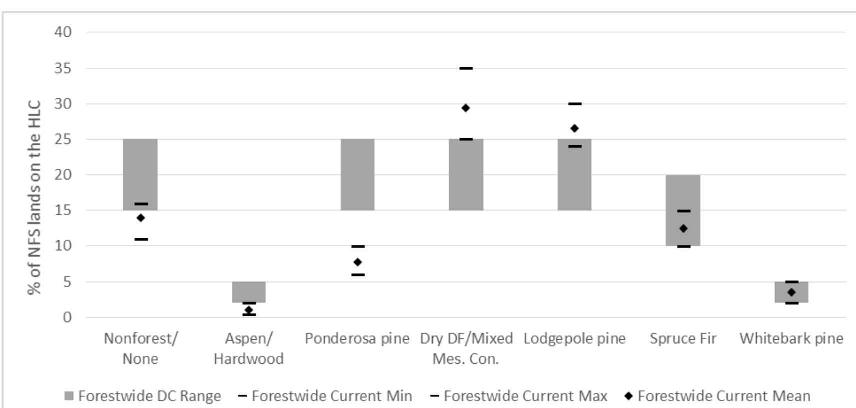


Figure 3. Forestwide cover type desired conditions compared to existing condition

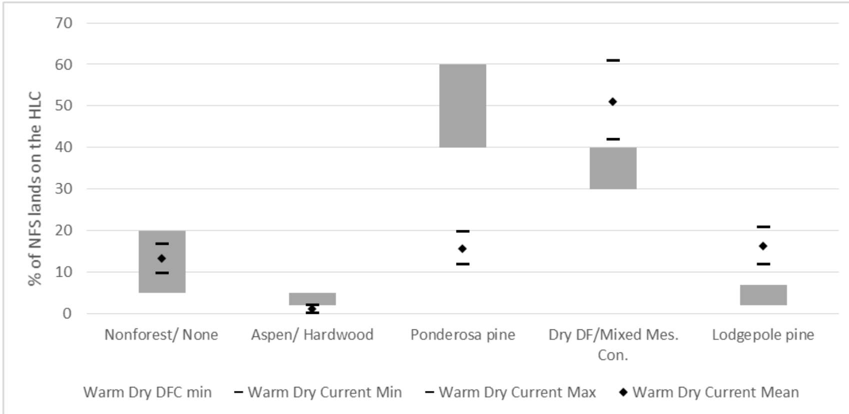


Figure 4. Warm dry PVT cover type desired conditions compared to existing condition

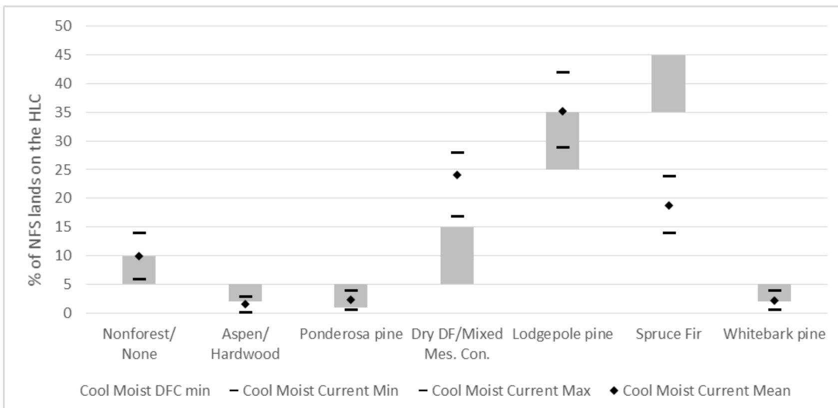


Figure 5. Cool moist PVT cover type desired conditions compared to existing condition

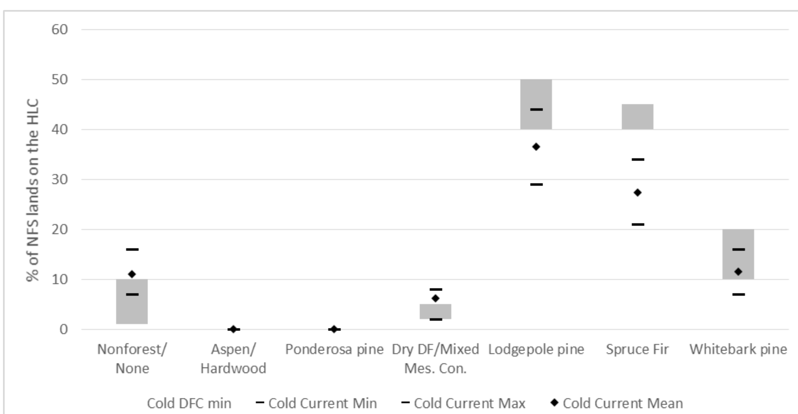


Figure 6. Cold PVT cover type desired conditions compared to existing condition

Nonforested plant community desired conditions

Nonforested plant communities are combined into the nonforested cover type. However, within this group there are distinct community types, which are addressed qualitatively as follows.

- *Xeric grasslands*: The desired condition is to have high diversity of tall and medium height, cool and warm season grasses (e.g., bluebunch wheatgrass, green/Columbia/western needlegrass), and short grasses (e.g., Sandberg bluegrass). There should a variety of forbs in varying amounts, and the diversity of plant species present allows for drought tolerance. Individual species varies greatly in the amount of production depending on growing conditions. Vegetation should have strong and robust root systems that allow production to increase with favorable growing conditions. This plant community provides for soil stability and a properly functioning hydrologic cycle. Plant litter is a common component and is available for soil building and moisture retention. Plant litter is well distributed with little movement off-site and natural plant mortality is typically low. Bare ground is present because of the warm dry nature of sites but at low amounts.

- *Mesic grasslands*: The desired condition is to have a variety of mesic forbs, dense cover, and high species richness characterized by long lived, moderately deep rooted cool and warm season grass species (e.g., rough fescue, Idaho fescue, blue gramma, tufted hairgrass, etc.). Shrubs may be present with minor cover and introduced species are rare. Bare ground should typically be low (less than 3%) across most sites with litter being a common component and available for soil building and moisture retention. Plant litter movement is expected to be limited with plant litter being properly distributed and rarely moving off-site.

- *Mesic shrublands:* The desired condition is that shrub species such as mountain big sagebrush and mesic deciduous shrubs (e.g., snowberry, ninebark, serviceberry) are dominant overstory species with graminoid species (e.g., Idaho fescue, mountain brome) and mesic forbs (e.g., cinquefoil, prairie smoke) dominating the understory. Canopy cover may vary, but should typically be moderate to high, and may result in lower cover of understory species.

- *Xeric shrublands:* The desired condition is to support shrub species such as Wyoming big sagebrush, basin big sagebrush, low sagebrush and black sagebrush. Overstory species vary by location and site type. The understory should typically be dominated by graminoid species such as needle-and-thread, Sandberg bluegrass and bluebunch wheatgrass. Canopy cover varies depending on the site and growing conditions, but should typically low to moderate. Bare ground is present in higher amounts relative to mesic shrubland sites.

- *Riparian/wetland:* Riparian vegetation should be comprised of a mosaic of plant communities dominated by species that tolerate periodic flooding and a seasonally high water table. Trees may be present along with riparian shrubs and herbaceous species. In wide valley bottoms, the vegetation typically should be a mosaic of all lifeforms with patterns reflecting the meander patterns of the stream/river. Dominant shrubs may include mountain alder, various species of willows, river birch, dogwood, hawthorn, chokecherry, rose, silver buffaloberry, Rocky Mountain maple and/or snowberry. A wide variety of herbaceous species including, grasses, sedges, rushes, spikerushes, bulrushes, and forbs should be present in the understory. In wetlands, the vegetation complex should be represented by a mosaic of herbaceous and woody plant communities that provide excellent erosion control. Herbaceous species may be dominated by cattails, sedges, rushes, spikerushes or bulrushes. Bryophytes, including sphagnum, are well represented in fens.

- *Alpine and rocky habitats:* Vegetation cover should typically be low to moderate. The plant communities are dominated by a number of shrubs, forbs and graminoids including: arctic willow (turf community), mountain avens, (cushion plant community), mountain heather and moss-heather (snow bed communities). In rocky habitats, vegetation may be sparse or lacking.

- *Xeric ecotones and savannas:* It is desirable to promote the open character of forest savannas (0-5% canopy cover of widely spaced, generally large diameter fire-tolerant conifers) and a dominance of grass and shrub communities in xeric ecotones, particularly given expected warm and dry climate conditions. These areas are present on both nonforested and warm dry PVTs.

Geographic area cover type desired conditions

The following figures display the cover type desired conditions for each GA, which are enumerated for each GA in chapter 3 of the 2020 Forest Plan. Using the logic presented in the forestwide desired condition section, the upper end of the desired condition for the nonforested cover type is higher than the modeled NRV, on some GAs where warm dry PVTs are abundant. In these cases, the desired condition for ponderosa pine is adjusted down accordingly.

The confidence interval for existing conditions at the GA scale can be wide for the small GAs that have few plots. The upper and lower bounds of the estimate should be considered when comparing to the desired condition range. For example, the Highwoods has a mean nonforested cover type abundance that is above the desired range; however, the bounds of the confidence interval are quite wide and encompass the range. Therefore, it cannot be concluded with certainty that the Highwoods is above the desired range.

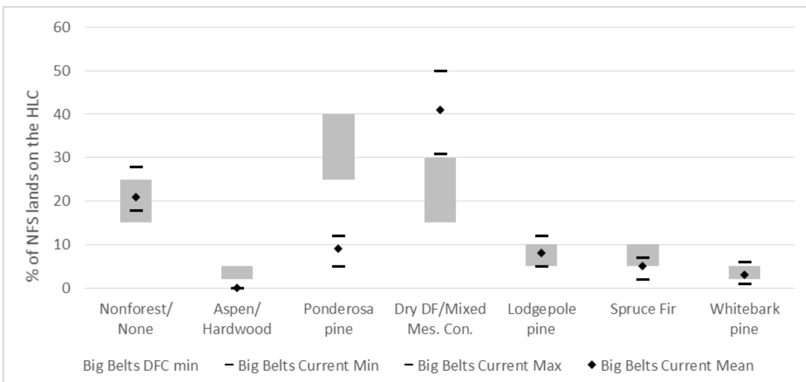


Figure 7. Big Belts GA cover type existing and desired conditions

Maintenance of nonforested cover types (including grasslands, shrublands, and savannas) is important in the Big Belts GA. Although not found on plots, aspen is known to occur. While the existing condition is similar, the desired condition indicates a higher level of the ponderosa pine cover type than the forestwide range. Historic records (Janssen, 1949) indicate a loss of low elevation ponderosa pine. Ponderosa pine restoration is particularly important in this GA. As a result, the need to reduce the Douglas-fir cover type relative to the 2018 condition is pronounced. There is less of the lodgepole pine cover type than the forestwide average, and the desired trend is to maintain 2018 levels. There is relatively little of the spruce/fir cover type present, and the 2018 condition is at the low end of the desired range. The proportion of the whitebark pine cover type existing and desired is similar to forestwide ranges.

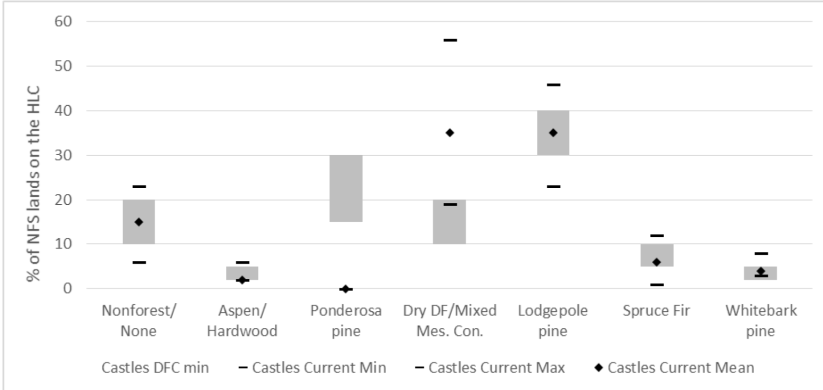


Figure 8. Castles GA cover type existing and desired conditions

In the Castles GA, limber pine savannas may be a focus within nonforested cover types. This GA contains opportunities for aspen restoration. For the ponderosa pine cover type, the lower bound of the desired condition is lower than the NRV to be more achievable. Ponderosa pine and limber pine do occur in the GA; promoting these species to become dominant is emphasized. The 2018 proportions for Douglas-fir dominated cover types indicate a desired decrease (to favor ponderosa pine). There is more of the lodgepole pine cover type present than forestwide, and maintenance relative to the 2018 condition is desired. There is relatively little of the spruce/fir cover type present in this GA, and the 2018 condition is at the low end of the desired condition. The proportion of the whitebark pine cover type existing and in the NRV is similar to forestwide ranges.

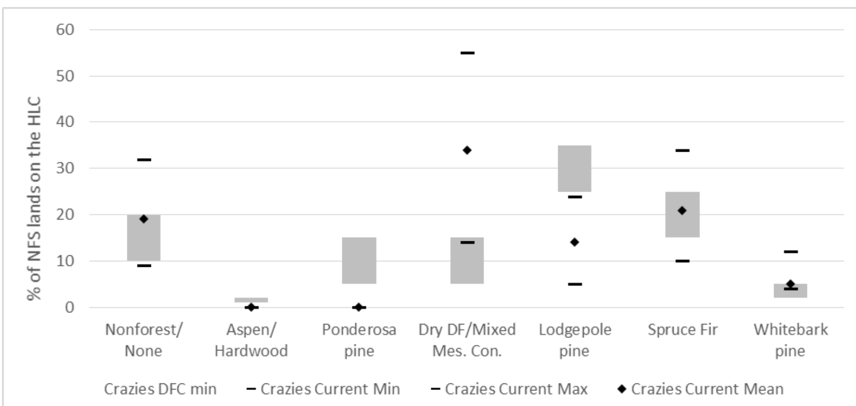


Figure 9. Crazies GA cover type existing and desired conditions

The Crazies GA has a relatively high proportion of nonforested cover types, including alpine areas. There is none of the aspen/hardwood cover type, although aspen is present and encouraging its dominance in some areas is desirable. There is also none of the ponderosa pine cover type found on plots, but there are limber pine and ponderosa pine individuals that could become more dominant. The need to decrease the Douglas-fir types is important (to favor ponderosa pine or lodgepole pine depending on the site). There is a smaller proportion of the lodgepole pine cover type present than forestwide, and desired condition indicates that increasing it is appropriate. The existing proportion and NRV range of the spruce/fir cover type is higher in this GA than the forestwide average. The proportion of the whitebark pine cover type existing and in the NRV is similar to forestwide ranges.

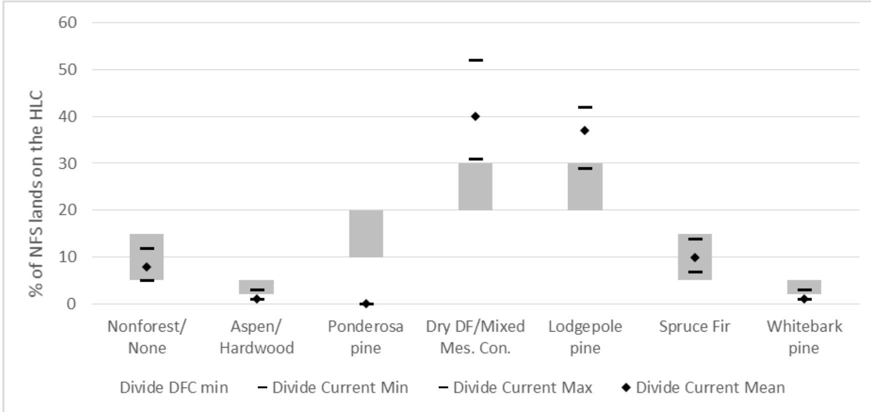


Figure 10. Divide GA cover type existing and desired conditions

In the Divide GA, open savannas may be a focus in the eastern portions. The desired trend of the aspen/hardwood cover type is similar to forestwide. Although the ponderosa pine cover type is not present, ponderosa and limber pine do occur. Promoting this type east of the continental divide is important. Decreasing the Douglas-fir types in this GA is important (primarily to promote the ponderosa pine cover type). Slightly decreasing the lodgepole pine type relative to the 2018 condition may be appropriate, to favor spruce/fir, Douglas-fir, ponderosa pine, or whitebark pine. Overall maintenance of spruce/fir relative to the 2018 condition is desired, although some reductions within the desired range may be warranted if needed to increase whitebark pine.

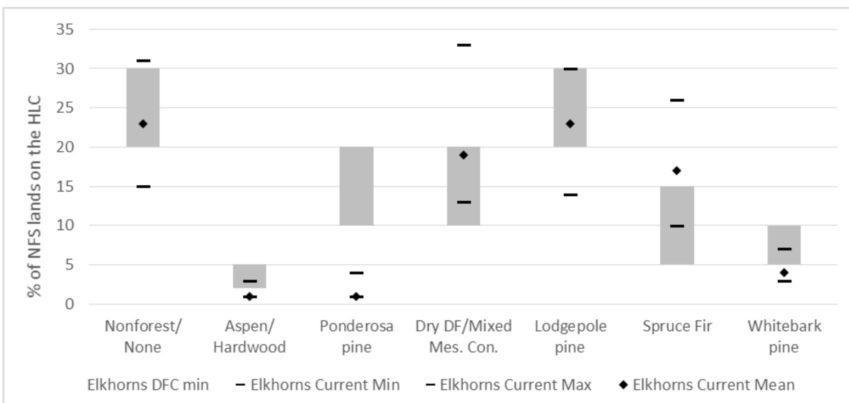


Figure 11. Elkhorns GA cover type existing and desired conditions

In the Elkhorns GA, nonforested and savannas are a focus in the low elevations; note the wide range of variability around the existing condition estimate. The existing and desired proportion of the aspen/hardwood cover type is similar to forestwide. The existing proportion of the ponderosa pine cover type is lower than forestwide, although ponderosa and limber pine occur. Restoration of this cover type is important in this GA, especially in the northwestern portion. The indicated decrease in Douglas-fir types is important but less pronounced in this GA than forestwide; note the wide range of uncertainty in the existing condition estimate. The lodgepole pine cover type desired trends are similar to the forestwide levels. In this GA, the need to decrease this type may be important to promote whitebark pine.

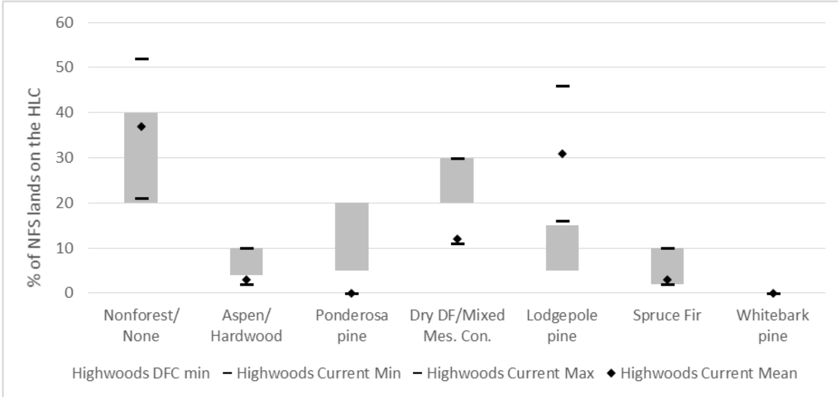


Figure 12. Highwoods GA cover type existing and desired conditions

In the Highwoods GA, the abundance of nonforested cover types is due to disturbance and extent of nonforested PVTs. The desired condition adjustments for this GA account for this and reflect the importance to elk and mountain goat populations. There is more aspen present and reflected in the desired range than forestwide. There is none of the ponderosa pine cover type present but limber and ponderosa do occur. The desired condition for that type is lower than the NRV range to account for the increases in the nonforested type. Unlike most other GAs, there may be a need to increase the Douglas-fir type, which may occur with decreasing lodgepole pine on dry sites where Douglas-fir is more fire resistant and drought tolerant. The existing and desired proportions of the spruce/fir type are lower than the forestwide averages. No whitebark pine is present or expected in this GA.

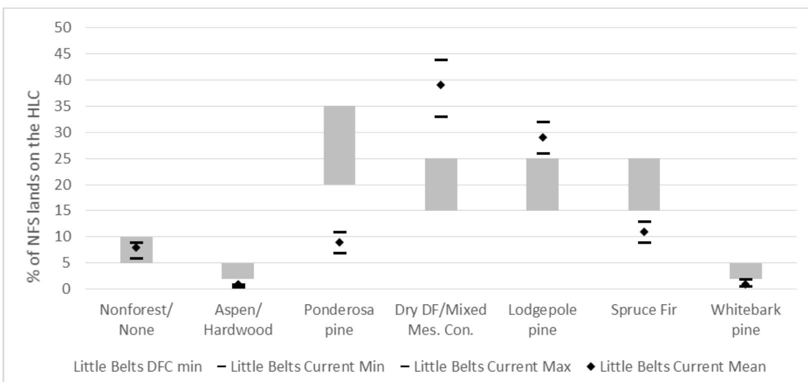


Figure 13. Little Belts GA cover type existing and desired conditions

In the Little Belts GA, open savannas a focus in some parts of the GA but there is relatively little of the nonforested over type present or expected. Similar to forestwide, it is desirable to promote aspen and ponderosa pine cover types, and to decrease Douglas-fir and lodgepole pine. Similar to forestwide, it is desirable to increase spruce-fir and whitebark pine cover types.

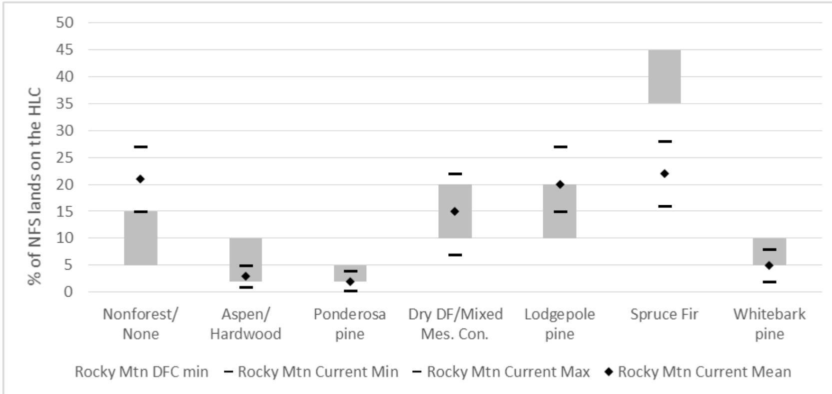


Figure 14. Rocky Mountain Range cover type existing and desired conditions

In the Rocky Mountain Range GA, the need to decrease nonforested cover types is related to recent fire areas that have not yet reforested. Maintenance of the aspen/hardwood type is particularly important in this GA, which contains more of these species than many other landscapes. There is little of the ponderosa pine cover type, and these areas are generally dominated by limber pine rather than ponderosa pine. There is relatively little of the Douglas-fir cover types, and the amounts are within the desired range. There is a smaller proportion of the lodgepole pine cover type than forestwide. The desired condition indicates that maintaining or slightly decreasing it is appropriate. The existing proportion of the spruce/fir cover type is relatively high in this GA, and increasing this type is appropriate (likely in burned areas). The proportion of whitebark pine is higher in this GA than forestwide.

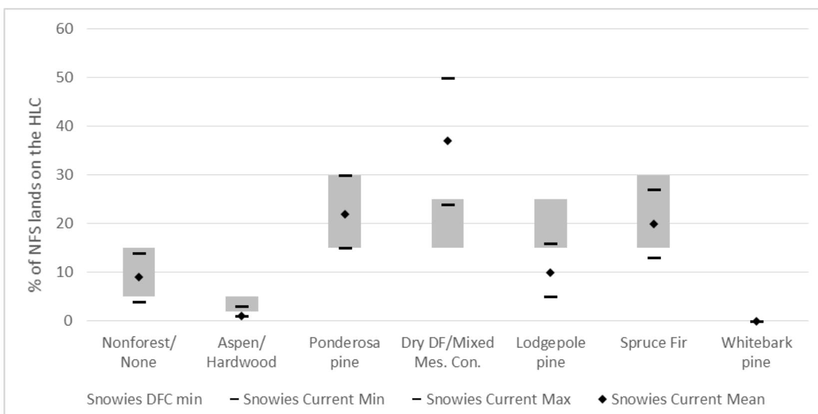


Figure 15. Snowies GA cover type existing and desired conditions

In the Snowies, GA, the narrow NRV range for the nonforested cover type is expanded for the desired condition to account for future variability. However, this is a primarily forested GA. The existing and desired levels for the aspen/hardwood cover type are consistent with the forestwide averages. There are relatively high levels of the ponderosa pine cover type, found in the Little Snowies. The existing and desired proportions of the Douglas-fir types are similar to the forestwide ranges. There relatively little of the lodgepole pine type, indicating that it is appropriate to increase this type in this GA. The spruce/fir type is relatively abundant (primarily in the Big Snowies), and maintenance of this level is appropriate in this GA. Whitebark pine is not present or expected.

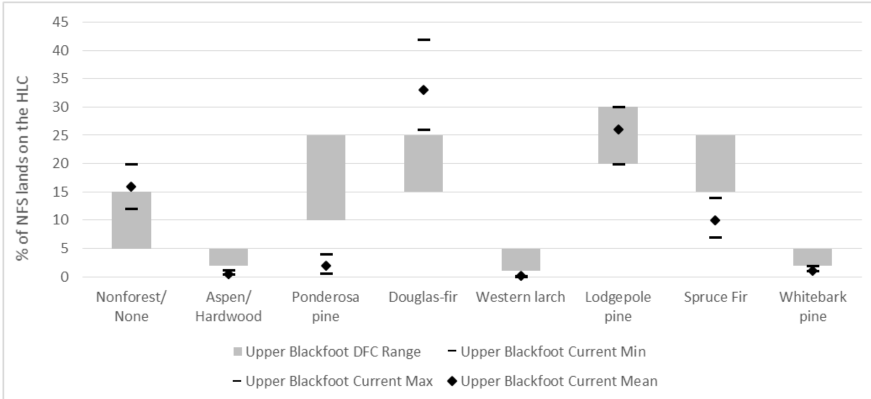


Figure 16. Upper Blackfoot GA cover type existing and desired conditions

In the Upper Blackfoot GA, the need to decrease nonforested cover types is related to recent fire areas that have not yet reforested. The desired trend for the aspen/hardwood type is consistent with forestwide ranges. There is little of the ponderosa pine cover type present on NFS lands, although ponderosa pine and limber pine do occur. The desired trend of the Douglas-fir types is similar to forestwide ranges. The western larch type occurs in small amounts in this GA, and opportunities to promote it are desired. The lodgepole pine is present to a similar degree as forestwide, and the desired condition indicates a need to generally maintain this level. The desired condition indicates slight increases in spruce/fir may be appropriate, which may coincide with the regeneration of burned forest.

Tree species presence

Data and modeling considerations

Existing condition data (FIA) can track the presence of at least 1 tree of a species on the plot. In SIMPPLLE, species presence is determined by inclusion in the species label (PP-DF would indicate both ponderosa pine and Douglas-fir are present). Species presence in the NRV may not capture the minor or rare presence of all species in highly diverse areas, since the labels only include the top 1 to 4 species in a pixel. Both data sources will add up to more than 100% of the area summarized because multiple species are often present on a given acre/plot/pixel.

Correlation to warm/dry climate periods and other considerations

Douglas-fir presence generally declines during warm/dry periods. This differs from the trend seen for the Douglas-fir cover type – while Douglas-fir may still dominate these areas, components of other species such as ponderosa pine become more prevalent. Subalpine fir declines during warm/dry periods. Rocky mountain juniper also declines in warm dry periods; even though it is drought-hardy, it likely decreases due to increased fire that favors grass/shrublands. Whitebark pine presence also decreases during warm/dry periods, although the whitebark cover type increases – this could be due to the fact that whitebark individuals spreading into the cool moist types decrease during times of drought and are more limited to cold sites where they can dominate. Lodgepole pine generally increases during warm/dry periods, while Engelmann spruce decreases and likely becomes more confined to moist areas. Limber pine tends to increase with warm/dry. Ponderosa pine tends to decrease, potentially due to losses from fire. Aspen tends to increase with warm/dry conditions, likely due to increased fire.

Additional considerations for tree species presence include:

- **Limber pine:** When dominant, limber pine contributes to the ponderosa pine cover type. It may be a component in other types and at a wide range of elevations. These trees can be present in savannas, as well alongside whitebark pine. It is subject to the same stressors and risks as whitebark pine.

BASI suggests that limber pine expanded with fire exclusion and is now less viable with drought (Halofsky et al., 2018b), which contrasts the NRV modeling; it might be most viable at the lower end of range especially in nonforested PVTs.

- **Rocky Mountain juniper:** Climate and fire may limit this species to ecotones. The NRV did not reflect measurable amounts of this species on the cool moist and cold PVTs although it does occur. When dominant this species can contribute to extent of the ponderosa pine cover type. This species can encroach into nonforested cover types on the warm dry PVT and nonforested PVTs.
- **Ponderosa pine:** The desired condition and NRV reflect the importance of drought-tolerant ponderosa pine. BASI suggests that ponderosa pine will be promoted by drought (Halofsky et al., 2018b), and should be managed at the higher end of range in warm dry PVTs.
- **Douglas-fir:** Douglas-fir may be stressed with future climate, but in some areas would be the most drought-tolerant and fire-resilient tree species available. Decreases in cool moist reflect the role of climate and disturbances which favor lodgepole pine. Douglas-fir may be at lower end of range in warm dry types (in favor of ponderosa pine); lower densities would improve resilience.
- **Aspen & Cottonwood:** Aspen should be featured in riparian types. It should respond well to increased disturbance but may be limited by moisture availability. Cottonwood may be less common than it was historically, but conversely may struggle with future climate (Halofsky et al., 2018b). Cottonwood occurs more extensively outside of NFS lands in the plan area.
- **Western larch:** Western larch is vulnerable to warming and may migrate to higher elevations.
- **Engelmann spruce:** Engelmann spruce will struggle with drought, and is likely to be confined to moist sites and riparian areas especially in the warm dry PVT. Where dominant this species contributes to the Spruce/Fir cover type. It can reduce resiliency by creating canopy layers, but also provides important habitat particularly in the cool moist PVT.
- **Lodgepole pine:** Lodgepole pine is expected to decrease in warm dry sites but expand into cool, wet sites, resulting in little overall net change. In the cold PVT, lodgepole can be a competitor of whitebark pine.
- **Subalpine fir:** Subalpine fir declines in the NRV during warm/dry periods, and is expected to be less tolerant to drought than its competitors, such as whitebark pine in the cold PVT. Where dominant this species contributes to the Spruce Fir cover type. It is not drought tolerant, so could decrease to favor Douglas-fir and lodgepole pine in cool moist although it could expand in cold.
- **Whitebark pine:** Whitebark pine is expected to become more confined to the cold PVT. While the effects of climate may vary, the ability of whitebark to compete and regenerate is dependent on fire disturbances. Whitebark pine needs restoration because of the exotic disease blister rust, and effects of climate will vary; maintain/increase in cold.
- More fire and drier climate may result in more ecotones that contained species such as limber pine, juniper, ponderosa pine, and Douglas-fir shifting to nonforested conditions.

NRV compared to existing condition

The following tables display the existing condition versus NRV for tree species presence.

Table 34. Tree species presence – NRV versus existing condition – forestwide

	PSME	ABLA	JUSC	PIAL	PICO	PIEN	PIFL2	PIPO	POTR
NRV	39-42	23-27	7-8	8-9	21-24	17-19	11-12	25-27	2-3
Existing	46 (43-50)	27 (24-27)	5 (4-7)	11 (9-14)	38 (35-42)	23 (20-26)	11 (9-13)	7 (5-9)	2 (1-3)

PSME = Douglas-fir; ABLA = subalpine fir; JUSC = juniper; PIAL = whitebark pine; LAOC = western larch; PICO = lodgepole pine; PIEN = Engelmann spruce; PIFL2 = limber pine; PIPO = ponderosa pine; POPUL = cottonwood; POTR = aspen.

Table 35. Tree species presence – NRV versus existing condition – by PVT

PVT		PSME	ABLA	JUSC	PIAL	PICO	PIEN	PIFL2	PIPO	POTR
Warm Dry	NRV	73-77	N/A	17-19	N/A	7-10	1-2	19-20	64-70	2-4
	Existing	70 (65-75)	0.4 (0.4-1)	12 (9-15)	2 (0.6-3)	24 (19-29)	5 (3-7)	16 (12-20)	17 (13-21)	2 (1-4)
Cool Moist	NRV	27-33	47-57	N/A	3-4	29-34	32-36	9-11	0	2-3
	Existing	43 (37-49)	42 (36-49)	0.7 (0.7-2)	10 (6-14)	52 (45-58)	42 (36-49)	9 (6-13)	0.4 (0.4-1)	3 (1-5)
Cold	NRV	10-13	43-49	0	39-41	48-54	35-39	4-5	0	0
	Existing	15 (9-20)	54 (47-61)	0.2 (0.2-1)	31 (24-38)	51 (44-59)	32 (25-39)	5 (2-9)	0	0

See footnote for Table 34.

Table 36. Tree species presence – NRV versus existing condition – by GA

GA		PSME	ABLA	JUSC	PIAL	PICO	PIEN	PIFL2	PIPO	POTR
Big Belts	NRV	59-63	8-11	7-10	4-5	13-17	7-9	6-7	48-52	3-5
	Existing	49 (42-54)	15 (10-19)	12 (21-17)	6 (3-9)	16 (12-21)	4 (1-6)	3 (1-6)	10 (6 -13)	1 (0.3-3)
Castles	NRV	24-27	5-10	3-5	5-6	37-42	3-5	40-42	23-26	0-0.1
	Existing	48 (38-62)	15 (7-24)	2 (1.9-6)	19 (10-28)	44 (32-56)	2 (1.9-6)	15 (6-23)	6 (6-12)	2 (2-6)
Crazies	NRV	13-16	18-27	1.4-4	17-20	28-39	15.1-21.2	23.9-27.3	4.6-5.9	0.0.2
	Existing	45 (30-58)	45 (33-60)	0	21 (11-35)	33 (20 -46)	12 (2-21)	12 (4-23)	0	0
Divide	NRV	48-52	10-13	9-12	4-5	29-33	7-10	5-6	30-35	3-6
	Existing	53 (46-59)	23 (18-29)	3 (0.6-5)	8 (4-11)	59 (53-65)	13 (10-19)	2 (1-3)	3 (0.6-5)	6 (3-9)
Elkhorns	NRV	34-38	6-11	7-12	9-10	29-34	5-8	6-7	23-27	1-2
	Existing	28 (20-38)	29 (19-37)	5 (1-9)	14 (6-20)	32 (22-41)	20 (11-27)	1 (1-4)	1 (1-4)	2 (2-5)
Highwoods	NRV	53-57	3-5	5-9	0	9-12	3-6	16-18	31-40	6-9
	Existing	34 (19-50)	3 (3-10)	0	0	46 (30 -62)	0	3 (3-10)	0	3 (3-10)
Little Belts	NRV	39-42	21-25	8-9	6-7	21-24	16-18	19-21	31-34	0.5-1
	Existing	59 (56-62)	23 (21-26)	4 (3-5)	10 (8-12)	43 (40-46)	27 (24-30)	24 (21-26)	8 (6-10)	1 (0.3-2)
Rocky Mtn	NRV	27-33	40-47	3-4	14-15	15-19	29-32	5-6	8-10	2-4
	Existing	29	36	3	14	32	33	5	0	5

		(23-35)	(29-43)	(0.4-5)	(9-20)	(26-40)	(27-40)	(2-8)		(2-8)
Snowies	NRV	41-44	20-28	3-5	9-10	25-33	16-20	5-6	23-25	6-9
	Existing	62 (54-70)	19 (13-27)	2 (2-4)	1 (1-2)	18 (12-25)	48 (39-56)	26 (19-34)	26 (19-34)	2 (2-5)
Upper Blackfoot	NRV	42-47	21-27	7-10	7-8	27-32	15-18	8-10	25-29	0.5-1
	Existing	45 (40-51)	34 (28-39)	2 (0.6-4)	7 (3-9)	46 (40-51)	15 (11-19)	9 (7-13)	1 (1-3)	1 (0.2-3)
	The Upper Blackfoot also contains WL on 1% (1.1-2.1), with a NRV of 0.1%.									

See footnote for Table 34.

Forestwide tree species distribution desired conditions

The following figures display the desired condition for tree species distribution forestwide and by broad PVT, which are enumerated in FW-VEGF-DC-01 in the 2020 Forest Plan. The following specific adjustments and rationale also apply:

- The desired condition of Rocky Mountain juniper is adjusted to be lower than the NRV, due to BASI that indicates it is more prevalent than it was historically, particularly on lands that were maintained in a nonforested condition due to frequent fire; and future climate/fire regimes may promote nonforested communities (Kitchen, 2010).
- The upper bound of the desired range for aspen is higher than NRV because BASI indicates aspen and cottonwood have decreased from historic (Bartos, 2001; Halofsky et al., 2018b, in press). Cottonwood may struggle with expected drought. Aspen is the more common of these two species on the HLC NF; but in both cases existing data does not represent them well due to their scattered, isolated distribution. They are combined for ease in quantifying.
- The desired upper bound for whitebark pine is above the NRV to account for the importance of this species as a candidate under the Endangered Species Act, and BASI that indicates it has decreased from its historic condition (Halofsky et al., 2018b, in press; Keane et al., 2012; U.S. Department of the Interior, 2010; Wong & Daniels, 2016).
- The desired condition for ponderosa pine on the cool moist PVT is slightly higher than NRV to allow for the possibility that it may compete at higher elevations in the future (Halofsky et al., 2018b).

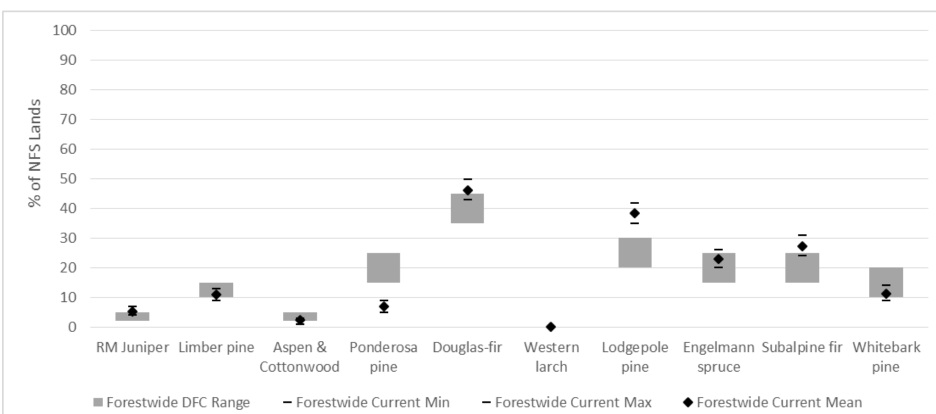


Figure 17. Forestwide tree species presence existing and desired conditions

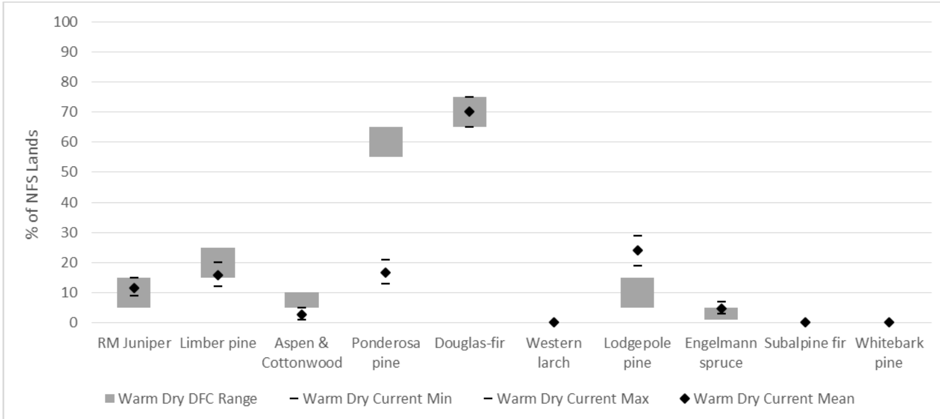


Figure 18. Warm dry PVT tree species presence existing and desired conditions

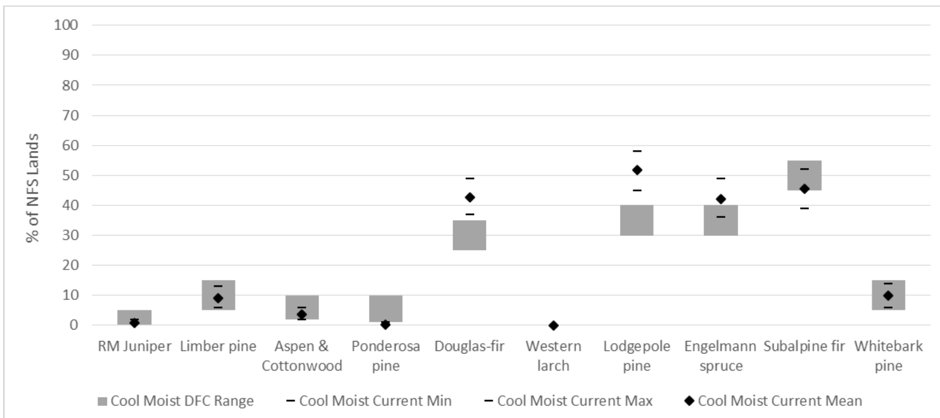


Figure 19. Cool moist PVT tree species presence existing and desired conditions

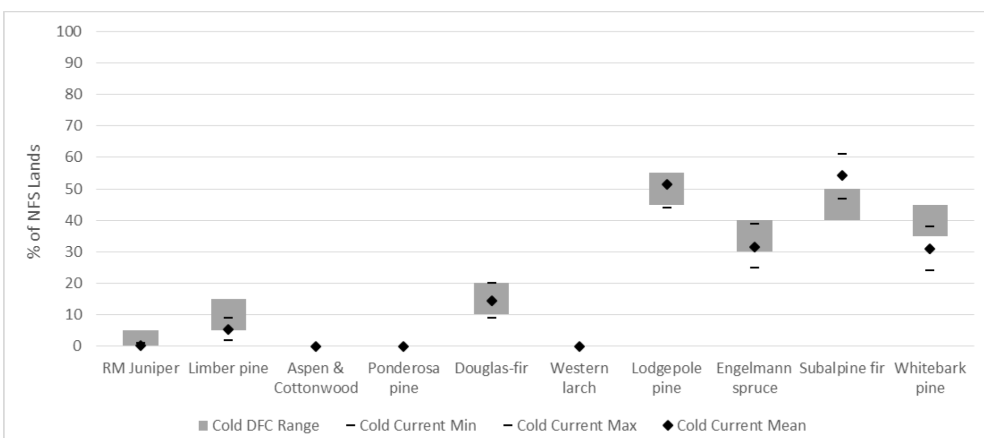


Figure 20. Cold PVT tree species presence existing and desired conditions

Geographic area tree species distribution desired conditions

Species presence desired conditions are also developed for each GA, as shown in chapter 3 of the 2020 Forest Plan. Additional species may occur in minor amounts. Refer to the discussion under forestwide desired conditions for rationale regarding the variance of desired ranges from NRV. The same assumptions used to develop the desired conditions forestwide for all species apply to the GA components. Other applicable GA-level considerations, if any, are described below.

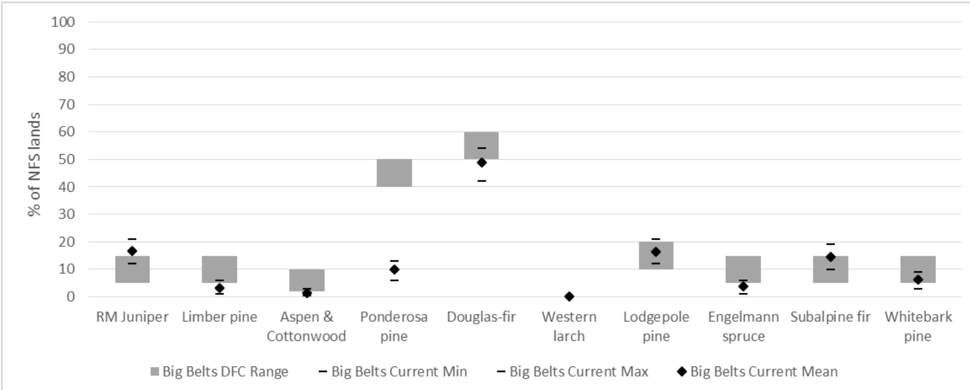


Figure 21. Big Belts tree species presence existing and desired conditions

In the Big Belts GA, limber pine should be promoted, while the extent of Rocky Mountain juniper should be reduced, especially in warm dry PVTs areas to enhance the resilience of dry forests, savannas, and grass/shrublands. Ponderosa pine should also be promoted, considering that open savanna structures may be appropriate. Douglas-fir should be maintained or promoted where it does not compete with ponderosa or limber. Aspen should be promoted when opportunities arise. Engelmann spruce is relatively uncommon in this GA and confined to moist sites. The extent of lodgepole pine is currently within the desired range. Subalpine fir should be reduced particularly where competing with whitebark pine.

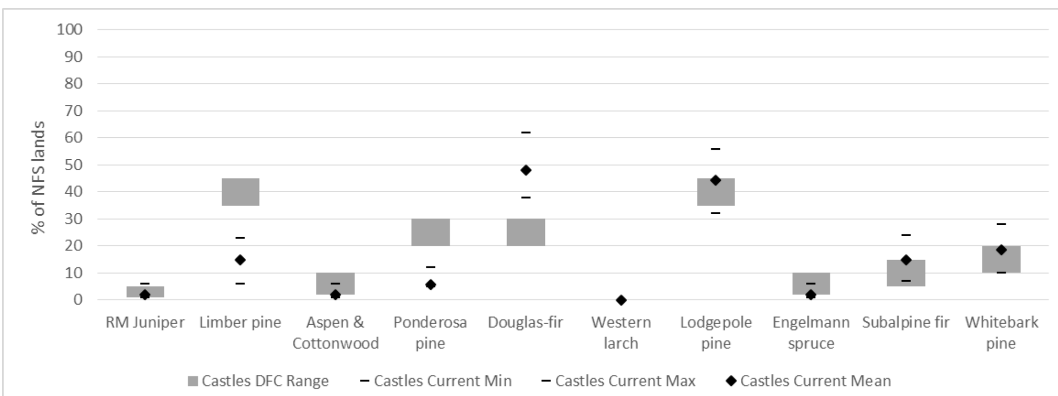


Figure 22. Castles tree species presence existing and desired conditions

Limber pine and ponderosa pine should be promoted on the warm dry PVT. Rocky Mountain juniper should be maintained at densities and locations that do not detract from the resilience of dry forests, savannas, and grass/shrublands. The extent of Douglas-fir should be decreased. Promote aspen when opportunities arise and maintain or promote Engelmann spruce. Lodgepole pine is at the upper end of the desired range. Generally maintain or decrease subalpine fir, with the goal of maintaining whitebark pine.

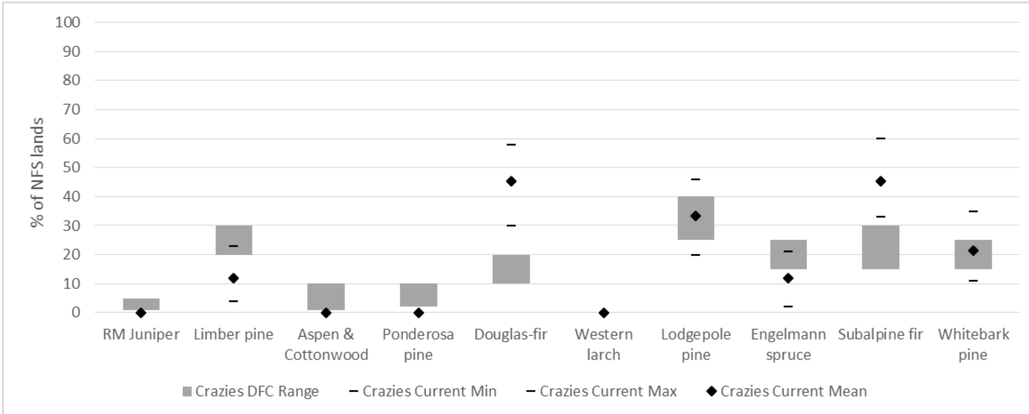


Figure 23. Crazies tree species presence existing and desired conditions

In the Crazies GA, the desired conditions indicate a need to increase extent of limber pine. Maintain Rocky Mountain juniper where opportunities arise; this species is rare. Increase extent of ponderosa pine on suitable sites; this species is also rare in this GA. Decrease Douglas-fir, especially where competing with limber or ponderosa. Promote aspen as opportunities arise. Increase the extent of Engelmann spruce on suitable (moist) sites. Generally maintain the extent of lodgepole pine. Decrease extent of subalpine fir, to favor lodgepole or whitebark pine. Maintain and promote whitebark pine.

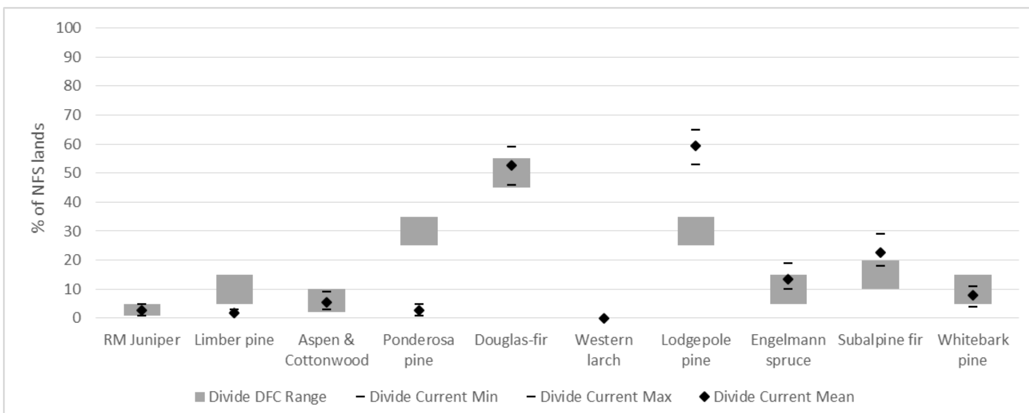


Figure 24. Divide tree species presence existing and desired conditions

In the Divide GA, slightly increase limber pine within the extent of its range (east of the Continental Divide). Maintain juniper where it does not detract from nonforested communities. Focus on increasing ponderosa pine on the warm dry PVT, east of the divide. Maintain or slightly decrease Douglas-fir to favor ponderosa pine. Maintain and promote aspen, which is particularly prevalent. Slightly decrease Engelmann spruce. Decrease lodgepole pine where it competes with ponderosa pine, aspen, or whitebark pine. This species is particularly prevalent in this GA. Decrease extent of subalpine fir, especially where it competes with whitebark. Maintain or increase whitebark pine, focusing in cold PVTs.

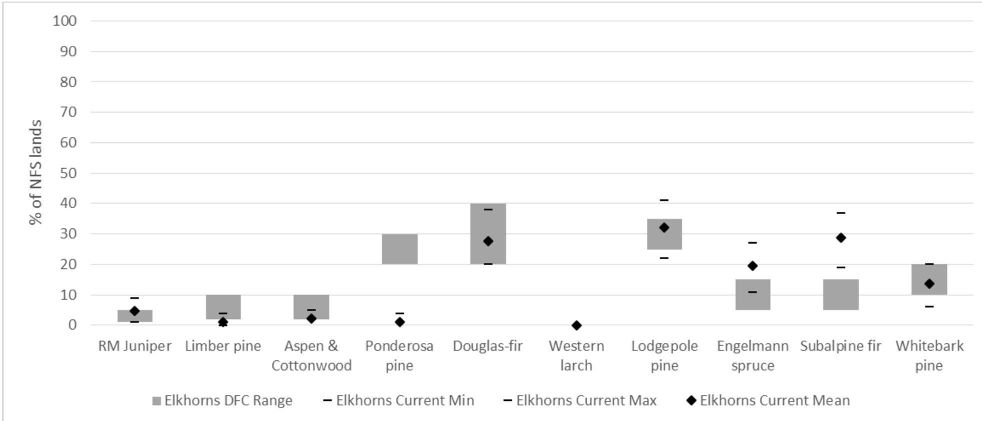


Figure 25. Elkhorns tree species presence existing and desired conditions

In the Elkhorns GA, the DCs indicate a need to slightly increase limber pine extent; this should be focused on sites most suited to forest vegetation or as very open savannas, rather than nonforested types. Decrease and maintain juniper in densities and locations that do not detract from resilience of dry forests and nonforested types. Increase extent of ponderosa pine on the warm dry PVT. Generally maintain extent of Douglas-fir, potentially as a minor component in areas dominated by ponderosa pine. Promote aspen as opportunities arise. Decrease Engelmann spruce, especially where it competes with whitebark pine. Generally maintain extent of lodgepole pine. Decrease subalpine fir, where it competes with whitebark or lodgepole. Maintain and promote whitebark pine as opportunities arise.

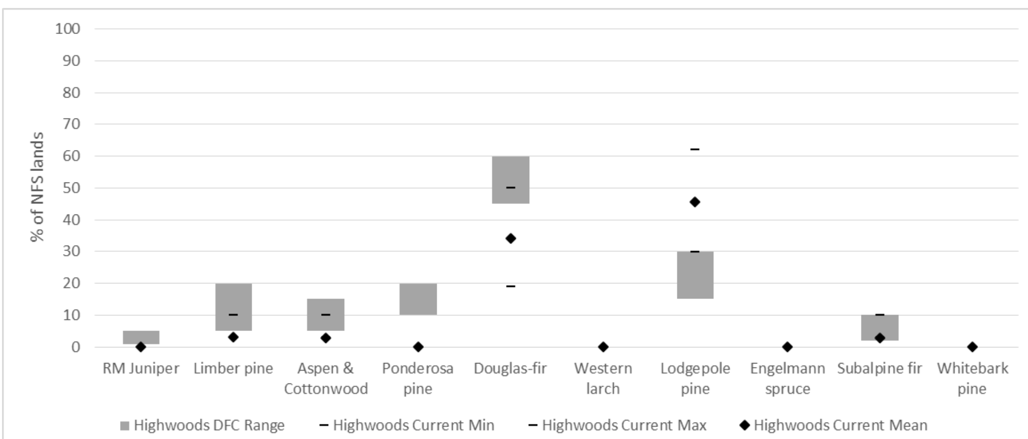


Figure 26. Highwoods tree species presence existing and desired conditions

In the Highwoods, the extent of limber pine should be increased on suitable sites. The lower bound of the desired range is adjusted down from the NRV to account for the needs of mountain goat habitat connectivity that is declining in parts of the GA due to limber encroachment (Mello, 1978; Rice & Gay, 2010). Increase extent of juniper; species is rare but known to occur in this GA. Increase ponderosa pine; species is rare but known to occur. The desired condition is below the NRV because suitable sites will be limited. There is a need to increase extent of Douglas-fir in this GA. This may be the most long-lived and fire resilient species available on some dry sites. Increase the extent of aspen. Decrease lodgepole pine but the species should remain common. The desired range is adjusted above the NRV to account for this species being more viable than ponderosa pine on many sites. Maintain extent of subalpine fir.

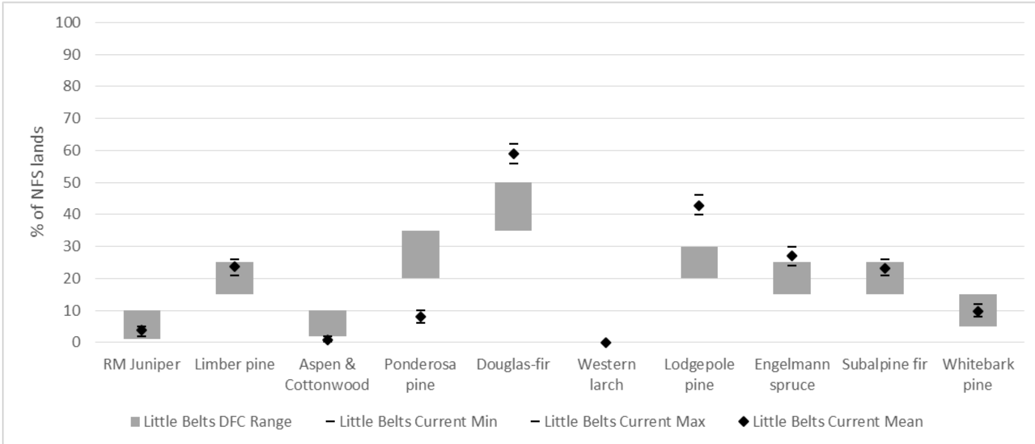


Figure 27. Little Belts tree species presence existing and desired conditions

The Little Belts are similar to the overall Forest depiction of tree species presence. Generally maintain extent or slightly decrease limber pine on dry sites. Maintain juniper at densities and locations that do not detract from extent and resilience of dry forests, savannas, and grass/shrublands. Increase extent of ponderosa pine as opportunities arise. Decrease extent of Douglas-fir primarily to favor ponderosa pine. Promote aspen where opportunities arise. Decrease Engelmann spruce, especially where it competes with whitebark pine. Decrease extent of lodgepole pine. Generally maintain or slightly decrease extent of subalpine fir. Generally maintain and promote whitebark pine where opportunities arise.

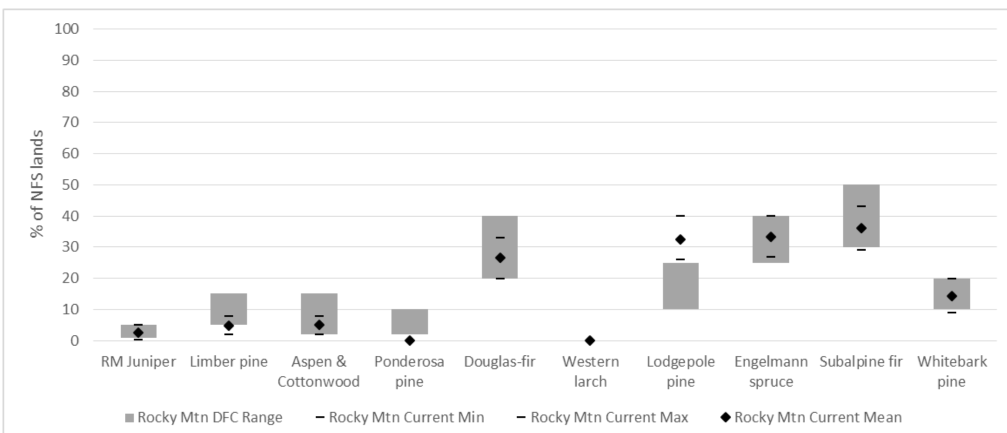


Figure 28. Rocky Mountain Range tree species presence existing and desired conditions

In the Rocky Mountain GA, promote limber pine. Maintain juniper, where it does not detract from nonforested types. Maintain and promote ponderosa pine where possible. Generally maintain extent of Douglas-fir. Promote aspen where possible. Generally maintain extent of Engelmann spruce; this GA has more of this species than most other areas. Decrease extent of lodgepole pine to favor other species diversity in burned areas. Generally maintain extent of subalpine fir. Generally maintain and promote whitebark pine where opportunities arise.

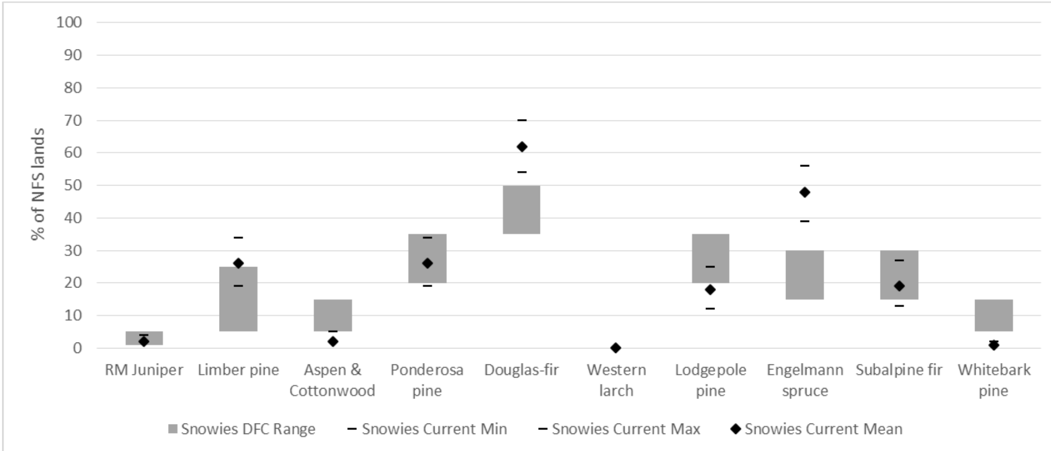


Figure 29. Snowies tree species presence existing and desired conditions

In the Snowies GA, the upper bound of the desired condition for limber pine is higher than NRV to reflect BASI that this species is less abundant than historically (Means, 2011). Maintain extent of juniper, where it does not detract from nonforested types. Maintain the extent of ponderosa pine - the Little Snowies is unique for its ponderosa pine community. Decrease Douglas-fir, especially where it reduces resilience of ponderosa. Increase the extent of aspen when opportunities arise. Decrease Engelmann spruce, especially where it competes with whitebark pine. Increase lodgepole pine, where it may be more resilient than spruce/fir. Generally maintain extent of subalpine fir. Increase extent and promote whitebark pine where opportunities arise.

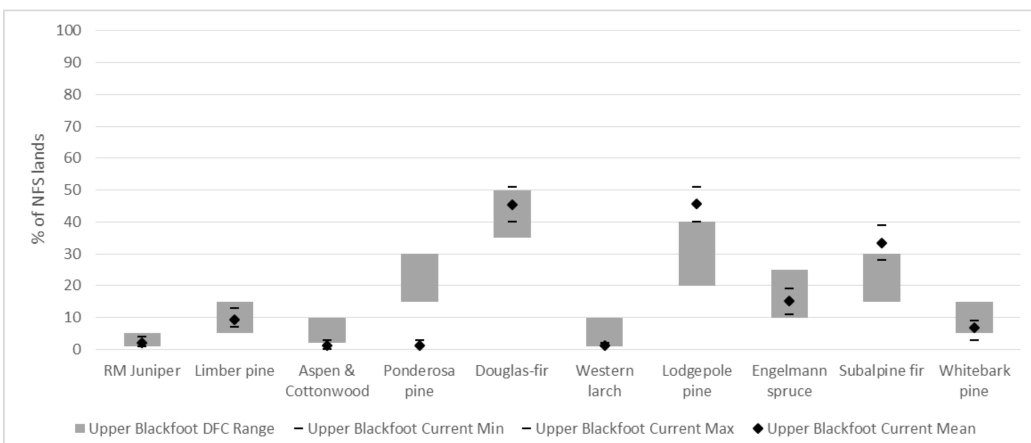


Figure 30. Upper Blackfoot tree species presence existing and desired conditions

In the Upper Blackfoot GA, the desired conditions indicate a need to maintain the extent of limber pine and juniper where they do not detract from nonforested types. Increase extent of ponderosa pine and aspen where opportunities arise. Generally maintain extent of Douglas-fir. Generally maintain extent of Engelmann spruce. Decrease extent of lodgepole pine, especially where competing with whitebark. Maintain western larch on suitable sites. The desired condition for western larch is slightly higher than NRV to reflect the existing levels which are desirable for diversity. Decrease subalpine fir, especially where it competes with whitebark pine. Maintain extent of whitebark pine. The upper bound of the desired condition for whitebark pine is adjusted up from NRV to reflect the existing amount which is desired given its candidate species status under the Endangered Species Act.

Desired conditions for structure and pattern

Discussion/summary

Forest size class is an indicator of the seral stage. Modeling indicates that large and very large size classes were at the lower end of the NRV range during warm/dry periods; this level still exceeds the existing condition. The seedling/sapling class fluctuates according to the size and frequency of stand replacing disturbance. Substantial proportions of the forest should be in the mid-successional stages of development (small to medium), where they can remain for long periods. Less dense forests or those on more productive sites may transition to large size class quickly, while higher density forests or those on harsh growing sites may take longer. Some cover types (such as lodgepole pine) may remain in the small and medium classes their entire lifespan. Many stands of all species will never achieve a very large size class, due to growing conditions and/or disturbances. A limited amount of the very large forest size class is possible based on the species and growing conditions found on the HLC NF.

Density class and vertical structure further describe landscape diversity in structure. The NRV analysis indicated that the low/medium canopy cover class was common, especially on the warm dry broad PVT. Many forests on the cool moist PVT also had low/medium density, which were likely forests in their early and mid-successional stages or older forests where disturbances opened up the canopy. In all types, the shift toward higher densities reflects the impacts of fire exclusion and the increased abundance of shade tolerant species. Low/medium density forests were at the higher end of their natural ranges during warm/dry periods, whereas medium/high and high density forests were at the lowest end. Vertical structures vary by cover type and disturbance regime; for example, lodgepole pine tends to be maintained in a 1-story condition by stand-replacing disturbance and regeneration ecology, whereas spruce/fir may be more likely to develop a multi-storied condition.

The abundance, average, and range of sizes of *early successional forest patches* (transitional and seedling/sapling size classes) is the key ecosystem characteristics to represent landscape pattern. Large fires would typically be associated with warm climatic periods and drought conditions.

The matrix below (Table 37) displays the relationship between the existing conditions and the desired conditions for structure and pattern. These comparisons are made using mean values and do not account for the error bars. Charts with error bars are available in the project file for alternatives A and F. Large-tree structure, vertical structure, early successional openings, old growth, snags, and coarse woody debris were not summarized by GA, because there are no GA desired conditions. There is less variability in structure than there is for species composition. The small tree size class is consistently above the desired condition, and the large and very large size classes (along with large-tree structure) are consistently below. The high-density class is commonly above the desired range and the lower density classes below.

In warm dry PVT, large and very large sizes forests would have been relatively open or clumpy patch mosaics, with the large trees generally being long-lived species capable of surviving moderate or low severity fire when mature. In sheltered riparian areas, groves of large Engelmann spruce could develop. The warm dry PVT is the most substantially departed from the NRV due to fire exclusion. These sites also historically supported more open forests. A variety of structure classes would be appropriate depending on the site. Single-storied forests are common, but in some cases may represent forests where low severity disturbance has not opened up the canopy to allow for understory trees to establish in a widely spaced distribution. Promoting multi-storied, yet open, forests would be desirable in some of these areas.

In cool moist PVTs, the need to increase large size classes is less pronounced because many areas are dominated by lodgepole pine, which naturally does not reach large sizes. In areas with large size classes, a fire tolerant large diameter overstory tree layer would typically exist (Douglas-fir) atop a more dense mid and understory tree layer. Large, old Engelmann spruce and subalpine fir could occur in moist settings.

The abundance of the high-density class may be indicative of dense understories of shade tolerant trees developing under lodgepole pine in the absence of fire, and/or with the release of these components due to mountain pine beetle infestation. A single storied condition is naturally abundant, reflecting the traits of lodgepole pine. Multi-storied forests are also important and are likely found in spruce/fir cover types.

In cold PVTs, the very large tree class is within the desired range, because the harsh conditions and species present on these sites make the achievement of a very large size difficult. Whitebark pine was historically the large tree component. Large subalpine fir and Engelmann spruce would develop in moist sites. In the past, fire promoted more open and uneven-aged whitebark pine forests. Single storied forests are likely dominated by lodgepole or whitebark pine, while spruce and fir would grow in a multistoried condition. Single-storied forests are at the high end of their natural abundance during warm/dry periods while two and multi-storied conditions are at the low end. A focus on increased resiliency through decreased density is important. The overabundance of high-density forests may reflect the shift from whitebark pine to spruce and fir with fire exclusion and other threats facing whitebark pine.

Forestwide and in all PVTs except cold, the current average seedling/sapling patch size is greater than the NRV mean and the 95th percentile range. In cold, the current average patch size is at the upper end of this range. In the future, reductions in patch size could occur where increased resiliency and landscape diversity results in stand-replacing disturbances that are more limited in time and space. Conversely, the impacts of climate change and increases in wildfires could result in a continuation of larger patch sizes.

Table 37. Matrix of existing condition (FIA) compared to desired condition at multiple scales – structure and pattern

	Forestwide	Warm Dry	Cool Moist	Cold	Big Belts	Castles	Crazies	Divide	Elkhorns	Highwoods	Little Belts	Rocky Mountain	Snowies	Upper Blackfoot
Seedling/Sapling size class	W	W/A	W	W	W	W	W	W	W/A	W/B	W	A	W	W
Small tree size class	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Medium tree size class	W/A	A	W	W	W/A	W	W	W	W	A	W/A	W	W/A	W
Large tree size class	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Very large tree size class	B	B	B	W/B	B	W/B	W/B	B	B	B	B	B	B	B
Large-tree structure (large)	B	B	B	B	N	N	N	N	N	N	N	N	N	N
Large-tree structure (Vlarge)	B	B	B	W/B	N	N	N	N	N	N	N	N	N	N
NF/Low/Med density class	W/B	W/B	W/B	B	W	W	B	B	B	B	B	W	B	W
Medium/High density class	W/B	W	B	B	W/B	W	W	W	W	W	B	B	B	W
High density class	A	W	A	A	W/A	W	W/A	A	A	A	A	A	A	W
Single-storied structure[1]	N	A	A	W	N	N	N	N	N	N	N	N	N	N
2-storied structure[1]	N	A	W	W/B	N	N	N	N	N	N	N	N	N	N
Multi-storied structure[1]	N	B	B	B	N	N	N	N	N	N	N	N	N	N
Early successional forests	A	A	A	W/A	N	N	N	N	N	N	N	N	N	N

W = within the DC range; A = above the DC range; B = below the DC range; N = not present or no DC for that scale.
When the existing condition is right at the boundary of the DC range, it is noted as W/A (at the upper end of the range) or W/B (at the lower end of the range).
[1]Vertical structure is shown relative to the NRV; there are no quantitative DCs for this; rather, it is addressed qualitatively as it relates to density class.
Items shaded in the dark gray tones and white font indicate conditions at the upper bound or above the desired range. Items shaded in light gray tones indicate conditions at the lower bound or below the desired range. Cells with no shading are within the desired ranges, or are not present/applicable.

Forest size class

Data and modeling considerations

The way SIMPPLLE and the R1 Classification System define size class is not the same. The R1 Classification System assigns a size class based on the average basal area-weighted diameter. With this method, plots classified in a size class may be dominated by trees that are smaller and/or larger than the assigned size class. Conversely, in SIMPPLLE, average stand diameter is assigned based on the age of the stand, using assumptions of how long each seral stage takes to progress into the next. These assumptions were crafted using professional expertise and reflect the largest, but not necessarily dominant, trees in the stand. For example, a stand with an overstory of large trees with high ingrowth of small trees may be classified as small by the R1 Classifier, but classified as a large in SIMPPLLE. The result of this is that the presence of large trees has a greater influence on the stand being classified into a large tree size class in SIMPPLLE than in the R1 Classification System, and therefore the NRV is not directly comparable to the existing condition.

To account for this, the large & very large size classes are adjusted from the NRV. The attribute of *large-tree structure* estimated on plots is more analogous to how size class is classified in SIMPPLLE (see appendix D of the 2020 Forest Plan for large-tree structure definitions). The relationship between large tree structure and size classes on FIA plots is used to create an adjustment factor for SIMPPLLE size class. Currently, most large-tree structure occurs in plots with smaller average size classes. Some proportion (but not all) of such areas may be classified as large size classes in SIMPPLLE. The table below shows the proportions of smaller size classes that could be classified as larger classes in SIMPPLLE, and the adjustment used on model results to be more comparable to the existing condition. These adjustments were applied to in the tables in this section and are labeled “NRV adjusted”.

Table 38. SIMPPLLE size class adjustments

R1 classification size class	% w/ large tree structure (FIA)	% w/ very large tree structure (FIA)	Proportion that could be mis-classified	SIMPPLLE Adjustment
Seedling/ Sapling	4%	4%	8%	Increase 5%
Small Tree	37%	16%	53%	Increase 25%
Medium Tree	42%	35%	77%	Increase 40%
Large Tree	7%	19%	26%	Decrease 40%
Very Large Tree	<1%	11%	11%	Decrease 30%

In addition, the desired conditions for size class only include forested areas; therefore, the percentages in the tables do not add up to 100%. Roughly 14% of the Forest total does not have a forest size class assigned in the existing condition. The ranges and confidence intervals around size class are large due to high variability (disturbances). Therefore, there is less uniqueness at the GA scale than with composition.

Correlation to warm/dry climate periods and other considerations

The seedling/sapling size class (<5” dbh) tends to increase and then fall during warm/dry periods, in response to increased fire and subsequent growth into small trees. The small tree size class (5-9.9” dbh) consistently increases during warm/dry periods. The medium tree class (10-14.9” dbh) is generally at the lowest end of its NRV range during warm/dry periods, and the large tree (15-19.9” dbh) and very large tree (20”+dbh) size classes decline and are at the lower end of their ranges during these times.

NRV and existing condition values

The tables below display adjusted NRV size class data versus the existing condition.

Table 39. Forest size class, NRV versus existing condition – % forestwide

	Seed/sap	Small tree	Medium tree	Large tree	Very large tree
NRV adjusted	1-15	4-18	4-20	23-28	9-24
Existing	13 (10-17)	39 (36-42)	21 (19-24)	5 (4-7)	2 (1-3)

Table 40. Forest size class – NRV versus existing condition – % by PVT

PVT		Seed/sap	Small tree	Medium tree	Large tree	Very large tree
Warm dry	NRV Adjusted	1-9	2-9	2-8	22-38	14-40
	Existing	11 (7-15)	36 (31-41)	25 (21-29)	9 (6-12)	4 (2-6)
Cool moist	NRV Adjusted	1-22	5-27	6-32	20-27	9-23
	Existing	12 (7-18)	42 (36-48)	24 (20-29)	4 (2-7)	0.2 (0.2-0.7)
Cold	NRV Adjusted	2-33	7-40	5-45	26-41	2-5
	Existing	22 (14-30)	44 (37-51)	14 (9-18)	1 (0.1-3)	0.2 (0.2-0.9)

Table 41. Forest size class - NRV versus existing condition – % of GA

GA		Seed/sap	Small	Medium	Large	Very large
Big Belts	NRV Adjusted	1-14	3-15	3-16	19-29	11-31
	Existing	7 (4-11)	31 (24-36)	18 (14-23)	8 (5-11)	2 (0.7-5)
Castles	NRV Adjusted	0.7-19	2-23	2-26	26-35	6-15
	Existing	7 (2-13)	50 (39-62)	7 (2-14)	13 (6-23)	4 (4-9)
Crazies	NRV Adjusted	0.7-22	2 -24	3-27	21-32	3-8
	Existing	5 (5-12)	43 (28-55)	10 (2-20)	12 (2-21)	5 (5-16)
Divide	NRV Adjusted	2-22	7-27	5-25	19-25	9-26
	Existing	17 (11-25)	46 (39-52)	17 (12-21)	6 (3-9)	3 (1-6)
Elkhorns	NRV Adjusted	1-21	6-26	4-26	15 -22	6-18
	Existing	21 (9-34)	29 (19-37)	9 (4-16)	7 (2-13)	0
Highwoods	NRV Adjusted	0.6-12	2-13	2-11	18-32	10-30
	Existing	0	23 (9-37)	23 (10-38)	3 (3-10)	0
Little Belts	NRV Adjusted	1-15	3-19	4-22	25-33	9-26

GA		Seed/sap	Small	Medium	Large	Very large
	Existing	10 (7-13)	46 (43-49)	26 (24-29)	5 (4-7)	2 (0.7-3)
RM Range	NRV Adjusted	1-13	4-16	3-17	22-28	8-21
	Existing	21 (16-27)	29 (24-33)	16 (13-20)	1 (0.3-3)	0
Snowies	NRV Adjusted	0.7-20	3-24	4-28	20-29	7-23
	Existing	14 (9-23)	47 (39-56)	27 (19-34)	1 (1-3)	1 (1-3)
Upper Blackfoot	NRV Adjusted	2-20	4-24	5-27	21-27	9-25
	Existing	17 (12-25)	30 (25 - 35)	18 (14-22)	7 (4-10)	0 (0.4-1)

Forestwide forest size class desired conditions

The following series of figures show the desired conditions for size class, forestwide and by PVT, as enumerated in FW-VEGF-DC-02. Desired ranges take into account the size class adjustment and warm/dry climate. Nonforested areas are not included; therefore, proportions do not add up to 100%. The array of size classes should occur on forested PVTs, and not as encroachment into nonforested areas. Overall, in most areas a shift toward large size classes is warranted. This may be achieved through succession as small and medium trees grow larger; as well as through disturbances or management that reduce density and increase growth rates and/or remove smaller trees. Shifts from the larger size classes into the seedling/sapling class may result from stand-replacing disturbance or vegetation management.

Forestwide, the desired conditions call for an increase in the large and very large size classes, with corresponding decreases in the small class and, to a lesser degree, medium. In the warm dry PVT, seedling/sapling and small classes should be present but limited relative to the other PVTs, because larger tree remnants would be left by natural disturbance regimes or management that imitates them. Still, small trees would remain abundant. In the cool moist PVT, smaller size classes should be prevalent due to abundance of lodgepole pine. There is wide variability because of the high severity, low frequency disturbance regime. Size class distribution is important to ensure disturbances occur at a natural scope and scale. In the cold PVT, the NRV is very wide. The proportions are currently heavy to the small class likely due to the preponderance of spruce and fir on these sites, and mortality of whitebark pine.

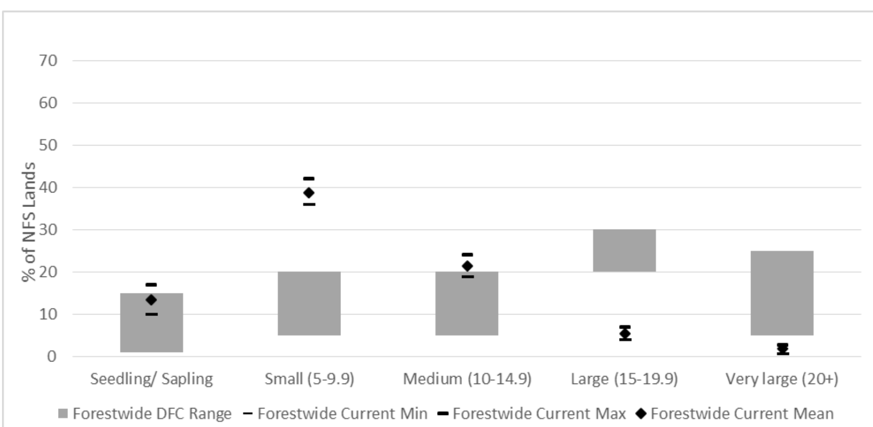


Figure 31. Forestwide forest size class existing and desired conditions

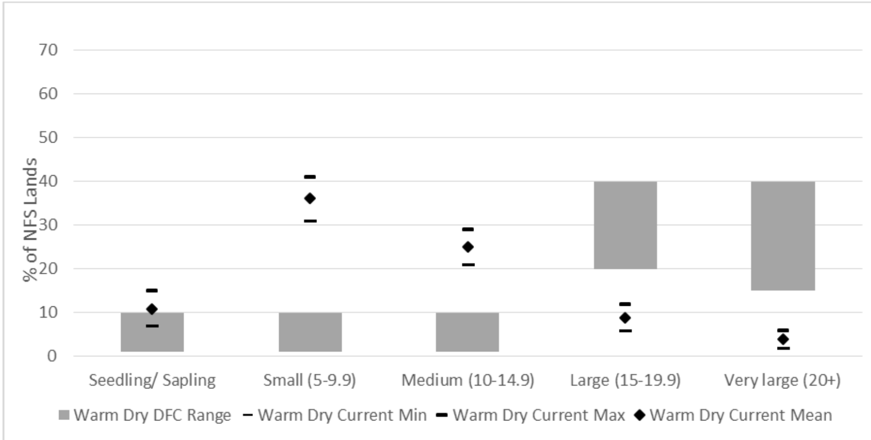


Figure 32. Warm dry PVT forest size class existing and desired conditions

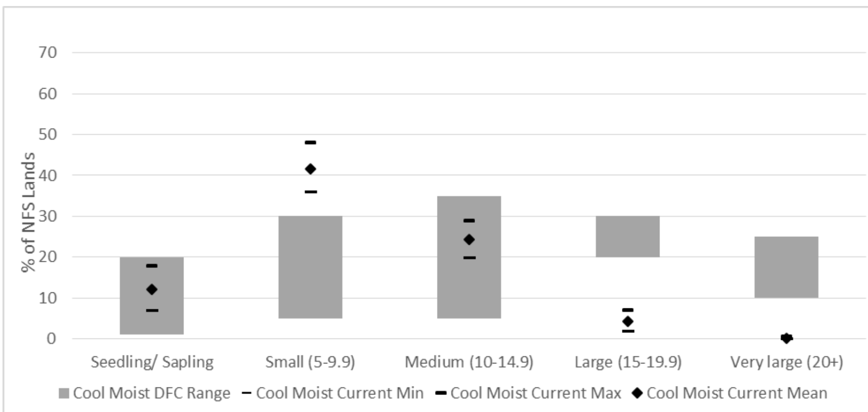


Figure 33. Cool moist PVT forest size class existing and desired conditions

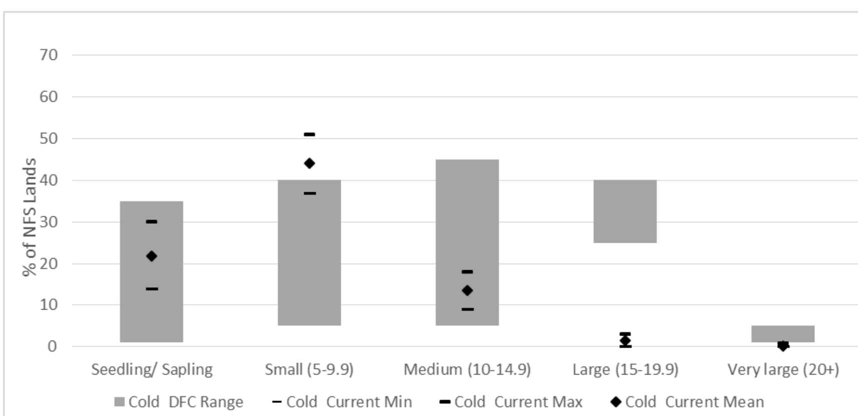


Figure 34. Cold PVT forest size class existing and desired conditions

GA quantitative size class desired conditions

There was relatively little variance across GAs with respect to the NRV for size class distribution, and they are similar to forestwide ranges. This indicates that primary differentiation in size class is responsive to PVT rather than topographical location. Nevertheless, GA-level plan components are provided in chapter 3, as shown in the following series of figures, to ensure that the array of size classes and associated habitat conditions are provided in each GA. In most GAs, it is desirable for the large size classes to increase, along with decreases in the small and/or medium size classes.

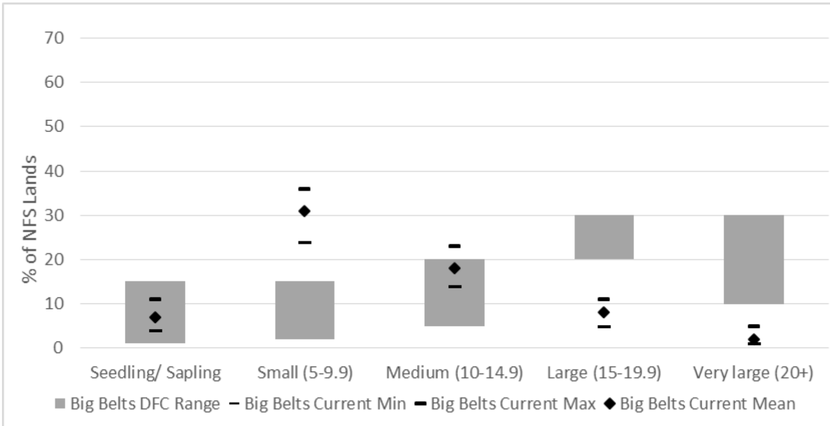


Figure 35. Big Belts size class existing and desired conditions

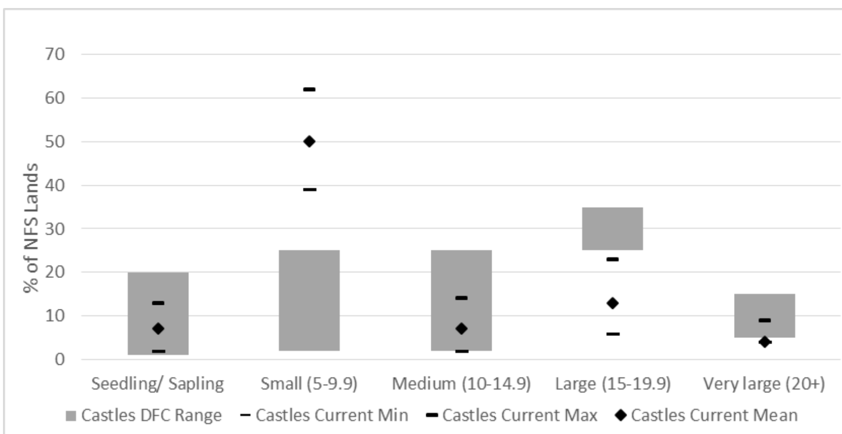


Figure 36. Castles size class existing and desired conditions

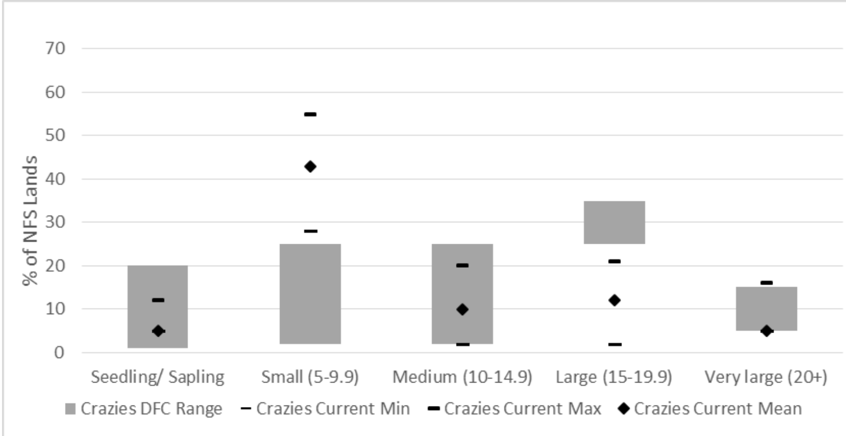


Figure 37. Crazies size class existing and desired conditions

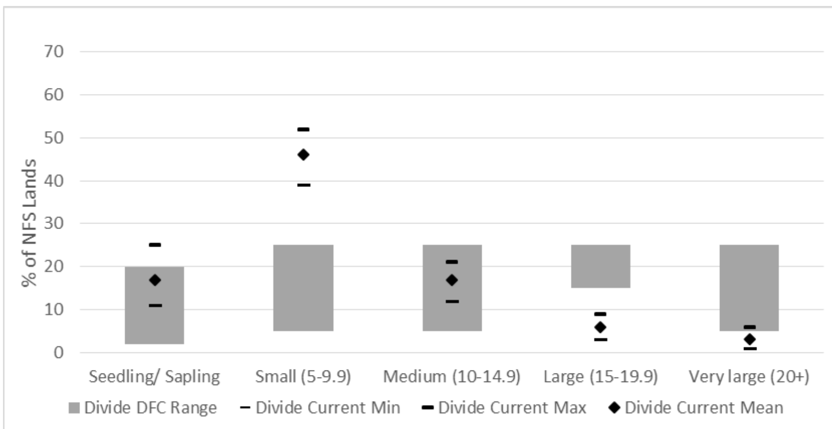


Figure 38. Divide size class existing and desired conditions

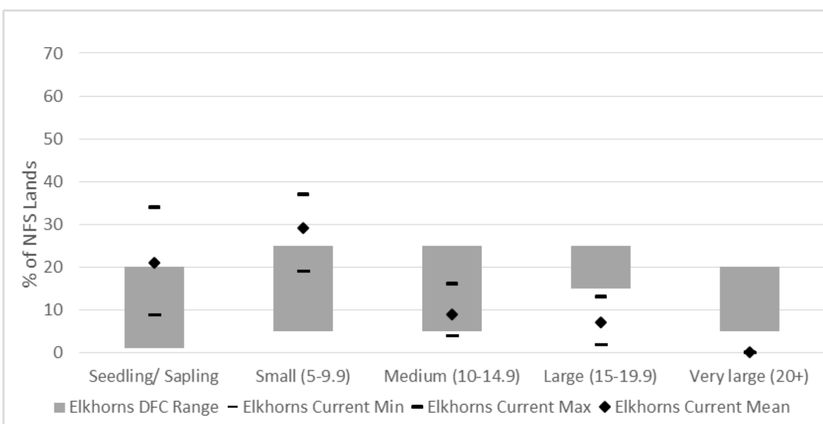


Figure 39. Elkhorns size class existing and desired conditions

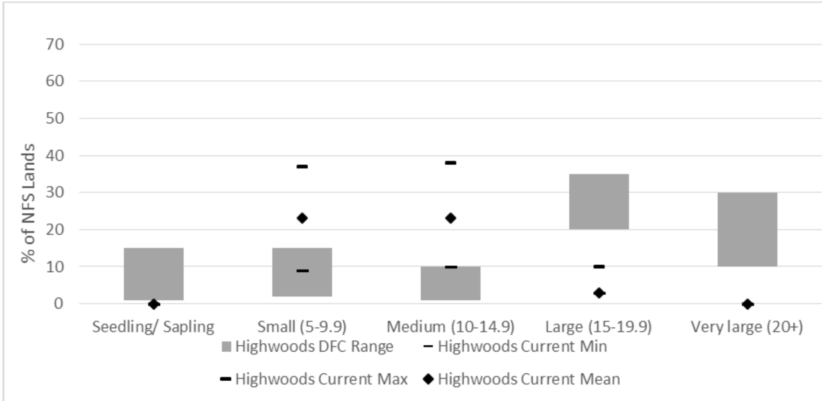


Figure 40. Highwoods size class existing and desired conditions

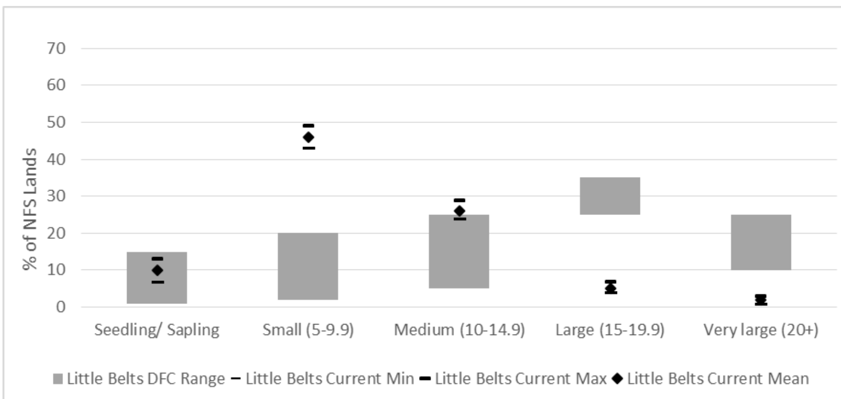


Figure 41. Little Belts size class existing and desired conditions

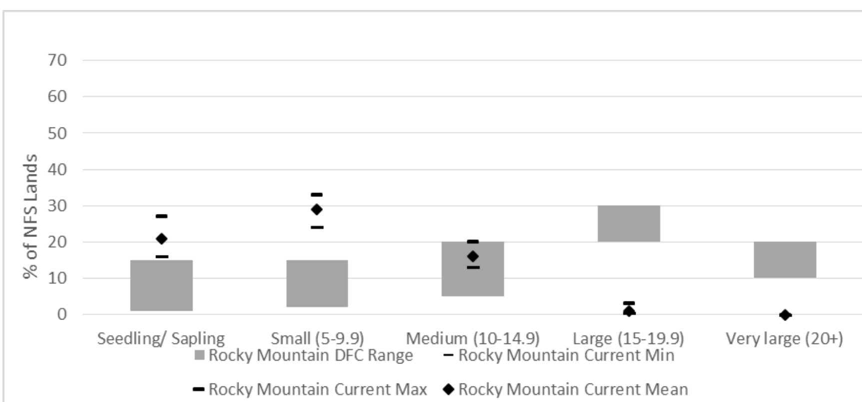


Figure 42. Rocky Mountain size class existing and desired conditions

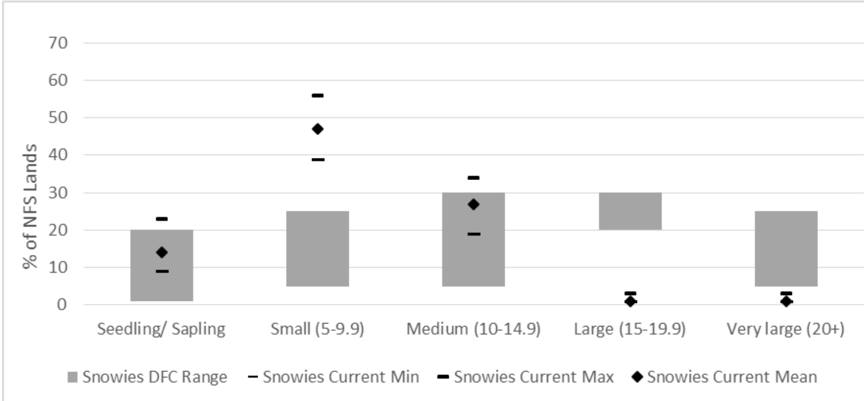


Figure 43. Snowies size class existing and desired conditions

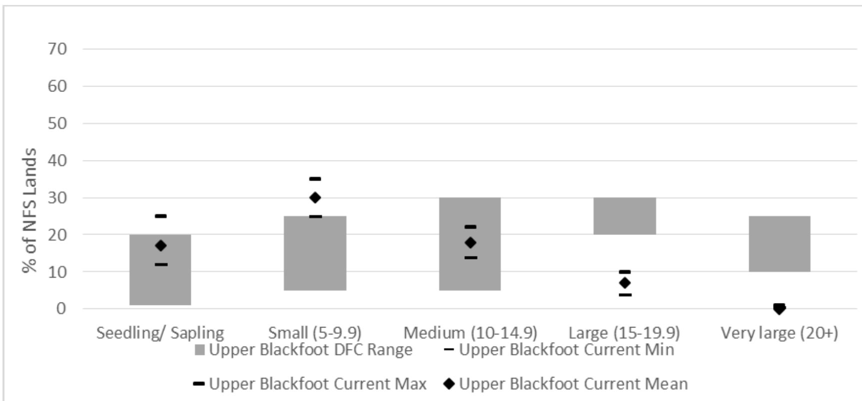


Figure 44. Upper Blackfoot size class existing and desired conditions

Large-tree structure

Data and modeling considerations

Large-tree structure (as defined in appendix D of the 2020 Forest Plan) identifies where large and very large trees are present in sufficient numbers to contribute to key ecosystem processes. This structure may occur within any forest size class. Based on FIA data, currently forestwide a large-tree structure is found in 2% of the seed/sap class; 20% of the small tree class; 81% of the medium tree class; 90% of the large tree class; and 100% of the very large tree class. SIMPPLLE does not track these classes explicitly. However, as discussed in the size class section, this attribute can be directly compared to the SIMPPLE NRV outputs for large and very large tree size classes.

Correlations to warm/dry climate periods and other considerations

The large and very large tree size classes generally decline and are at the low end of their NRV ranges during warm/dry climate periods, likely due to fire. We expect more fires and insect outbreaks; these components provide key seed sources to contribute towards resiliency to disturbances and drought.

NRV and existing condition values

Table 42 compares existing condition of the large-tree structure versus the NRV. A small amount of these components occur on nonforested PVTs in the R1 summary database (3%); but SIMPPLLE did not assign size class to these areas, so this amount is excluded from the comparison.

Table 42. Distribution of large-tree structure, existing condition versus NRV

PVT		Large	Very large
Forestwide	NRV	38-47	13-34
	Existing	14 (12-16)	7 (6-9)
Warm dry	NRV	37-64	19-57
	Existing	16 (13-19)	13 (9-16)
Cool moist	NRV	34-45	13-33
	Existing	16 (12-20)	5 (3-7)
Cold	NRV	43-68	3-7
	Existing	9 (6-13)	2 (0.5-3)

Forestwide large-tree structure desired conditions

The following figures display the desired condition of large-tree structure forestwide by broad PVT, as enumerated in FW-VEGF-DC-04. The desired ranges are derived from the NRV modeling of the large and very large size classes. This attribute complements desired size class distributions which indicate that the large/very large size classes should be increased; however, this metric underscores the importance of promoting large trees even in stands that classify into a smaller size class.

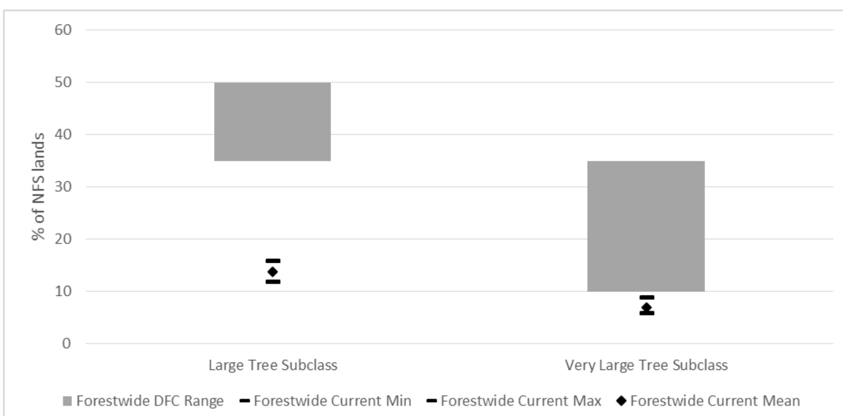


Figure 45. Forestwide large-tree structure existing and desired conditions

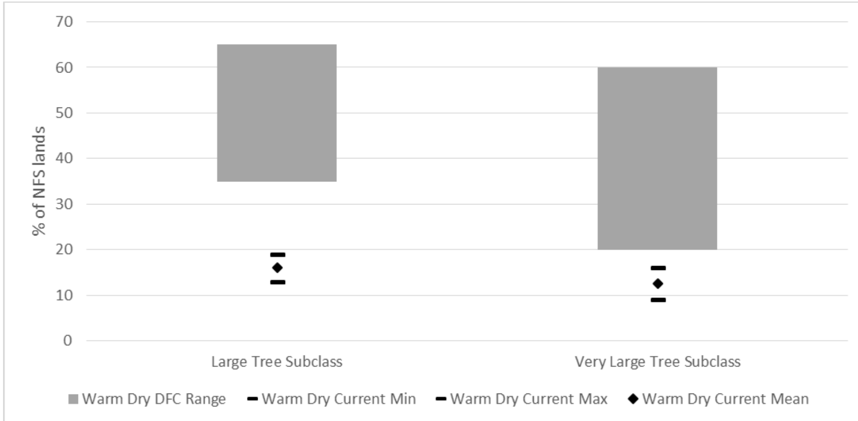


Figure 46. Warm dry PVT large-tree structure existing and desired conditions

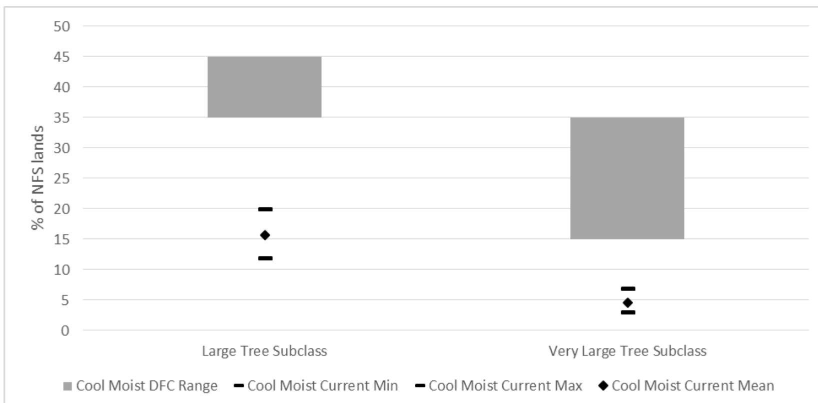


Figure 47. Cool moist PVT large-tree structure existing and desired conditions

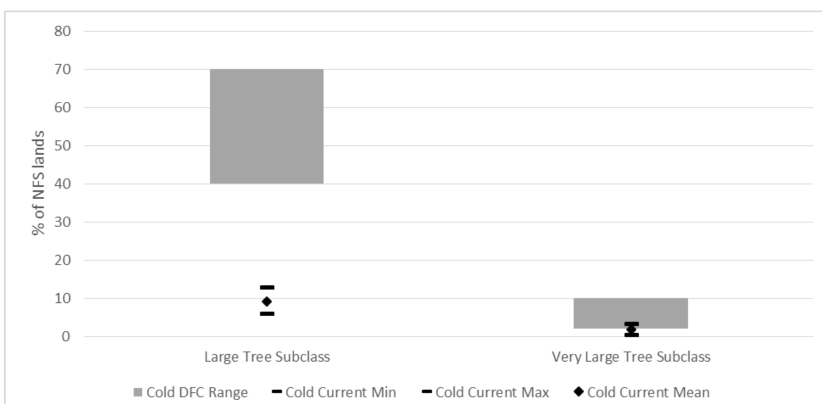


Figure 48. Cold PVT large-tree structure existing and desired conditions

To ensure the DCs can be met, as well as to contribute to future snags, a guideline was developed (FW-VEGF-GDL-01) to retain large and very large trees at the project level. The data source used is Bollenbacher (2008) which describes the mean quantities of large and very large live trees using periodic FIA data. The estimates used are the mean numbers of large and very large live trees found in wilderness and roadless areas across Eastern Montana in plots with a 1-4.9" size class, by snag analysis group as measured by periodic FIA plots (Table 4b on page 47 of Bollenbacher et al 2008). The Eastern Montana zone was used because the wilderness/roadless sample on the HLC NF did not have adequate data. Using plots in a seedling/sapling size class reflects conditions after a stand-replacing disturbance, which would be a minimum of large/very large trees that should exist after management activities.

Density Class

Data and modeling considerations

The R1 Summary Database classifies density class according to percent canopy cover. However, estimates of canopy cover from FIA plots are based on an algorithm that uses assumptions regarding species, tree size, and trees per acre; it is not based on field measurements of canopy cover. There are known deficiencies with the accuracy of this algorithm. In contrast, the VMap more directly estimates canopy cover using aerial imagery. Therefore, because it is more accurate than plot data for this attribute, the VMap condition for density class (as listed in the starting condition for the SIMPPLLE model) is used to estimate the existing condition rather than FIA plot data. There are no confidence intervals associated with these estimates. The low (10-24.9% canopy cover) and medium (25-39.9%) density classes are combined for the purposes of the forest plan revision, because there are no meaningful ecological thresholds that must be distinguished between them (e.g., specific habitat conditions). These density classes are also combined the nonforested density class (<10% canopy cover) because the classes cannot be consistently separated between the data sources (FIA plots, VMap, and SIMPPLLE).

Correlation to warm/dry climate periods and other considerations

Low tree and medium tree cover tend to be at the highest end of their ranges during warm/dry climate periods, whereas medium high and high tree cover tend to be at the lowest end. There is also a desire to increase resilience to wildfire and insects, which may warrant promoting for lower densities (or at low end of range for higher density classes) especially in the warm dry PVT. Very open savannas, a proportion of nonforested, are important to maintain. Higher densities are also important for wildlife hiding cover and specific habitats, such as lynx habitat in the cool moist PVT.

NRV and existing condition values

The following table displays existing condition versus NRV for density class.

Table 43. Density class– NRV versus existing condition

		NF/low/medium	Med/high	High
Forestwide	NRV	16-41	35-46	21-47
	Existing	26	27	48
Warm Dry	NRV	14-47	22-47	21-59
	Existing	26	29	45
Cool Moist	NRV	9-31	39-48	23-51
	Existing	22	20	58
Cold	NRV	10-41	48-60	12-33
	Existing	14	21	65
Big Belts	NRV	15-48	32-49	18-48
	Existing	33	29	39
Castles	NRV	11-36	33-46	25-54
	Existing	28	46	26

		NF/low/medium	Med/high	High
Crazies	NRV	19-47	31-42	21-46
	Existing	25	29	46
Divide	NRV	14 -49	32-50	17-49
	Existing	18	39	43
Elkhorns	NRV	17-45	32-48	20-45
	Existing	15	34	52
Highwoods	NRV	10-40	33-49	23-53
	Existing	10	33	57
Little Belts	NRV	13-37	33-45	23-53
	Existing	15	25	61
Rocky Mountain	NRV	20-43	35-43	20-44
	Existing	38	17	45
Snowies	NRV	16-47	34-49	18-46
	Existing	18	19	63
Upper Blackfoot	NRV	14-43	39-53	16-43
	Existing	28	41	31

Forestwide forest density class desired conditions

The following figures show desired conditions for density class, forestwide and by broad PVT, as enumerated in FW-VEGF-DC-03. To take into account the desired resiliency and expected future climate and drought, the following adjustments were made relative to the NRV to define the desired conditions based on BASI that indicates lower forest densities will be crucial to resilience and drought tolerance in the future (Halofsky et al., 2018b; Vose, Clark, Luce, & Patel-Weynand, 2016): the upper and lower bounds of nonforested/low/medium are adjusted up 10%; the upper and lower bounds of the high class are adjusted down 10%; and the desired range for medium is rounded to encompass a range of at least 20% to provide for variability given the adjustments made to the other size class.

Forestwide, it is desirable to reduce the high cover class by increasing the medium/high class in productive forests and low/medium density dry forests and/or nonforested areas. In the warm dry PVT, promote nonforest and open density forests, and reduce high density. In the cool moist PVT, promote medium/high cover class while decreasing high. Forests with high cover class include lynx habitat. Maintain nonforested/low/ medium forests or increase within the desired range to promote resilience. In the cold PVT, increase the lower density classes and decrease high, focusing on whitebark pine.

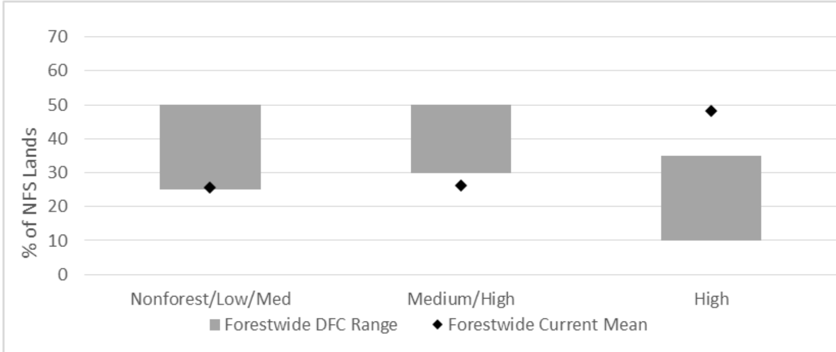


Figure 49. Forestwide forest density class existing and desired conditions

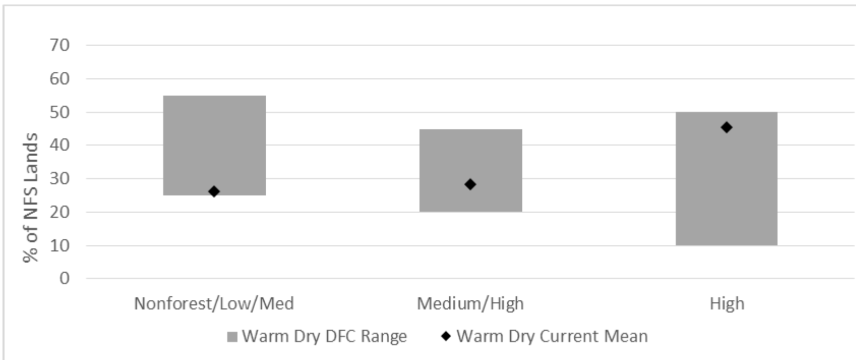


Figure 50. Warm dry PVT forest density class existing and desired conditions

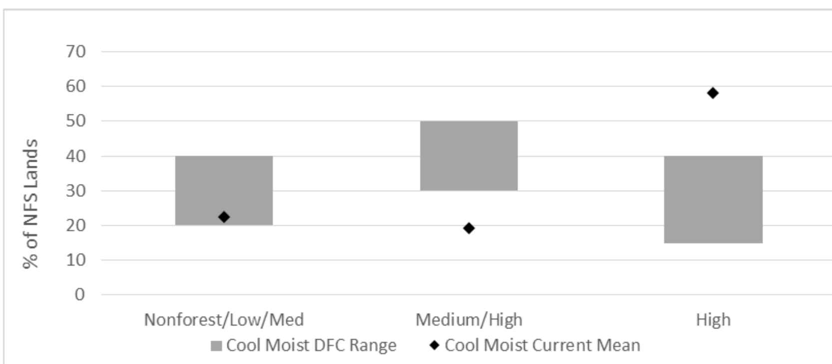


Figure 51. Cool moist PVT forest density class existing and desired conditions

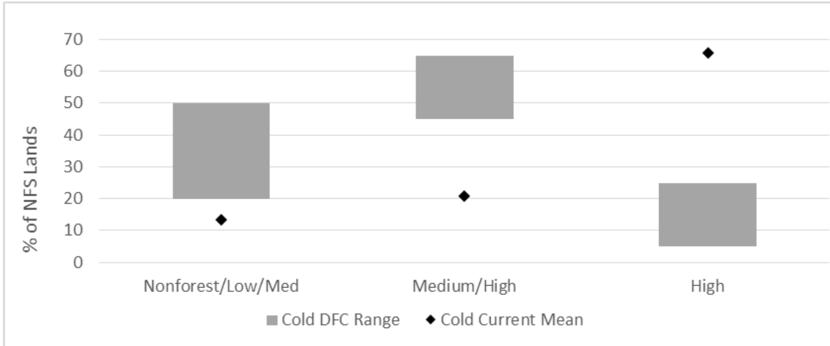


Figure 52. Cold PVT forest density class existing and desired conditions

GA forest density class desired conditions

The figures below show the density class DCs at the GA scale. The bounds are adjusted as described for the forestwide ranges. There is relatively little variance across GAs, and they are similar to the forestwide ranges. This would indicate that density is responsive to PVT rather than spatial location. Nevertheless, GA-level desired conditions are provided in chapter 3 of the 2020 Forest Plan so that the array of density classes and associated habitats are present within each GA.

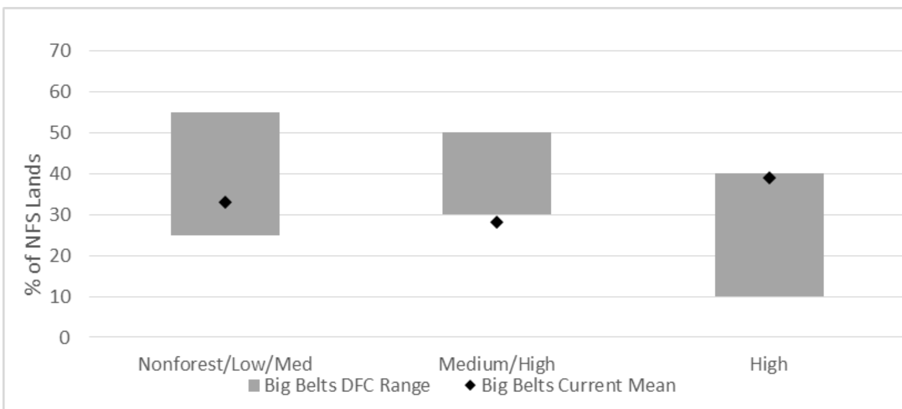


Figure 53. Big Belts density class existing and desired conditions

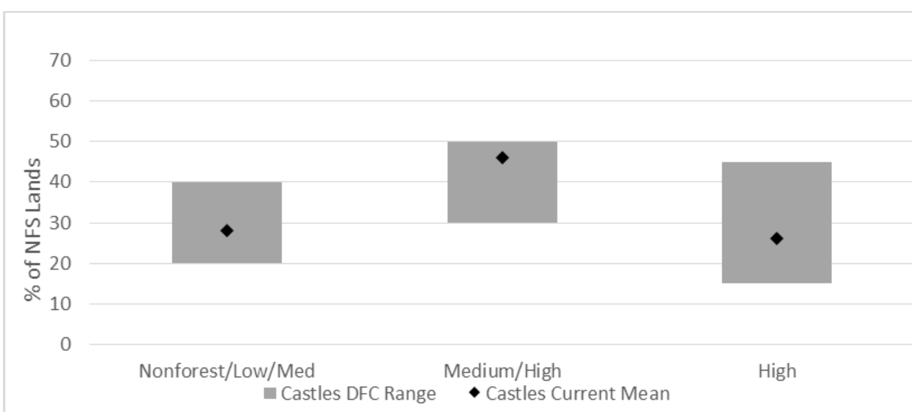


Figure 54. Castles density class existing and desired conditions

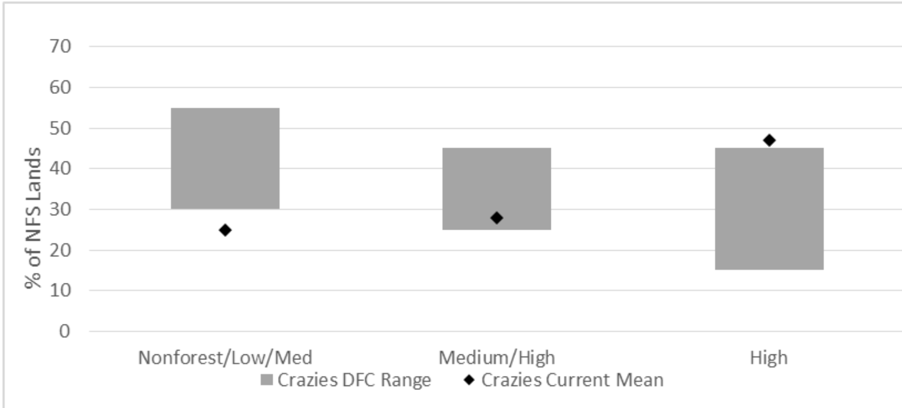


Figure 55. Crazies density class existing and desired conditions

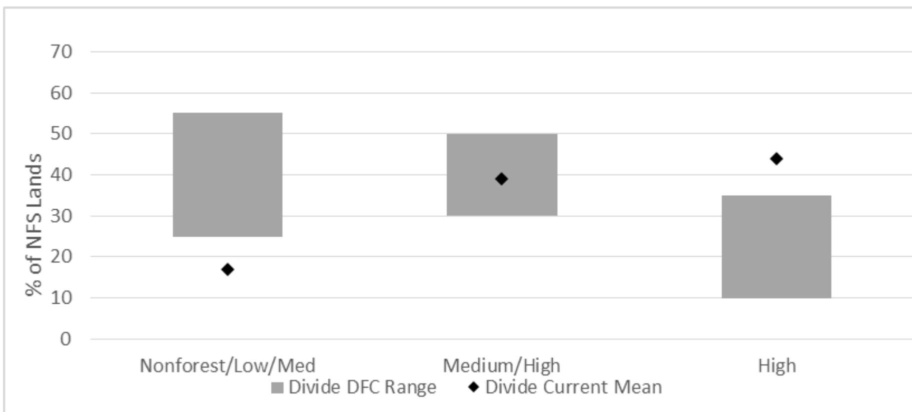


Figure 56. Divide density class existing and desired conditions

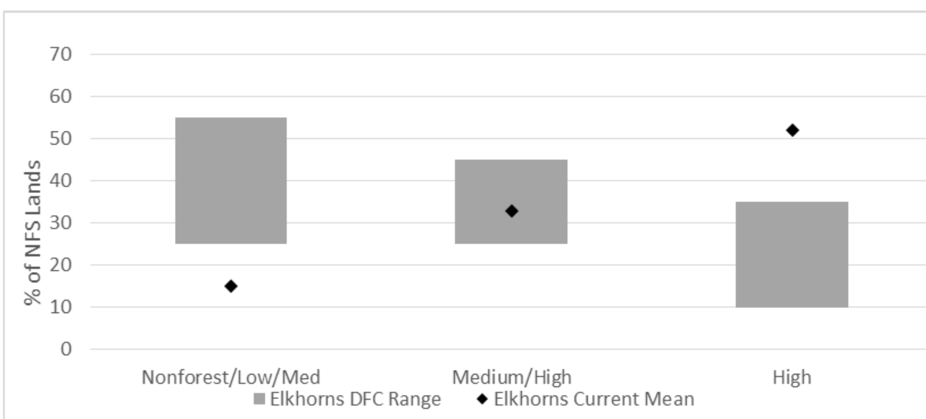


Figure 57. Elkhorns density class existing and desired conditions

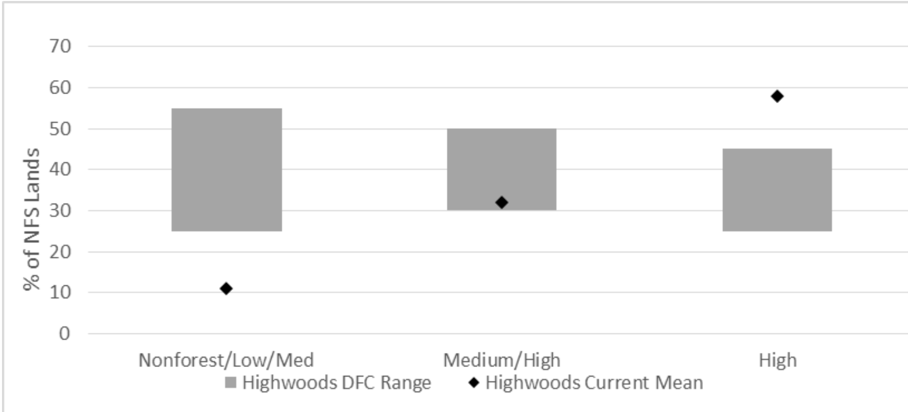


Figure 58. Highwoods density class existing and desired conditions

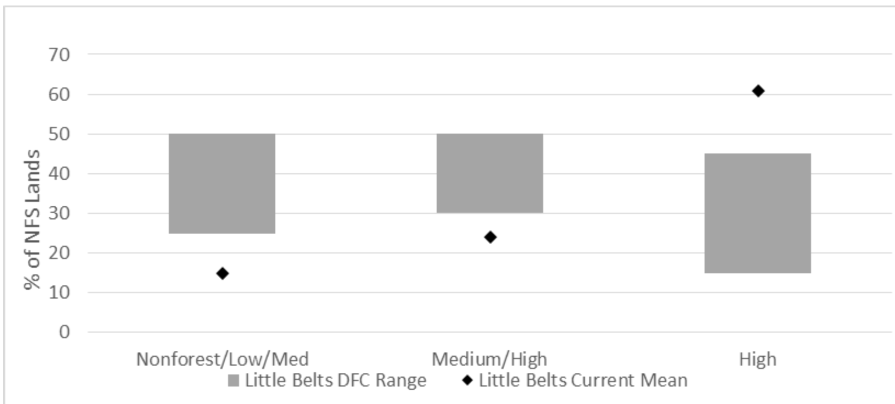


Figure 59. Little Belts density class existing and desired conditions

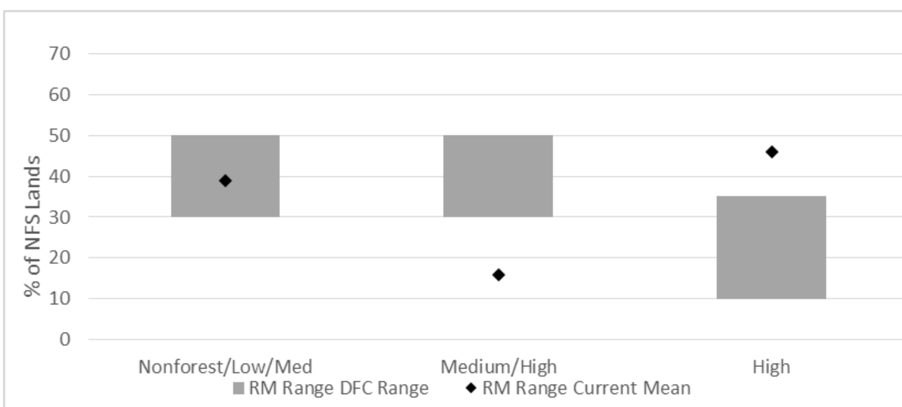


Figure 60. Rocky Mountain Range density class existing and desired conditions

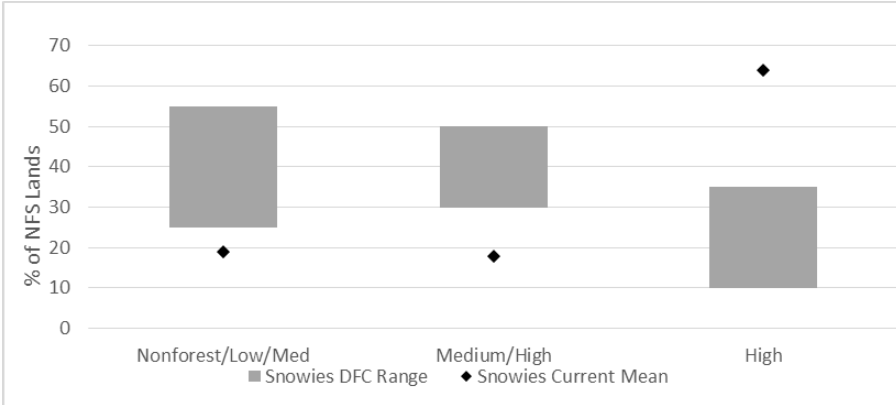


Figure 61. Snowies density class existing and desired conditions

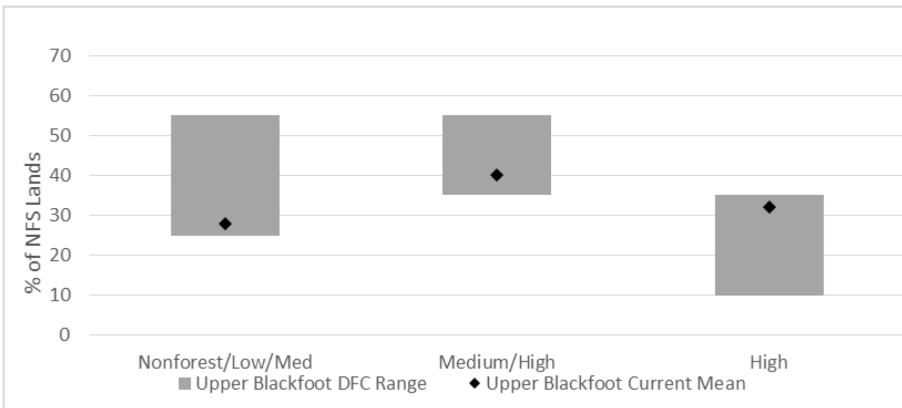


Figure 62. Upper Blackfoot density class existing and desired conditions

Forest vertical structure

Data and modeling considerations

SIMPPLLE derives vertical structure based on assumptions tied to species composition and time since disturbance, whereas the R1 Summary Database calculates vertical structure based on trees per acre in different size classes. Generally speaking, these should be comparable, given that calibrations were done to the SIMPLLE input file to match existing vertical structure distributions. The crosswalk from SIMPPLLE labels is as follows: Seed/Sap and Single Story = 1; Two Story = 2; Multi Story = 3 and C (continuous). Non-forested areas (or "none") are excluded.

Correlations to warm/dry climate periods and other considerations

Single-storied forests (seed/sap and single-storied) increase and are at the high end of their NRV ranges during warm/dry periods. Two storied conditions tend to be at the low and but increasing during warm dry periods. Multi-storied conditions decrease and are at the low end of their NRV range during warm/dry periods. There is a desire for more open densities and less layering for resiliency (when stand density is high); but also, multi-story conditions are important for certain wildlife habitats.

NRV and Existing condition values

The following table compares the existing condition to the NRV for vertical structure class.

Table 44. Forest vertical structure – NRV versus existing condition

PVT		1	2	3 or C
Warm dry	NRV	8-20	4-7	74-86
	Existing	60 (55-64)	12 (9-15)	13 (10-17)
Cool moist	NRV	14-48	5-16	49-64
	Existing	54 (48-59)	9 (6-12)	20 (16-25)
Cold	NRV	12-65	5-19	46-62
	Existing	58 (51-64)	5 (3-9)	18 (13-24)

It was determined that a quantitative desired condition for this attribute is not necessary, as forest structures should develop as appropriate in the framework of the desired conditions defined for cover type, species presence, size class, and density class. The NRV indicates that an increase in multistoried conditions may be warranted even in warm/dry types – this would likely correspond to open, uneven-aged stands as opposed to dense multistoried stands as would be expected to develop on more moist sites. These considerations for vertical structure are blended into the descriptions for FW-VEGT-DC-01.

Desired conditions for landscape pattern (early successional forest openings)

Data and modeling considerations

An analysis of seedling/sapling forest patches ("forest openings") was done to address landscape pattern. The dominance of grass, forbs, shrubs and short trees in early successional forests creates a patch with 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, but the seedling/sapling patch type is also meaningful for evaluation of wildlife habitat, 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.

An analysis of NRV for patch size of early successional forest was conducted using SIMPPLLE. The depiction of early seral forest patches includes the seedling/sapling size class and grass/shrub/forb communities on forested PVTs, which are in transition from a recent disturbance but are expected to reforest. The existing condition is based on the SIMPPLLE input file. The minimum patch size considered was 10 acres based on the pixel sizes of the data layer.

For the NRV modeling, the analysis was conducted in two ways. First, an opening was included in the calculation for as long as it remained in the seedling/sapling size class. This provides the ecological picture of the extent and duration of openings. This is the analysis that is pertinent to the effects discussed in the environmental consequences section. Second, the analysis was run assuming that a patch is no longer an opening beyond 10 years after its creation. This provides for assessing appropriate patch sizes for even-aged harvest entries as required by the National Forest Management Act. Only natural disturbances created forest openings in the NRV analysis.

Correlations to warm/dry climate periods and other considerations

The largest patches are correlated with warm/dry climate periods.

NRV and existing condition values

Table 45 shows the NRV and existing condition of early successional forest patches; patches are included for as long as they remain in the seedling/sapling size class.

Table 45. NRV and existing condition of early successional forest patches >10 acres

	Forestwide	Warm dry	Cool moist	Cold
NRV – average acres	78 (45-119)	45 (30-70)	64 (44-84)	59 (39-84)
NRV – area weighted mean acres1	3,824 (160-12,973)	646 (46-2,703)	930 (142-2,664)	496 (73-1,482)
Existing Condition – average acres	163	91	133	76

[1] The area weighted mean patch size calculation is based on each patch getting a weight based on the size of the patch, with the bigger patches getting more weight.

NFMA requires that limits be placed on the maximum opening size allowed for even-aged regeneration timber harvest. In this context, a seedling/sapling patch would be considered a timber opening temporarily until regeneration is established. Therefore, the analysis was run to include seedling/sapling patches only for the first period (10 years) after their creation (Table 46).

Table 46. NRV of early successional forest patches >10 acres, with a 10 year limit of duration

	Forestwide	Warm dry	Cool moist	Cold
NRV – average acres	82 (30-151)	43 (27-77)	67 (28-110)	51 (0-93)
NRV – area weighted mean acres[1]	3,066 (40-14,051)	406 (34-1,695)	804 (31-2,864)	346 (0-1,357)

[1] The area weighted mean patch size calculation is based on each patch getting a weight based on the size of the patch, with the bigger patches getting more weight.

Forestwide desired condition

The desired condition integrates the results of the NRV analysis to encourage the continued presence of early successional forest openings in appropriately sized patches across the landscape. However, a qualitative component was developed, rather than quantitative, to capture the full range of diversity in a more general way, and to include all successional stages. This approach is appropriate given the uncertainty in factors that influence model results for the NRV of average landscape patch size, as compared to the context for existing patch sizes, which varies by GA.

Maximum size of regeneration harvest openings standard

The NRV analysis of patch sizes created for 1 period (Table 46) was used to inform a standard for maximum patch size of even-aged regeneration harvest for the HLC NF (FW-TIM-STD-08), to contribute to desired landscape patterns. The modeling shows that a maximum opening greater than 40 acres would reflect natural landscape patterns; the forestwide NRV average patch size is well above the NFMA limit of 40 acres. As described in FW-VEGF-DC-08, classifying areas by PVT is meaningful because different disturbance regimes are associated with each, and so to the desired landscape pattern should vary. However, to the extent that PVTs are present in small patches, the area of a large contiguous patch could be artificially reduced in the summarization process. For example, if a large warm dry seedling/sapling patch is separated by a small cool moist strip (e.g., a riparian area), it would be summarized as two smaller patches. Therefore, the forestwide patch number is used to inform FW-TIM-STD-08 because it avoids the issue of PVT mapping artificially reducing the functional patch size. Not requiring a PVT breakdown when applying the standard also improves simplicity for implementation, as well avoids the issue of PVT mapping being used to create larger contiguous openings that would functionally represent a single opening. A maximum even-aged regeneration harvest opening size limit of 75 acres is used in FW-TIM-STD-08. This value represents a point below the average but within the range of the forestwide NRV number, and does not exceed the maximum end of the range for any single PVT. The maximum opening number does not reflect the high end of historical conditions, but rather a midpoint.

Desired conditions for special components (old growth, snags, and coarse woody debris)

Discussion

Other special vegetation components include old growth, snags, and coarse woody debris. These attributes cannot be modeled with SIMPPLLE, and therefore the development of desired conditions varies from the composition and structure attributes discussed in previous sections.

Because old growth definitions are based in part on the presence of large trees, a correlation can be drawn with the presence of large-tree structure. This concept is also similar to how large and very large size classes are modeled in SIMPPLLE. The NRV range of large-tree structure and large/very large size classes would indicate that past amounts of old growth were likely higher than the existing condition, especially in the warm dry broad PVT. The use of exact values as desired conditions is unadvisable given the wide span of assumptions used.

Snags (standing dead trees) are naturally irregularly distributed. Fire is a dominant process that creates snags, especially in smaller diameter classes. Snags are also created by competition, insects, and diseases. Bark beetles tend to create snags in the largest trees available. The availability of large snags depends on the growth of large trees. Desired conditions for snags (by snag analysis groups) are designed to reflect the conditions that would be expected to occur under natural disturbance regimes.

The development of plan components for downed woody debris is complex, because different amounts, sizes, and distributions are meaningful for different resources (e.g., wildlife, fuels, and soils). The desired condition for downed wood is to maintain amounts that contribute to forest structural diversity, soil ecological function, and habitat, focusing on coarse woody debris because larger downed wood is more valuable to ecosystem function than smaller debris. The desired conditions are based on the best available science (J. K. Brown, Reinhardt, & Kramer, 2003). The ecosystem conditions described in the paper are relevant but are based on data west of the continental divide and therefore adjustments using local data were appropriate.

Old growth

Data and modeling considerations

There is no means to determine a statistically sound, quantifiable estimate of the NRV for old growth based on the current accepted definition (Green et al., 1992), because the characteristics can be determined only through site specific inventory. Old growth definitions can be applied and estimated reliably for the current condition with the R1 summary database.

Other adjustments and considerations

All vegetation desired conditions contribute to the long-term persistence of old growth. Lodgepole pine old growth is the least valuable type due to the natural short-lived nature of that species. There is no known BASI to quantify the NRV condition of old growth abundance, distribution, or patch size specific to the landscapes on the HLC NF. Without this information, a quantitative old growth DC or guideline is difficult to develop; and it is unknown what the appropriate scale to consider old growth would be (forestwide, GA, watershed, etc).

NRV and existing condition values

Because old growth definitions are based in part on the presence of a certain number of large trees, a correlation can be drawn with *large-tree structure*, which can be compared to large and very large size classes in SIMPPLLE for NRV. However, because other attributes are needed to define old growth, only a proportion of areas with large-tree structure are actually old growth, as shown in Table 47. Nearly half (44%) of the plots with large-tree structure are old growth.

Table 47. Proportion of plots estimated to be old growth forestwide

Large/very large tree structure	% old growth
Large tree structure	20% (14-26)
Large or very large tree structure	24% (17-31)
Large or very large tree structure not present	5% (4-7)

The way large-tree structures are identified is similar to the way SIMPPLLE defines the large/very large size class. Therefore, in rough terms, about half of the areas in the unadjusted large and very large size classes in the NRV may have been old growth, as postulated in Table 48. It is likely that there is also less old growth on the landscape than in the NRV, especially in the warm dry PVT.

Table 48. Existing old growth and potential NRV (44% of the large/very large size classes)

Scale	Existing condition (FIA)	Potential NRV
Forestwide	11% (9-13)	20-25%
Warm dry	8% (6-11)	33-52%
Cool Moist	14% (10-19)	11-19%
Cold	15% (11-20)	28-40%

Other adjustments and considerations

Distribution of old growth across forested PVTs and cover types is desired to support the full range of ecosystem diversity and wildlife species habitat needs.

Old growth desired condition

The old growth desired condition as shown in FW-VEGF-DC-05 does not include a quantitative value, due to the limitations of the analysis described above. Rather, a desire to maintain and increase old growth on the landscape is addressed qualitatively, including a distribution across the Forest and in every GA. To help achieve the desired condition, guideline FW-VEGF-GDL-04 was developed.

Snags

Data and modeling considerations

The SIMPPLLE model does not provide a quantified NRV for snags. NRV ranges were derived from Bollenbacher and others (2008), and (R. Bush & Reyes, 2020), using snag estimates inside wilderness and roadless areas as an indicator of the NRV. As noted by Bollenbacher and others (2008), this is the best available data to provide context for the potential historical condition of snags. Three snag classes are included: medium (10+); large (15+) and very large (20+). *Snag analysis groups* (warm dry PVT, cool moist PVT, cold PVT, and lodgepole pine dominance groups) are used. These groups are consistent with the BASI for snags on eastside forests in Region 1 (Bollenbacher et al 2008; Bush & Reyes 2020).

Other adjustments and considerations

In the future, we expect larger pulses of snags with more fires and insect outbreaks. The Assessment showed a comparison between the wilderness and the "front country", which indicated that there are fewer medium snags in the front country, but the amounts of large and very large were comparable. Fewer medium snags may be related to cutting of dead lodgepole pine after the pine beetle outbreak from firewood cutting and roadside hazard tree removal. Plan components consider the impacts of firewood cutting in roaded areas, which results in snag losses or reduced distribution in these areas. Literature sources reviewed in development of snag conditions and guidelines include (Bate, Wisdom, & Wales, 2007; Bollenbacher et al., 2008; Bull, Parks, & Torgersen, 1997; Franklin, Berg, Thorburgh, & Tappeiner, 1997; Harris, 1999). The quantitative plan components are based on the most local data (Bollenbacher et al., 2008). The specific per-acre recommendations from Bull and others (1997) are not appropriate to use for the HLC NF because it reflects very different ecosystem conditions found in the Pacific Northwest, in terms of tree species, tree size, disturbance regimes, and appropriate distribution.

NRV and existing condition values

The tables below compare existing snag data to the best depiction of NRV. By snag analysis group, the NRV is represented by snags in wilderness/roadless areas on the HLC NF measured by periodic FIA plots prior to the mountain pine beetle outbreak.

Table 49. Snags per acre –existing condition versus NRV – forestwide by snag analysis group

Scale		Medium 10-14.9"+	Large 15-19.9"+	Very large 20"+
PICO	NRV	12.9 (8.1-18.3)	2.0 (0.8-3.4)	0.2 (0.0-0.6)
	Existing	11.9 (9.1-15.0)	1.3 (0.7-2.0)	0.1 (0-0.2)
Warm dry	NRV	4.3 (2.0-7.0)	1.1 (0.3-2.2)	0.2 (0.0-0.4)
	Existing	6.8 (4.9-8.9)	2.2 (1.3-3.3)	0.8 (0.4-1.2)
Cool moist	NRV	12.3 (8.3-16.8)	2.4 (1.4-3.5)	0.4 (0.1-0.8)
	Existing	15.1 (11.5-19.1)	3.4 (1.9-5.1)	1.0 (0.4-1.8)
Cold	NRV	13.4 (6.6-21.9)	2.3 (1.1-3.7)	0.9 (0.2-1.8)
	Existing	18.4 (12.9-24.7)	4.3 (2.4-6.7)	0.9 (0.3-1.6)

Source: Bollenbacher (2008) supplemental tables (2017) for NRV (periodic) and existing condition (Hybrid 2011).

Table 50. Snag distribution (% area with snags) – existing condition versus NRV – forestwide by snag analysis group

Scale		Medium 10-14.9"+	Large 15-19.9"+	Very large 20"+
PICO	NRV	14.6 (9.7-19.8)	5.0 (2.5-7.9)	1.5 (0.2-3.4)
	Existing	22.22 (17.48-27.11)	4.12 (2.03-6.54)	0.36 (0.36-1.04)
Warm dry	NRV	7.6 (4.4-11.3)	3.9 (1.6-6.8)	1.6 (0.3-3.1)
	Existing	16.86 (13.08-20.74)	7.13 (4.65-9.78)	3.57 (1.87-5.41)
Cool moist	NRV	19.7 (14.6-25.1)	9.6 (6.0-13.5)	2.9 (0.9-5.3)
	Existing	31.03 (24.43-38.00)	9.20 (5.11-13.74)	2.87 (0.81-5.34)
Cold	NRV	19.5 (11.8-27.7)	9.5 (4.7-15.0)	5.3 (1.6-9.7)

Scale		Medium 10-14.9”+	Large 15-19.9”+	Very large 20”+
	Existing	29.54 (21.66-37.55)	11.39 (6.13-17.21)	3.38 (0.69-6.66)

Source: Bollenbacher (2008) supplemental tables (2017) for NRV (periodic). Existing condition from Hybrid 2011.

Snag desired condition

The snag desired condition is enumerated in FW-VEGF-DC-06. The existing and desired ranges are derived from Bush & Reyes 2020. The desired snags per acre are consistent with the NRV, based on the 90% confidence interval around the mean of snags found in wilderness and roadless areas on the HLC NF, as measured by periodic FIA plots which represent conditions prior to the mountain beetle outbreak. The existing condition is shown as a mean with 90% confidence interval for those same areas, based on the Hybrid 2011 FIA dataset. The desired distribution reflects the proportion of the snag analysis group across the HLC NF that contains one or more snags in the indicated size class.

To ensure the desired condition can be met and provide for viability of snag dependent species in the managed landscape, a guideline (FW-VEGF-GDL-02) is developed to retain snags at the project level. Using the same data as the desired condition, minimum retention numbers for the guideline are based on upon the lower bound of the 90% confidence interval around the mean snags present.

Downed woody debris

Data and modeling considerations

For wildlife habitat, downed wood of the largest sizes is the most valuable, and the most meaningful measure is percent cover of downed wood. However, this measure is not available in our data sources. For both fuels and soils considerations, a common measure is tons/acre of woody material greater than 3” diameter; this is quantifiable with FIA data in the R1 summary database. 3” is also the minimum size for coarse woody debris used in the BASI used to develop the desired condition (J. K. Brown et al., 2003).

Downed woody debris is not modeled w/ SIMPPLLE. NRV is represented by FIA queries for quantities and distribution within wilderness/roadless areas on the HLC NF. All estimates are done in spreadsheets because the R1 Summary Database Estimator does not currently provide the necessary groupings (multi-grouping functionality to split out both broad PVT and wilderness/IRA is not yet available in the summary database estimator tool). Both quantity and distribution of woody debris are important.

Other adjustments and considerations

Drier conditions and more fires might mean less downed wood, and/or wider swings in amounts/distributions. For fuels management purposes, generally the minimum quantities needed to meet other resource needs is desired in areas of elevated fuel concern (such as WUI areas). In many cases these areas are also in the warm dry PVT, where natural fuel levels are also lower, and therefore resource desires are complementary. In the short term, a pulse of coarse woody debris is expected to be recruited as trees killed in the recent mountain pine beetle outbreak fall to the forest floor. Recent fire areas will also be sources of woody debris.

The BASI for coarse woody debris on the HLC NF was reviewed (J. K. Brown et al., 2003; Graham et al., 1994). Brown et al 2003 provides information that is helpful to inform our understanding of the NRV and appropriate DC, while Graham et al is more specifically used to guide the development of a guideline for coarse woody debris retention in vegetation management areas.

NRV and existing condition values

Table 51 was developed to compare NRV (wilderness/roadless) and existing condition in terms of large woody debris distribution (>3” diameter) using queries done with Hybrid 2007. There is no appreciable difference in the distributions in wilderness/roadless areas versus the landscape as a whole. 30 to 50% of the landscape has no woody debris present, and that distribution is greatest on cool moist broad PVT. Most of the woody debris present is <10 tons/acre.

Table 51. Distribution of large woody debris (1000-fuels or >3" dbh)

Scale		CWD distribution (Presence)				
		>=0 tons/ac	>=5 tons/ac	>=10 tons/ac	>=20 tons/ac	>=40 tons/ac
Forestwide	Wild/IRA	56%	26%	14%	6%	2%
	Existing	55%	25%	15%	6%	2%
Warm dry	Wild/IRA	59%	19%	4%	0%	0%
	Existing	57%	17%	6%	1%	0%
Cool moist	Wild/IRA	64%	42%	26%	10%	3%
	Existing	65%	43%	28%	11%	3%
Cold	Wild/IRA	52%	23%	17%	11%	5%
	Existing	51%	24%	16%	9%	3%

Table 52 shows an approximation of the NRV (in wilderness and roadless) compared to the existing condition of woody debris >3" diameter. Existing condition numbers are from the Hybrid 2011 dataset, as is the NRV forestwide. For the broad PVTs, queries done in excel on Hybrid 2007 data are used for NRV. The existing condition is similar to the NRV forestwide and in the warm dry PVT, but slightly less in cool moist and cold.

Table 52. NRV and existing tons/acre of woody debris >3" diameter by broad PVT

Scale	Tons/ac >3" diameter	
	In wilderness/IRA	Existing condition
Forestwide	5.6 (4.8-6.6)	5.2 (4.6-5.9)
Warm dry	3.4	3.4 (2.7-4.2)
Cool moist	10.6	7.2 (5.8-8.8)
Cold	10.3	7.0 (5.3-8.9)

Downed woody debris desired condition

The desired condition for downed woody debris is enumerated in FW-VEGF-DC-07. The desired conditions are based on the best available science (J. K. Brown et al., 2003). Brown and others (2003) take into account many considerations of woody debris, including wildlife habitat, soil nutrient cycling, fire hazard and behavior, soil heating, and historic quantities. The ecosystem conditions described in the paper are relevant but are based on data west of the continental divide and therefore some adjustments using local data were appropriate. Snag analysis groups are not used by Brown and others (2003). The publication is based on habitat type groups and does not break out the lodgepole pine cover type. Therefore, for consistency the desired condition is based on potential vegetation groups rather than snag analysis groups.

Brown and others (2003) identified optimum ranges of coarse woody debris to provide biological benefits without creating an unacceptable fire hazard. The range that best meets resource needs is 5 to 20 tons per acre for the warm dry PVT and 10 to 30 tons per acre for other types. The amount and distribution of coarse woody debris in roadless and wilderness areas was also used to inform the narrative of desired trends, because this reflects conditions on landscapes that have been influenced minimally by human activities. For the HLC NF the average amounts in these areas are slightly lower than the optimum described by Brown and others (2003). The natural range of downed wood in the warm dry types on the HLC NF is lower because these areas include open savannas, where grass and shrubs dominate. Therefore, the lower end of the range described by Brown and others (2003) is adjusted downward to account for the unique conditions on the HLC NF as indicated by FIA data in the wilderness and roadless areas. The desired average tons/acre are not applicable to every forest stand, but rather as broad scale averages. There is no desired condition for nonforested PVTs, as there is generally no source of downed wood (i.e. trees) in those areas.

To ensure the desired condition can be met, a guideline (FW-VEGF-GDL-06) was developed to retain downed wood at the project level. The data source used is Graham et al 1994. Although this study uses primarily data taken from western Montana, Idaho, and Arizona, the ecosystems studied are relevant to the HLC NF and there is no more local research available. The analysis provided recommended woody debris tons/acre by habitat type; those found in MT and on the HLC NF were reviewed. The drier Douglas-fir types tended to have a range starting at a minimum of 5 tons/acre and the moist subalpine fir types tended to have a range starting at a minimum of 10 tons/acre. These levels are consistent with the lower end of the desired ranges. It is logical that by providing for these minimums in vegetation treatment units, management will not preclude achievement of the forestwide desired average. Higher amounts of downed wood can be expected in unmanaged areas, which dominate the HLC NF.

Identification of lands suitable for timber production

The National Forest Management Act directs that, "*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*." The 2012 planning rule directives (USDA, 2015) provide guidance regarding the identification of lands as not suited and suited for timber production. Per this direction, lands suitable for timber production have been identified for each alternative using the methodologies described in this section; maps are included in appendix A. During plan implementation, site-specific suitability would be validated at the project level.

Timber harvest is the removal of trees for wood fiber use and other multiple-use purposes. *Timber production* is the purposeful growing, tending, harvesting, and regeneration of regulated crops of trees to be cut into logs, bolts, or other round sections for industrial or consumer use (U.S. Department of Agriculture, Forest Service, 2012). In addition to the identification of lands suitable for timber production, lands that are unsuitable for timber production, but where timber harvest may occur, were also identified. Criteria for determining lands not suitable for timber production are assessed with two-steps:

1. Identify lands that are not suited for timber production based on legal and technical factors. These lands do not vary by alternative and are identified in the assessment or prior to development of alternatives. This is a preliminary classification. 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*.
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 for those lands. This is done for each alternative.

The calculation of timber metrics is dependent upon timber suitability land classifications (Box 2).

Box 2: Summary of timber suitability classifications and associated timber metrics

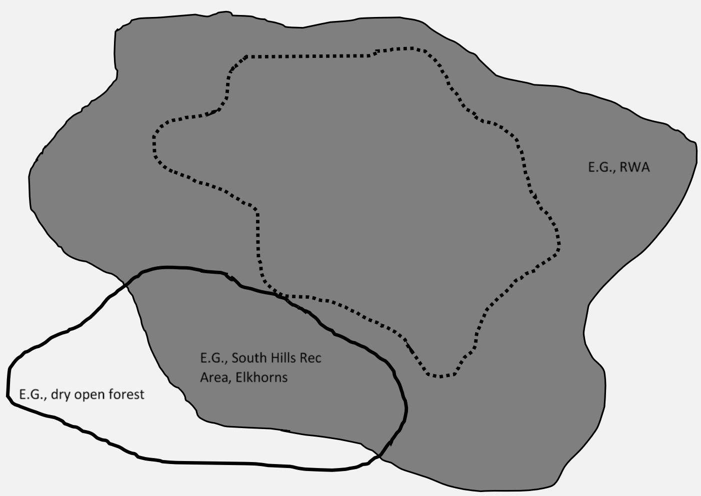
A. *Lands that May be Suited for Timber Production*  Includes all lands that meet the technical NFMA criteria. Does not vary by alternative. Provides the area from which lands suitable for timber production may be selected.

B. *Lands that Are Suited for Timber Production*  A subset of Lands that May be Suited, where timber production is a primary or secondary purpose consistent with other resource objectives. Varies by Alternative.

C. *Lands Unsuitable for Timber Production, where Harvest Can Occur*  Lands where harvest is permitted, but are not suitable for timber production. Varies by Alternative. May include lands outside of those areas that May be Suited for timber production (for example, very dry or low productivity forests).

Sustained Yield Limit (SYL) is calculated from all Lands that May be Suited for timber production (A). It is a limit on harvest. It includes lands that are not suitable in an alternative.

Projected Timber Sale Quantity (PTSQ) and Projected Wood Sale Quantity (PWSQ) are calculated from all lands where harvest may occur (B + C).



Lands that may be suitable for timber production

Table 53 defines the technical factors used to identify that lands that are not suited for timber production. These lands were subtracted from the total NFS acreage, and the remaining areas are those that *may be suited for timber production*. The determination of lands that may be suited for timber production provides the first step and basis for determining the lands that are suited for timber production, and it is the landbase used to calculate the sustained yield limit.

Table 53. Criteria for the lands that may be suited for timber production

Technical factor (36 CFR 219.11(a))	Summary of description (FSH 1909.61.1)
(i) Statute, Executive Order, or Regulation prohibits timber production; or (ii) The Secretary of Agriculture or Chief of the Forest Service has withdrawn the land from timber production.	Timber production may be prohibited on certain lands by statute, Executive order, regulation, or where the Secretary of Agriculture or Chief of the FS has withdrawn the land from timber production.

Technical factor (36 CFR 219.11(a))	Summary of description (FSH 1909.61.1)
(iv) The technology is not currently available for conducting harvest without causing irreversible damage to soil, slope, or other watershed conditions.	Lands not suited because technology to harvest timber without causing irreversible damage is not currently available may include areas where soils, geology, or other physical site conditions are such that harvest may cause irreversible damage, or where tree regeneration and growth is severely inhibited.
(v) There is no reasonable assurance that such lands can be adequately restocked within 5 years after regeneration harvest.	The Responsible Official should identify criteria for what constitutes adequate restocking after final regeneration harvests for timber production. Specific land types, soil types, and vegetative conditions should be evaluated for appropriate management systems to assess if reasonable assurance exists that the lands can be regenerated to achieve adequate restocking 5 years after final regeneration harvest.
(vi) The land is not forest land	Lands less than 10% occupied by trees or that formerly had tree cover but are developed for nonforest uses (e.g., agriculture, improved roads, recreation areas, powerlines). Lands that were formerly occupied by tree cover, but do not have tree cover, should be identified as nonforest unless the land will be regenerated in the near future. Canopy cover of live trees at maturity may be used to estimate if an area is at least 10% occupied. Unimproved roads, trails, intermittent or small perennial streams, and clearings may be included as forest if < 120’ wide.

A spatial analysis was conducted to methodically subtract unsuitable lands from the total land area based on the legal or technical factors. The areas were eliminated in the order shown; therefore, factors that were eliminated first may encompass conditions that would have been eliminated in later steps. Due to the resolution of data sources, there are likely inclusions of suitable lands in unsuitable areas and vice versa.

Table 54. Exclusions from lands that may be suitable for timber production

Factor	Areas eliminated	Acres
	Total NFS lands	**2,883,227**
36 CFR 219.11(a) (i) and (ii)	Designated wilderness	564,082
	Designated wild and scenic rivers	0
	Rocky Mountain Front Conservation Management Area	196,132
	Wilderness study act areas	168,268
	Research natural areas	11,919
	Tenderfoot Experimental Forest	7,671
	Inventoried roadless areas	1,010,643
	Total acres eliminated for this factor	*1,958,714*
36 CFR 219.11(a) (vi)	Administrative sites and campgrounds[1]	166
	Roads, railroads, and utility corridors[2]	19,805
	Water bodies and streams >120’ wide	927
	Nonforest lifeforms[3]	148,374
	Total acres eliminated for this factor	*169,271*
	Areas with soil stability or damage concerns[4]	15,156
	Areas with low growth/regeneration potential[5]	72,957

Factor	Areas eliminated	Acres
36 CFR 219.11(a) (iv) and (v)	*Total acres eliminated for this factor*	*88,113*
	Lands that may be suitable for timber production	**667,129**

1 The latest administrative site and campground layers were utilized, applying a 200' buffer.
2 All roads not planned for decommissioning are assumed to be "improved". Line files provided by Northwestern Energy were used. A 33' width buffer was applied to roads, corridors, and railroads.
3 Nonforest lifeforms were depicted by VMap classes of water, sparse, herb, shrub, or urban; or Ecoclass of Scree; unless recent fires or harvest had occurred, and the potential vegetation type was forested.
4 Average slopes >80%; severe slump/mass failure risk; or percent slope >50% and bedrock type of slide deposits.
5 Areas with a potential vegetation type of sparse, limber pine, whitebark pine, subalpine larch, juniper, alpine, poplar/aspen, or ripdecid; or a tree growth composite index of 5 or 6 unless recently disturbed; or a tree growth composite index of 4 and dominated by juniper, whitebark pine, limber pine, or tree canopy <10% unless recently disturbed. These areas were also reviewed and modified with input from local resource specialists.

Lands that are suitable for timber production, by alternative

The identification of lands that are suitable for timber production in each alternative is based on compatibility with desired conditions and objectives (USDA, 2015), and are a subset of the lands that may be suited described above. These lands are identified based on the desired conditions, goals, and objectives developed for the 2020 Forest Plan and for each alternative.

Table 55. Criteria for identification of lands suited for timber production

Factor	Description in FSH 1909.61.2
36 CFR 219.11(a) (iii) Timber production would not be compatible with the achievement of desired conditions and objectives established by the plan	The Responsible Official should consider the following to determine if timber production is compatible with the desired conditions and objectives of the plan: Timber production is a desired primary or secondary use of the land; Timber production is anticipated to continue after desired conditions have been achieved; A flow of timber can be planned and scheduled on a reasonably predictable basis; Regeneration of the stand is intended; Timber production is compatible with the desired conditions or objectives for the land designed to fulfill the requirements of 36 CFR 219.9 to 219.10.

Lands suitable for timber production were mapped for the initial proposed action, which was made available for public scoping. Timber harvest, volume outputs, and lands suitable for timber production were identified as a key or significant issue based on the public comments received. Therefore, it was one element that drove the development of alternatives, as described in Table 56.

Table 56. Determination of lands suitable for timber production by alternative

Alternative	Considerations and rationale
Alternative A, No Action	Suitability for timber production was mapped as defined in the 1986 plans, and updated to reflect the regulatory changes that have occurred since then. The primary change incorporated was the removal of suitability where IRAs were established. It was also updated to be consistent with the new may be suited layer in terms of the technical factors (e.g., forested lands), because it is based on new data. RMZs are excluded west of the Divide (consistent with RHCAs under INFISH).
All Action Alternatives	The following areas were excluded from lands suitable for timber production, because timber production is not compatible with other resource plan components and would not be a primary or secondary management objective: • Eligible wild and scenic river corridors

Alternative	Considerations and rationale
	• Inner and outer RMZs • Elkhorns Wildlife Management Unit • Missouri River and Smith River corridors • Tenderfoot land acquisition area • The Badger-Two Medicine area • Cultural/historical sites: Alice Creek Historic District, Chinese/Robertson Wall, Mann Gulch Historic District, Lincoln Gulch Historic District • RWAs (*amount/location varies by alternative*) • Areas with poor access and low harvest feasibility, indicated by ROS Primitive or Semi-Primitive Non-motorized (*amount/location varies by alternative*)
Alternatives B, C, and D	Additional areas eliminated from lands suitable for timber production included the Highwoods GA, Snowies GA, and the Dry Range portion of the Big Belts GA due to marginal productivity and limited feasibility; and the South Hills Recreation Area because timber production would not be a primary or secondary management objective.
Alternative E	The South Hills Recreation area is not in this alternative; the lands that may be suited in this area are included as suitable for timber production. Also keep suitability in those portions of the Highwoods, Snowies, and Dry Range (Big Belts) GAs that may be suited.
Alternative F	Retain timber suitability in the Dry Range of the Big Belts GA and in the Little Snowies portion of the Snowies GA, as in Alt E. Eliminate suitability from the South Hills Recreation area as in Alts B/C/D.

The following tables provide the acres and percent of land area determined to be suitable for timber production by alternative, at the forestwide scale and for each GA.

Table 57. Lands suitable for timber production by alternative (acres and percent)

Land classification category	Alt A	Alt B/C	Alt D	Alt E	Alt F
A. Total NFS lands in the plan area	2,883,227	2,883,227	2,883,227	2,883,227	2,883,227
B. Lands not suited for timber production due to legal or technical reasons.	2,216,098	2,216,098	2,216,098	2,216,098	2,216,098
C. Lands that may be suited for timber production (alternatives A and B)	667,129	667,129	667,129	667,129	667,129
D. Total lands suited for timber production because timber production is compatible with the desired conditions and objectives established by the plan	**414,936 (14%)**	**356,633 (12%)**	**348,586 (12%)**	**384,199 (13%)**	**368,814 (13%)**
E. Lands not suited for timber production because timber production is not compatible with desired conditions and objectives established by the plan (alternatives C and D)	252,193	310,496	318,543	282,930	298,315
F. Total lands not suited for timber production (alternatives B and E)	2,468,291 (86%)	2,526,594 (88%)	2,534,641 (88%)	2,499,028 (87%)	2,514,413 (87%)

Table 58. NFS land suitable for timber production by GA and alternative (acres and percent)

GA	Alternative A		Alternatives B/C		Alternative D		Alternative E		Alternative F	
Big Belts	43,538	14%	53,937	17%	53,879	17%	55,476	18%	54,701	17%
Castles	17,743	25%	15,084	22%	14,601	21%	15,084	22%	15,084	22%
Crazies	12,826	22%	5,353	9%	4,971	9%	5,701	10%	5,353	9%
Divide	70,095	35%	53,152	26%	50,866	25%	61,299	30%	54,387	27%
Elkhorns	0	0%	0	0%	0	0%	0	0%	0	0
Highwoods	1,170	3%	0	0%	0	0%	741	2%	0	0
Little Belts	208,968	26%	187,412	23%	182,573	23%	187,417	23%	187,412	23%
Rocky Mountain	1,683	<1%	0	0%	0	0%	0	0%	0	0
Snowies	16,028	14%	0	0%	0	0%	14,425	12%	9,531	8%
Upper Blackfoot	42,887	13%	41,696	12%	41,696	12%	44,056	13%	42,348	13%

Lands unsuitable for timber production, where harvest can occur

Lands where harvest is not permitted include designated wilderness, wilderness study areas, research natural areas, and recommended wilderness (RWA). Harvest may occur on the remainder of lands unsuitable for timber production for other multiple use purposes, although it may be constrained by plan components. Constraints which are limiting include those applied to IRAs, which make up a large percentage of the unsuitable lands. For this reason, lands where harvest may occur are summarized including and excluding IRAs. Other lands where harvest is permitted that would be particularly constrained or limited include wild and scenic river corridors, RMZs, and primitive and semi-primitive non-motorized ROS settings. The summary of lands where harvest can occur includes nonforested vegetation, because it may be possible that harvest could occur in sparsely forested areas.

In alternative A, the management areas where harvest is never allowed include N-1, P-1, and P-3 on the Helena NF; and M, N, P, and Q on the Lewis & Clark NF. Updates were made to incorporate wilderness additions that would apply to this alternative (Rocky Mountain Range GA). For the action alternatives, there are no management areas, but land allocations where harvest can never occur as listed above were excluded. Table 59 shows a summary of all lands unsuitable for timber production, and the proportions thereof where harvest may occur, including and excluding IRAs. Table 60 shows this information by GA.

Table 59. NFS lands unsuitable for timber production where harvest may occur by alternative (acres/% of all NFS lands)

	Including IRAs	Excluding IRAs
Alternative A	1,654,916 (57%)	521,619 (18%)
Alternative B/C	1,654,935 (57%)	571,126 (20%)
Alternative D	1,455,781 (50%)	551,631 (19%)
Alternative E	1,749,318 (61%)	548,815 (19%)
Alternative F	1,673,853 (58%)	561,696 (19%)

Table 60. NFS lands unsuitable for timber production where harvest can occur by GA and alternative (acres and percent)

Geographic Area	Alternative A		Alternatives B/C		Alternative D		Alternative E		Alternative F	
	Total	Without IRAs	Total	Without IRAs	Total	Without IRAs	Total	Without IRAs	Total	Without IRAs
Big Belts	222,578 (71%)	92,867 (29%)	214,231 (68%)	81,824 (26%)	191,939 (61%)	81,548 (26%)	228,062 (72%)	80,887 (26%)	213,692 (68%)	81,110 (26%)
Castles	51,966 (75%)	22,584 (32%)	54,625 (78%)	25,243 (36%)	24,502 (35%)	23,517 (34%)	54,625 (78%)	25,243 (36%)	54,625 (78%)	25,243 (36%)
Crazies	44,842 (78%)	7,300 (13%)	52,315 (91%)	14,767 (26%)	27,728 (48%)	12,403 (22%)	51,966 (90%)	14,419 (25%)	52,315 (91%)	14,767 (26%)
Divide	115,817 (57%)	68,459 (34%)	116,003 (57%)	82,055 (40%)	90,134 (44%)	77,043 (38%)	140,112 (69%)	76,092 (38%)	114,072 (56%)	82,749 (41%)
Elkhorns	161,251 (100%)	86,501 (54%)	161,251 (100%)	86,501 (54%)	156,745 (97%)	86,494 (54%)	161,251 (100%)	86,501 (54%)	159,673 (99%)	86,501 (54%)
Highwoods	42,291 (97%)	1,487 (4%)	42,291 (100%)	2,657 (6%)	42,291 (100%)	2,657 (6%)	41,545 (98%)	1,911 (5%)	42,291 (100%)	2,657 (6%)
Little Belts	510,015 (63%)	153,500 (19%)	516,156 (64%)	174,139 (22%)	424,378 (53%)	164,030 (20%)	530,620 (66%)	174,114 (22%)	530,646 (66%)	174,139 (22%)
Rocky Mountain Range	290,086 (37%)	30,467 (4%)	324,932 (42%)	32,245 (4%)	324,932 (42%)	32,245 (4%)	324,932 (42%)	32,245 (4%)	324,932 (42%)	32,245 (4%)
Snowies	13,289 (11%)	4,238 (4%)	22,241 (19%)	19,786 (17%)	22,244 (19%)	19,786 (17%)	14,892 (13%)	5,841 (5%)	14,084 (12%)	10,520 (9%)
Upper Blackfoot	203,953 (61%)	54,216 (16%)	150,892 (45%)	51,908 (16%)	150,892 (45%)	51,908 (16%)	201,314 (60%)	51,563 (15%)	167,524 (50%)	51,763 (16%)

Results

PRISM model results

Budget

The PRISM model was run both with and without a constrained budget, to display the possible outcomes of a scenario in which budgets were unlimited but all resource constraints and desired conditions applied. The "unconstrained budget" runs represent a theoretical ecological maximum amount of timber harvest that could occur in the 2020 Forest Plan and still be consistent with all plan components. The figure below displays how much additional funding would be needed, above the foreseeable budget level of approximately $5.32M/year, to achieve the outcomes displayed in the unconstrained budget scenario. The amount needed in the early decades is greater than that in the later decades. The alternatives are generally similar, although alternative E tends to require the most additional funding and alternative A the least.

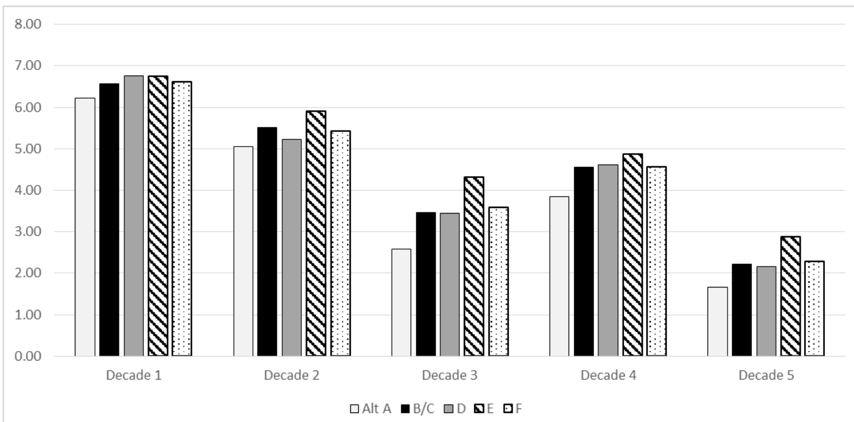


Figure 63. $(M) needed per year above constrained budget to achieve unconstrained model outcomes

Acres of vegetation treatments

Timber Harvest

Harvest modeled in PRISM is of two general types: even-aged regeneration, and non-regeneration. The model scheduled treatments based on the condition of the landscape and the ability of treatments to move the forest towards the desired conditions, while considering all constraints.

Table 61 displays the total harvest acres by alternative projected to occur (on both lands suitable and unsuitable for timber production) in the first 2 decades of the plan period. Figure 64 displays this information for 5 decades. Under the constrained budget scenario, alternative E harvests the least number of acres. This is because alternative E achieves its objective of maximizing timber production by harvesting fewer, but higher volume, acres, whereas the other alternatives harvest more, but lower volume acres, to achieve their objective of maximizing the desired condition. Preferred alternative F represents a compromise between these two approaches. Although all desired conditions had an influence, the primary desired conditions that influenced the model to schedule harvest were increasing ponderosa pine and the large tree size class, because these desired conditions are different than the existing condition. Alternative E was modeled to maximize timber production as a priority in addition to achieving desired conditions; this was done to provide a range of possible management emphases. Under an unconstrained budget scenario, all alternatives are fairly similar, with alternative E harvesting the most acres. This is because without a budget constraint, alternative E can schedule additional harvests that both maximize timber production and achieve desired conditions.

Table 61. Average annual acres treated by treatment type by alternative, decades 1 and 2, with and without a reasonably foreseeable budget constraint

Type and decade of harvest		Alt A	Alts B/C	Alt D	Alt E	Alt F
Even-aged regeneration harvest	Decade 1 Constrained	2004	2139	2070	1396	2279
	Decade 1 Unconstrained	3213	3195	3119	3464	3255
	Decade 2 Constrained	957	847	887	1919	1760
	Decade 2 Unconstrained	1362	1423	1320	1557	1426
Other harvest	Decade 1 Constrained	67	37	31	739	0
	Decade 1 Unconstrained	1039	1781	1747	2000	1686
	Decade 2 Constrained	1959	2000	2000	0	950
	Decade 2 Unconstrained	2099	2000	2000	2000	2000
Total harvest	Decade 1 Constrained	2072	2176	2101	2134	2279
	Decade 1 Unconstrained	4252	4976	4867	5464	4942
	Decade 2 Constrained	3461	2847	2887	1919	2709
	Decade 2 Unconstrained	4,599	3423	3320	3557	3426

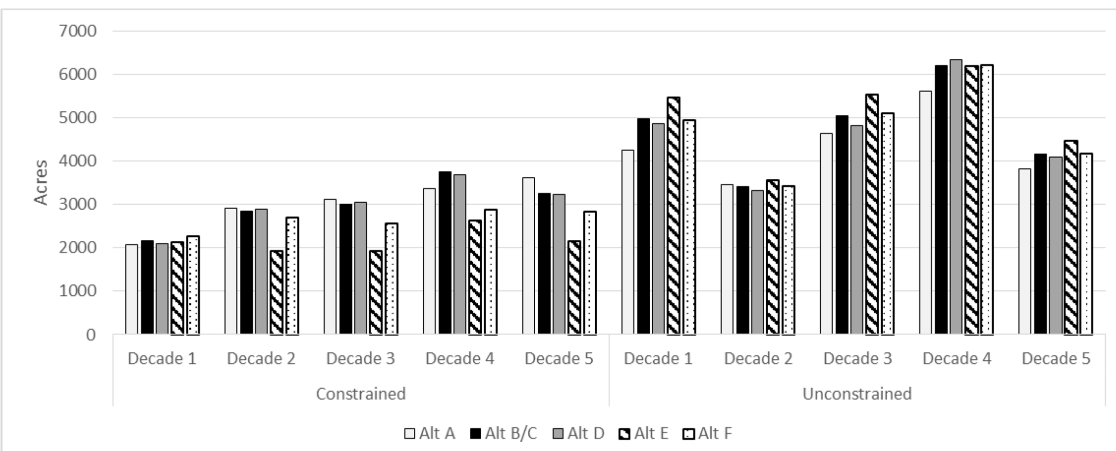


Figure 64. Harvest average acres per year by decade, by alternative, with and without budget constraint

The model predicts a mix of even-aged regeneration harvest and other harvest (intermediate and uneven-aged harvest). The ratio of these harvest types varies by decade, depending on the most optimum solution identified by the model. PRISM generally projected a higher proportion of even-aged regeneration harvest as opposed to intermediate harvest. This was in part due to the desired conditions specified which are not always translated intuitively by the model. For example, a 2-aged shelterwood harvest is a common prescription used on the HLC NF, wherein a very open overstory is retained indefinitely, but the stand is classified as a regeneration harvest because a new cohort is established. Based on yield table information, the model considers the residual overstory to contribute to a large size class condition. Therefore, the model could efficiently meet a large size class desired condition while also producing timber volume, and it selected this prescription fairly frequently. In practice, intermediate harvests are often utilized to meet a large size class desired condition, by removing smaller trees and retaining a fully stocked stand dominated by larger trees. During plan implementation, the appropriate prescription and type of harvest for a stand would be determined site-specifically during project design and analysis, based on the suite of desired conditions in the forest plan.

Figure 65 displays the projected acres of timber harvest by type for a five-decade period, on lands both suitable and unsuitable for timber production, assuming a reasonably foreseeable budget. The model tends to schedule regeneration harvest more-so than other types of harvest, as the most rapid method to achieving the prescribed desired conditions.

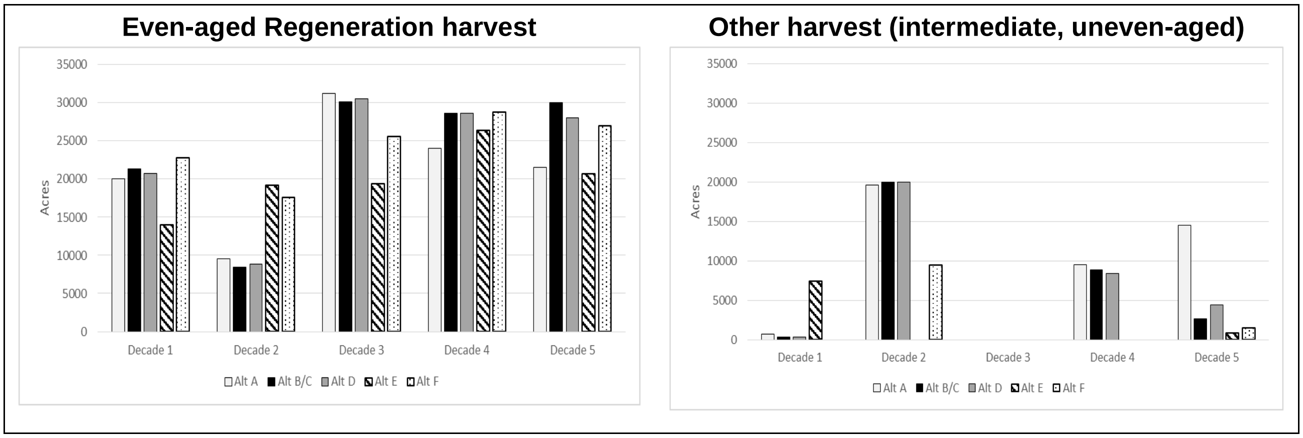


Figure 65. Harvest average acres per year by decade, alternative, and harvest type, reasonably foreseeable budget

Prescribed burning

Prescribed burning was also scheduled by PRISM. Two types are included: low severity burning as an intermediate treatment or site preparation activity within a harvest prescription; and ecosystem burning that occurs as its own stand-alone prescription which could occur with a variety of severities depending on the vegetation conditions. The total acres include both types. Under the constrained budget scenario alternatives B/C and D, followed by F, burn the most acres while alternative E burns the least.

Table 62. Average annual acres burned by alternative, decades 1 and 2

	Alt A	Alts B/C	Alt D	Alt E	Alt F
Decade 1 constrained	3,018	3,072	3,108	3,019	3,165
Decade 1 unconstrained	10,000	10,000	10,000	10,000	10,000
Decade 2 constrained	4,264	4,247	4,015	2,813	3,565
Decade 2 unconstrained	10,000	10,000	10,000	10,000	10,000

Burning includes prescribed burning in harvested stands, and stand-alone ecosystem burning in forested types.

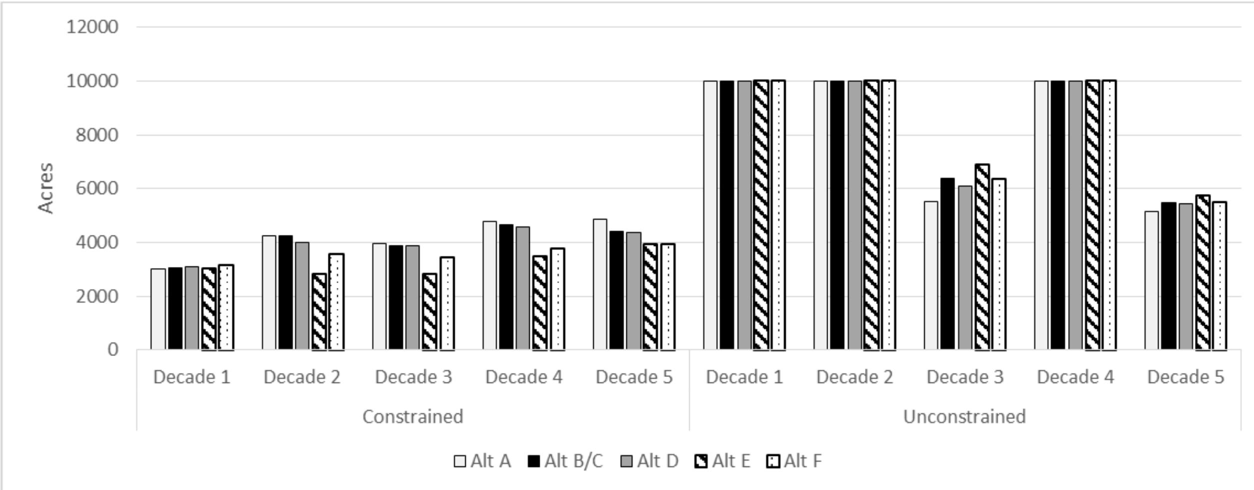


Figure 66. Prescribed burning average acres/year by decade, by alternative, with and without a budget constraint

The figures below display the acres of prescribed fire in forested types projected to occur in lands suitable versus unsuitable for timber production, with and without a budget constraint. The model tends to schedule burning associated with timber harvest. However, this is the result of several attributes of the vegetation desired condition and does not take into account other desired conditions in the Plan. Under a constrained budget, alternative E tends to apply less burning due to its objective of utilizing its budget to maximize timber outputs. Alternative A tends to apply the most burning, followed by B/C and D. The amount burning in lands suitable versus unsuitable for timber production is relatively even. However, in an unconstrained budget scenario, the model places more burning on unsuitable lands, because it has the funds to do so after also achieving desired timber outputs. Under this scenario, it varies by decade and land classification as to which alternative applies the most burning.

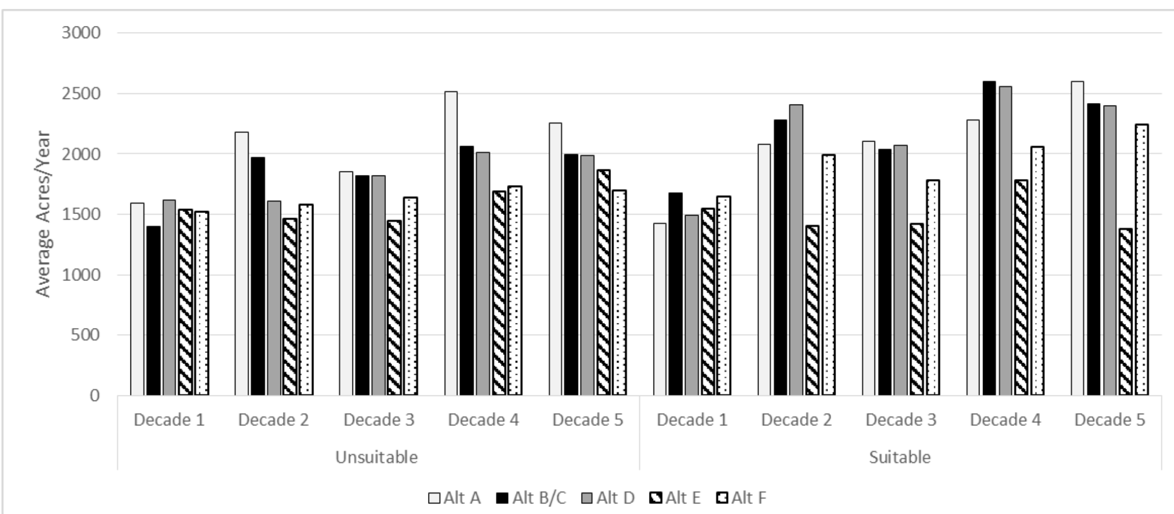


Figure 67. Prescribed burning on lands suitable versus unsuitable for timber production, by alternative and decade – with a constrained budget

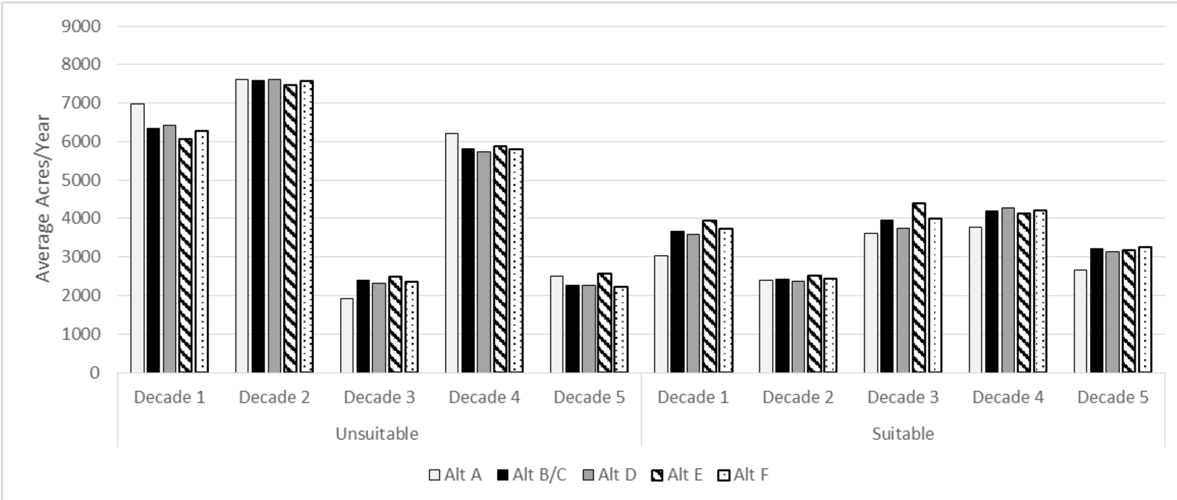


Figure 68. Prescribed burning on lands suitable versus unsuitable for timber production, by alternative and decade – with an unconstrained budget

Sustained yield limit

PRISM provides an estimate of the sustained yield limit, as required by the 2012 planning rule and associated directives. The sustained yield limit is the amount of timber meeting applicable utilization standards that can be removed from a forest annually in perpetuity on a sustained yield basis from all lands that may be suitable for timber production. It does not include potential salvage or sanitation harvest that may occur in response to disturbances. It is not limited by desired conditions, other plan components (resource constraints), or the HLC NF's fiscal capability or organizational capacity. Sustained yield limits must be calculated for each proclaimed forest; these values are reflected in FW-TIM-STD-07.

Table 63. Sustained yield limit for the HLC NF

	SYL – mmcf	SYL - mmbf
Helena National Forest	5.75	31.21
Lewis & Clark National Forest	4.95	26.36
HLC Combined Forest	10.7	57.57

The projected timber sale quantity may not exceed this amount, unless a departure limit is specified by the responsible official for the first decade or two of the plan to achieve multiple-use management objectives. However, the projected timber sale quantity does not approach sustained yield limit under any alternative or budget scenario due to other resource constraints.

Timber volume outputs: PTSQ and PWSQ

PRISM provides estimates of the timber volume outputs expected to be sold during the life of the plan, as required by the 2012 planning rule and associated directives. Projected timber sale quantity (PTSQ) is the volume of timber that meets sawlog specifications. Projected wood sale quantity includes the PTSQ timber volume plus other wood products such as nonsaw and biomass and firewood. Neither of these estimates includes potential salvage or sanitation harvest. Estimates are shown with and without a budget constraint (Table 64, Figure 69).

Table 64. Average annual projected timber and wood sale quantities by alternative – decades 1 and 2

Category	Decade	Alt A		Alts B/C		Alt D		Alt E		Alt F	
		mmcf	mmbf	mmcf	mmbf	mmcf	mmbf	mmcf	mmbf	mmcf	mmbf
With a reasonably foreseeable budget constraint											
Timber Products[1] A1. Lands suitable for timber production	1	3.37	16.21	3.72	17.76	3.55	17.03	4.43	21.61	3.98	19.05
	2	3.30	15.51	3.86	18.13	4.11	19.32	4.44	21.88	4.22	19.99
Timber Products[1] A2. Lands not suitable for timber production	1	1.33	6.28	1.13	5.47	1.32	6.30	2.27	11.21	1.72	8.25
	2	1.40	6.57	0.99	4.55	0.76	3.49	2.26	11.08	1.48	7.03
Projected Timber Sale Quantity[1] (PTSQ, A1 + A2)	1	4.70	22.49	4.85	23.23	4.87	23.33	6.70	32.82	5.70	27.30
	2	4.70	22.07	4.85	22.68	4.87	22.81	6.70	32.96	5.70	27.03
Other Wood Products[2] B. All lands	1	2.06	3.37	2.07	3.48	2.08	3.50	2.36	4.92	2.21	4.10
	2	2.06	3.31	2.07	3.40	2.08	3.42	2.36	4.94	2.21	4.05
Projected Wood Sale Quantity[3] (PWSQ, A1+A2+B)	1	6.76	25.86	6.92	26.71	6.95	26.83	9.06	37.74	7.91	31.40
	2	6.76	25.38	6.92	26.09	6.95	26.23	9.06	37.91	7.91	31.08
Without a reasonably foreseeable budget constraint											
Timber Products[1] A1. Lands suitable for timber production	1	5.38	25.46	5.47	25.88	5.33	25.19	6.08	28.76	5.66	26.78
	2	3.79	18.01	5.32	25.56	5.24	25.15	5.51	26.50	5.28	25.37
Timber Products[1] A2. Lands not suitable for timber production	1	1.82	8.59	2.42	11.54	2.39	11.35	2.62	12.44	2.27	10.82
	2	3.41	16.41	2.57	12.28	2.48	11.86	3.19	15.32	2.65	12.62
Projected Timber Sale Quantity1 (PTSQ, A1 + A2)	1	7.20	34.05	7.89	37.41	7.71	36.54	8.70	41.20	7.93	37.60
	2	7.20	34.42	7.89	37.83	7.71	37.01	8.70	41.82	7.93	37.98
Other Wood Products[2] B. All lands	1	2.43	5.11	2.54	5.61	2.51	5.48	2.66	6.18	2.54	5.64
	2	2.43	5.16	2.54	5.67	2.51	5.55	2.66	6.27	2.54	5.70
Projected Wood Sale Quantity[3] (PWSQ, A1+A2+B)	1	9.63	39.16	10.43	43.03	10.22	42.02	11.36	47.38	10.47	43.24
	2	9.63	39.58	10.43	43.51	10.22	42.57	11.36	48.10	10.47	43.68
Amount annual budget would need to increase[4]	1	$6.22 M		$6.57 M		$6.76 M		$6.75 M		$6.62 M	
	2	$5.06 M		$5.52 M		$5.23 M		$5.9 M		$5.42 M	

1 Projected timber sale quantity (PTSQ) includes volumes (other than salvage or sanitation) that meet timber product utilization standards.
2 Other Wood Products - Fuelwood, biomass, and other volumes that do not meet timber product utilization standards (small diameter 3 -7 inches).
3 Projected wood sale quantity consists of the projected timber sale quantity as well as other woody material such as fuelwood, firewood, or biomass.
4 This displays the amount of money needed per year above the current budget constraint of $5.322M to achieve the projected volume outputs.

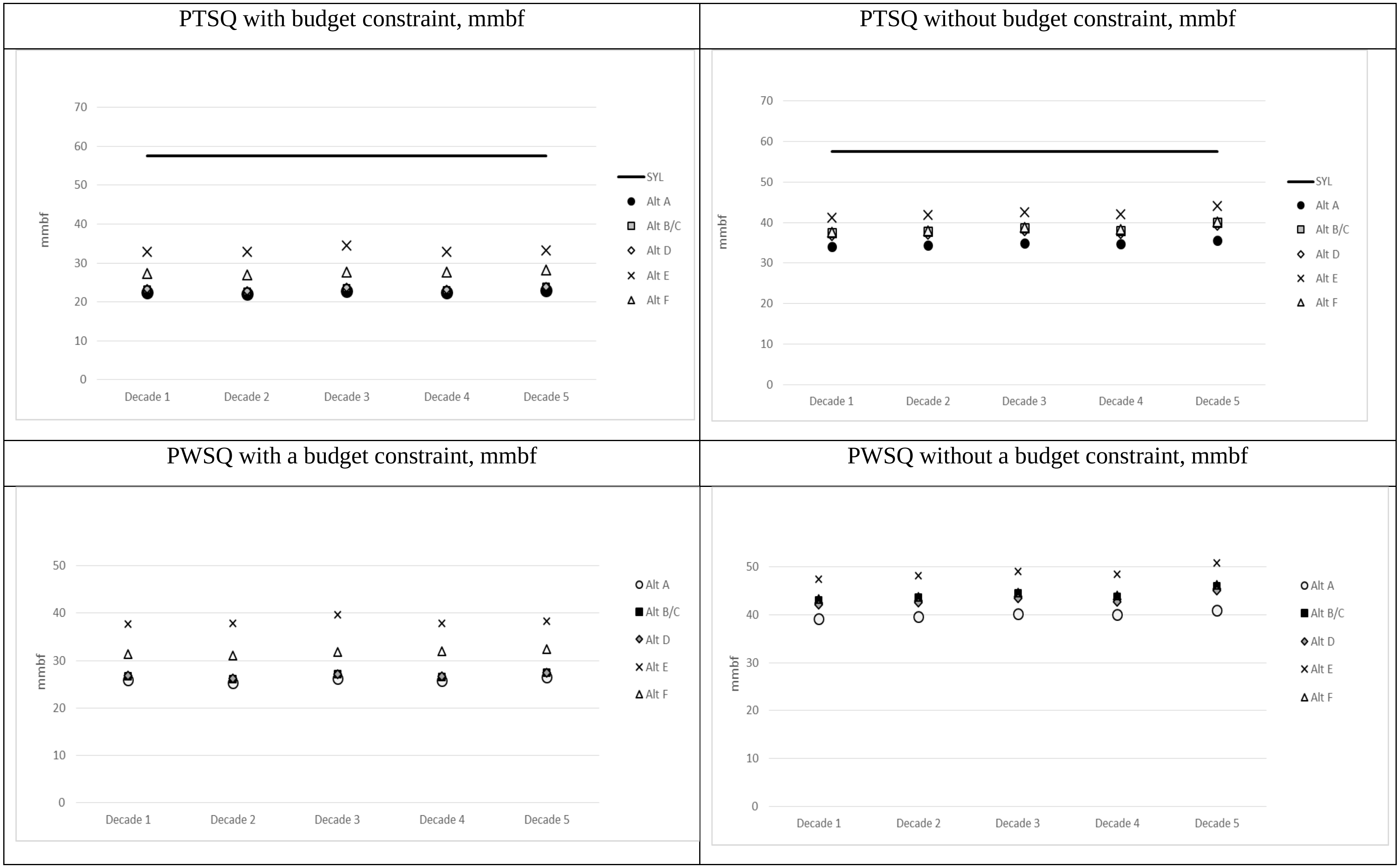


Figure 69. Projected timber sale quantities (average annual mmbf) by alternative

Departure score

In the PRISM model, every acre that is not within the desired condition minimum and maximum is assigned a “penalty point”; these points are totaled together to determine a “departure score” from the desired condition. Penalty points can accrue in any time period in the model. The objective is to minimize total penalty points, and therefore have the lowest departure score possible. The departure scores provide a relative comparison of how well treatments in PRISM contribute to terrestrial vegetation desired conditions. The desired conditions utilized by PRISM are vegetation type (cover type by PVT), size class, and density class. The many other desired conditions in the 2020 Forest Plan are not represented by this model. The departure scores indicate that with respect to vegetation desired conditions, under the constrained budget alternative E results in the poorest condition. Alternatives A, B/C, and D are all similar, and alternative F performs slightly less well but much better than alternative E. However, when the budget limitation is removed, all alternatives perform similarly well, because the model was able to assign actions that both met the timber goals (as in alternative E) and maximized the attainment of desired condition. Under this scenario, alternative A performs the poorest, and alternative E is the best. Preferred alternative F, as well as B/C and D, perform only slightly more poorly than alternative E.

Hazard to disturbances

Hazard to several disturbances was assessed in the PRISM model, utilizing hazard ratings applied to yield tables. The results do not include the iterative modeling with climate and disturbances that SIMPPLLE provides. Results reflect the hazard to these disturbances based on stand characteristics, and do not indicate expected acres affected (refer to SIMPPLLE model results).

The hazard of stand replacing fire in forested vegetation types was estimated using the fire and fuels (FFE) extension of the Forest Vegetation Simulator. The budget constraint does not substantially impact this attribute; while fire hazard is likely reduced in areas treated by harvest or fire, the difference in acres treated between the constrained and unconstrained runs are minor in comparison to the entire landbase.

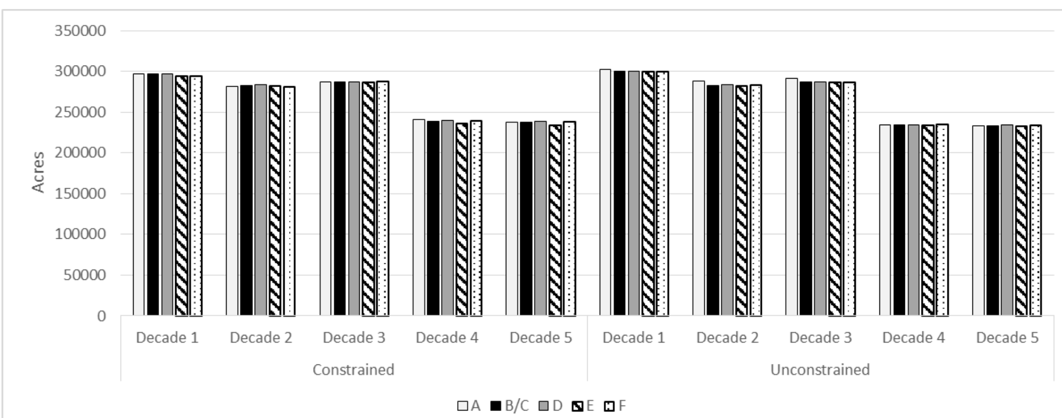


Figure 70. Acres with high hazard of stand replacing fire by alternative, with and without a budget constraint

Hazard to bark beetles (mountain pine beetle in lodgepole pine and Douglas-fir beetle) and defoliators (western spruce budworm) were developed using the Forest Vegetation Simulator (Randall & Bush, 2010). Figure 71 shows that the hazard to Douglas-fir beetle generally increases over time, as large Douglas-fir forests are promoted, but is variable depending on alternative and budget scenario. The hazard to mountain pine beetle in lodgepole pine (Figure 72) tends to decrease over time, with all alternatives being similar and not a large variance between the constrained and unconstrained budget scenarios, although the unconstrained scenario results in slightly lower acres of high hazard in decades 4 and 5. The hazard to mountain pine beetle in ponderosa pine (Figure 73) is more sensitive to alternative and budget scenario, with lower acres with a high hazard resulting from the unconstrained budget scenario. Overall the hazard increases slightly over time but not to a great degree. High hazard to western spruce budworm (Figure 74) declines over time under all alternatives and budget scenarios, due in part to vegetation treatments but likely to natural processes to a greater degree. All alternatives are similar to one another. The unconstrained budget run results in a slightly lower amount of acres with high hazard to this pest than the constrained budget run, indicating there is some influence from vegetation treatments.

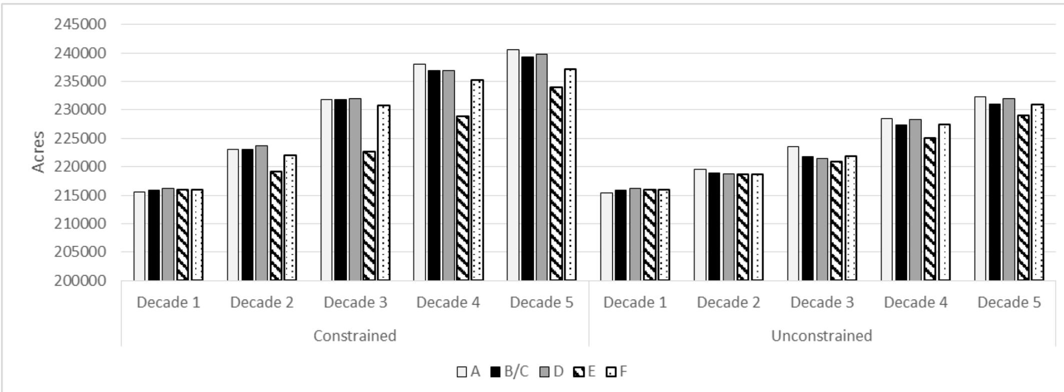


Figure 71. Acres with high hazard to Douglas-fir beetle infestation by alternative, with and without a budget constraint

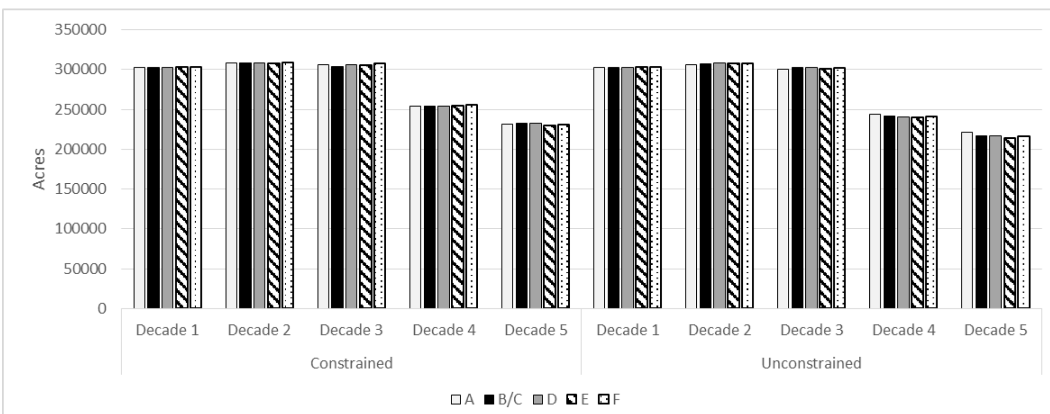


Figure 72. Acres with high hazard to mountain pine beetle infestation in lodgepole pine by alternative, with and without a budget constraint

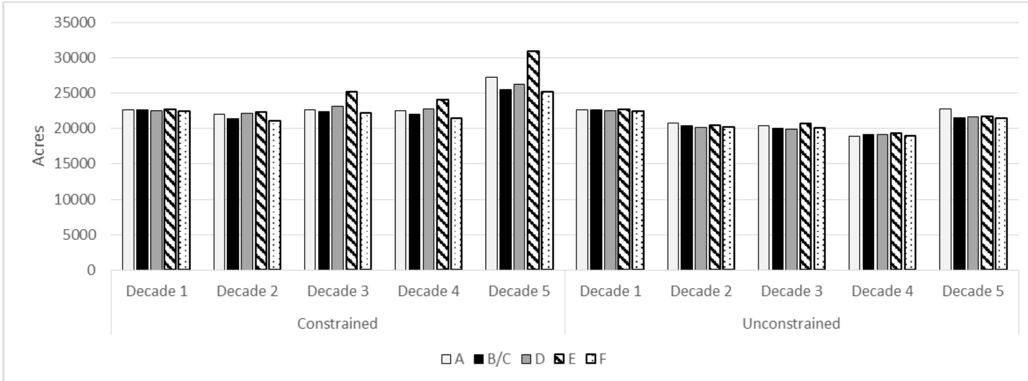


Figure 73. Acres with high hazard to mountain pine beetle infestation in ponderosa pine by alternative, with and without a budget constraint

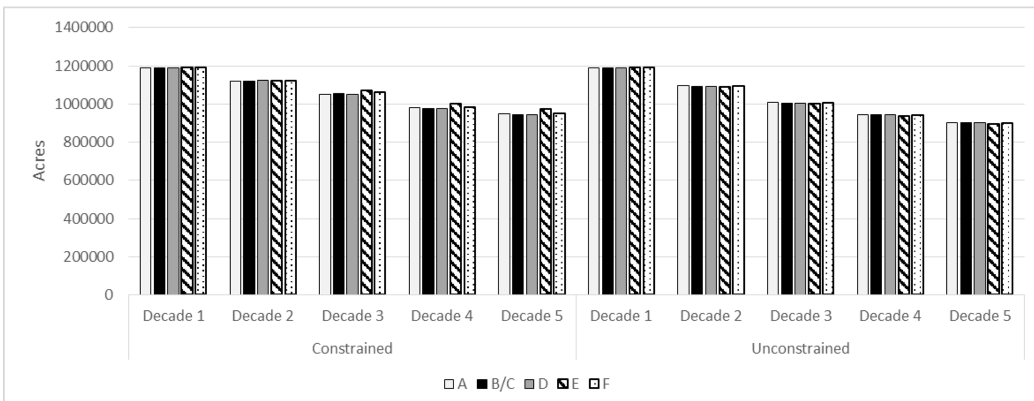


Figure 74. Acres with high hazard of defoliation by alternative, with and without a budget constraint

Sensitivity analysis

Sensitivity analysis is conducted to examine the trade-offs caused by constraints and determine if the PRISM model is working correctly. Eight runs were made to test the major features and the effect of constraints. The sensitivity analysis runs used the data from alternative B, but results would be similar for all alternatives. All runs were made with the objective to move towards vegetation desired future condition. Table 65 describes the sensitivity analysis runs. Runs 1 through 6 are hierarchical, each building on the parameters included in the previous run to assess the incremental effect of adding constraints. Runs 7 and 8 isolate the effects of lynx and budget, respectively, against the baseline.

Table 65. Type, description, and purpose of sensitivity analysis modeling runs

Run	Description and purpose
1	Baseline run. Model included only harvest flow and ending inventory constraints. The purpose of this run is to provide for comparison of the effect of other constraints.
2	Includes parameters for Run 1, plus the Management Area Group (MAG) treatment intensity constraints. These constraints ensured that the model focused harvest intensity in the appropriate areas (i.e., lands suitable for timber production).
3	Includes parameters for Runs 1 & 2, plus opening limits. The opening limits were designed to ensure harvests were distributed appropriately across the landscape.

Run	Description and purpose
4	Includes parameters for Runs 1, 2, & 3, plus lynx constraints. Lynx constraints were designed to ensure the Northern Rockies Lynx Management Direction is followed.
5	Includes parameters for Runs 1, 2, 3, & 4, plus additional operational limits (such as the minimum/maximum acres possible for burning, the appropriate silvicultural mix).
6	Includes parameters for Runs 1, 2, 3, 4, & 5 plus adds the budget constraint.
7	Includes parameters for Run 1 (baseline), plus the lynx constraints. This was done to isolate and understand the impact of lynx direction given no other model constraints.
8	Includes parameters for Run 1 (baseline), plus the budget constraint. This was done to isolate and understand the impact of the reasonably foreseeable budget constraint.

The results of the sensitivity analysis are displayed by comparing selected outputs. For most attributes, the budget and management area group (i.e., land allocations) constraints were the most constraining factor. For all outputs, runs 2 and 3 were identical, indicating that the opening limitations were not constraining. Therefore, run 3 is not compared in detail.

Departure score

The first attributes compared is the departure score (Figure 75). This score indicates the amount of penalty points incurred by the run. The points are accumulated over all 15 decades. The best (lowest) score is attained under the baseline run (#1), with the most flexibility in management and no constraints.

- Management area group constraints (run 2 versus 1) reduce attainment of desired condition 39% compared to the baseline.
- Lynx constraints (run 4 versus 2) incrementally reduce the attainment of desired condition an additional 0.56%. Lynx constraints independent of other variables (run 7 versus 1) reduce attainment of desired condition 0.07% compared to the baseline.
- Operational constraints (run 5 versus 4), incrementally reduce attainment of desired condition an additional 6.7%.
- Budget constraints (run 6 versus 5) incrementally reduce attainment of desired condition an additional 18%. Budget constraints independent of all other variables (run 8 versus run 1) reduce attainment of desired condition 38% compared to the baseline.
-

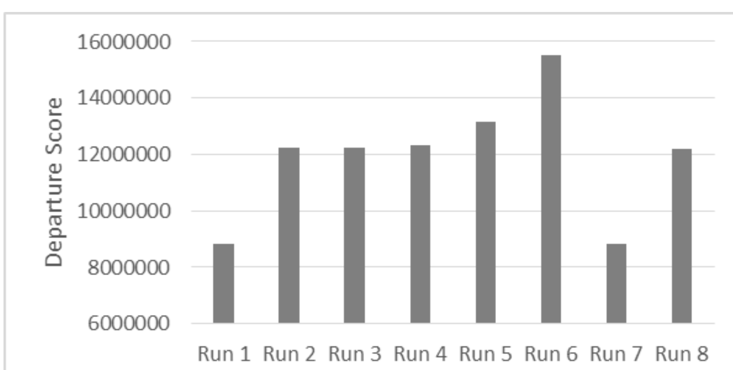


Figure 75. Departure score across PRISM sensitivity runs

Projected timber sale quantity

The second attribute compared was projected timber sale quantity (PTSQ). The summary compares the impact of constraints on the PTSQ estimated for Decade 1 of the planning period. Budget and management area constraints are the most influential. The impacts of lynx constraints are very minor.

- Management area group constraints (run 2 versus 1) reduce PTSQ 19% compared to the baseline.
- Lynx constraints (run 4 versus 2) incrementally reduce PTSQ 1.36%. Lynx constraints independent of other variables (run 7 versus 1) reduce PTSQ 0% compared to the baseline.
- Operational constraints (run 5 versus run 4) incrementally reduce PTSQ 2.68%.
- Budget constraints (run 6 versus 5) incrementally reduce PTSQ an additional 42%. Budget constraints independent of other variables (run 8 versus run 1) reduce PTSQ 54%.

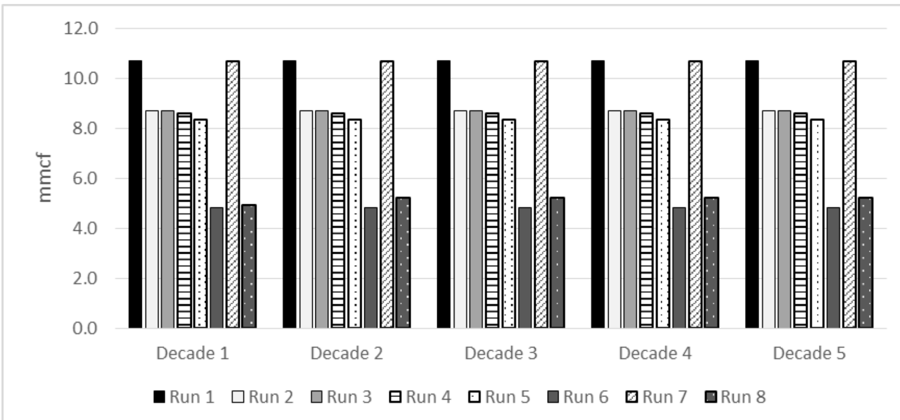


Figure 76. Projected timber sale quantity across PRISM sensitivity runs

Projected harvest acres

The following summary compares the impact of constraints on the projected harvest acres estimated for Decade 1 of the planning period. Budget and management area constraints are the most influential.

- Management area group constraints (run 2 versus run 1) reduce harvest acres 16.26%.
- Lynx constraints (run 4 versus 2) incrementally reduce harvest acres 3.42%. Lynx constraints independent of other variables (run 7 versus 1) reduce harvest acres 0% compared to the baseline.
- Operational constraints (run 5 versus run 4) decrease the harvest level by 7.46%.
- Budget constraints (run 6 versus 5) incrementally reduce harvest acres 67.39%. Budget constraints independent of all other variables (run 8 versus run 1) reduce harvest acres 61.64%.

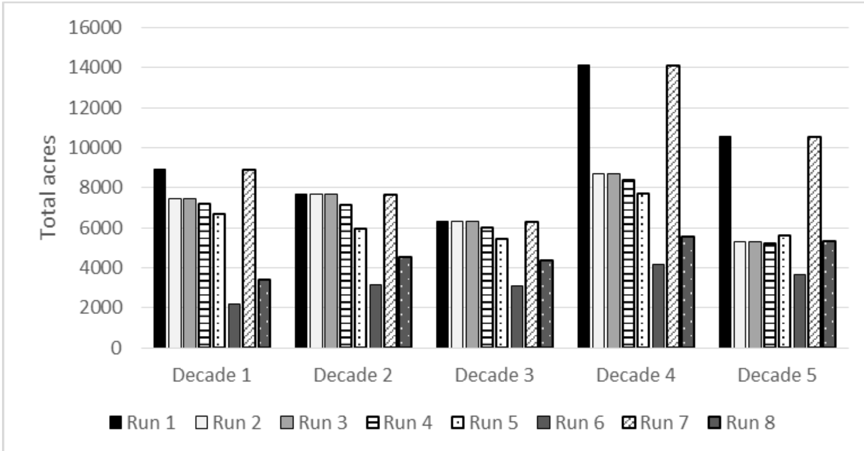


Figure 77. Projected harvest acres across PRISM sensitivity runs

Projected prescribed burning acres

The following summary compares the impact of constraints on the projected burning acres estimated for Decade 1 of the planning period. Budget and operational constraints are the most influential. Constraints that may limit harvest (i.e. lynx) result in increased burning.

- Management area group constraints (run 2 versus run 1) decrease burning acres 35.18%.
- Lynx constraints (run 4 versus 2) incrementally increase burning acres 3.79% in Decade 1. Lynx constraints independent of other variables (run 7 versus 1) increase burning acres 0.78%.
- Operational constraints (run 5 versus run 4) incrementally decrease burning by 74.92%.
- Budget constraints (run 6 versus 5) incrementally reduce burning acres 69.28%. Budget constraints independent of all other variables (run 8 versus run 1) reduce burning acres 88.85%.

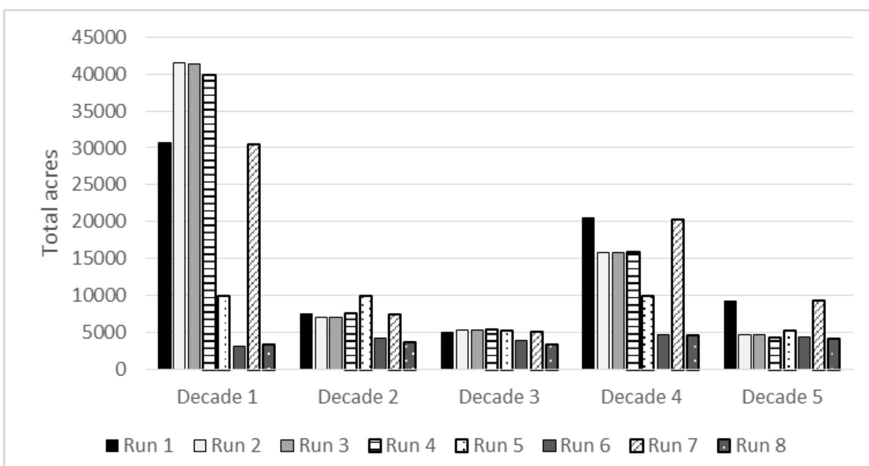


Figure 78. Projected prescribed burning acres across PRISM sensitivity runs

Budget

The total management costs, or how much of budget was used, was also evaluated. The addition of management constraints results in lower costs compared to the baseline scenario, because the amount of activities that can be done becomes limited. However, none of these constraints reduce the management costs below the budget limitation that is applied in runs 6 and 8. The following summary compares the impact of constraints on the budget for Decade 1 of the planning period. Runs 6 and 8 are identical because they both employ the reasonably foreseeable budget constraint.

- Management area group constraints (run 2 versus run 1) increases budget used by 15% compared to the baseline scenario.
- Lynx constraints (run 4 versus 2) incrementally reduces budget used by 3.19%. Lynx constraints independent of other variables (run 7 versus 1) reduce costs 2.45% compared to the baseline.
- Operational constraints (run 5 versus run 4) incrementally decreases budget used by 52.93%.
- Budget constraints (run 6 versus 5) incrementally reduce budget used 61%. Budget constraints independent of all other variables (run 8 versus run 1) reduce budget used 79.44%.

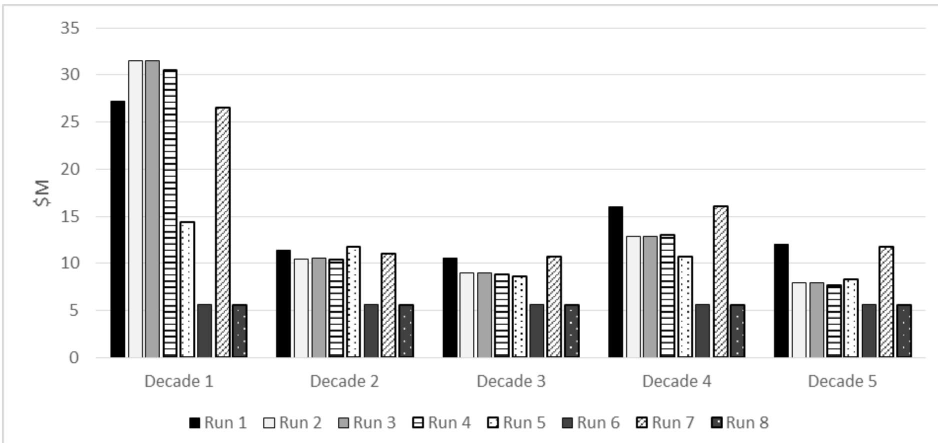


Figure 79. Comparison of projected budget used across PRISM sensitivity runs

SIMPPLLE model results

The following section provides the detailed outputs from the SIMPPLLE model. The following additions or changes are incorporated relative to how SIMPPLLE results were presented in the DEIS:

- There is a modeled alternative labeled as “FUN”, or “alternative F, unconstrained”. This alternative represents alternative F, with a timber schedule that is unconstrained by budget. This was done to provide analysis to support the footnotes provided in FW-TIM-OBJ-01 and 02, disclosing the potential levels of harvest that could be accomplished if budgets were not constrained.
- Additional scales of analysis are addressed: inside/outside of wildland/urban interface (WUI) areas; and inside/outside of managed landscapes. Managed landscapes are defined as those areas that are not wilderness, RWA, IRA, or other land allocations that prohibit or substantially limit harvest. The WUI is mapped based on County Wildland Protection Plans (CWPPs) where available, and standard Hazardous Fuels Reduction Act (HFRA) definitions where CWPPs are unavailable. The WUI will change over time as human developments and land use change.
- In addition to individual tree species presence, other composition and structural attributes are displayed at the GA scale, because desired conditions were quantified for them in the 2020 Forest Plan (cover type, size class, and density class).

In the Composition and Structure/Pattern sections, box and whisker charts are provided to compare alternative A and F. The other alternatives are not included in these charts due to complexity; rather, these two alternatives are selected to provide a snapshot of the statistical variability surrounding the estimates. In the other charts, the mean for all alternatives is shown to provide a complete comparison of alternatives. In most cases, there is little variance across alternatives. Additional box and whisker plots, along with all of the raw data and statistical information, can be found in the project record.

Disturbances

Disturbances play a key role in the ecosystems of the HLC NF. SIMPPLLE is used to estimate the probable extent and severity of wildfire, insects, and disease in the future, taking into account climate, vegetation treatments, and fire suppression. The SIMPPLLE model projected that in the future, assuming warm/dry climate conditions persist, western spruce budworm will impact the most acres overall, followed by wildfire and bark beetles. The alternatives are similar, except that alternative F-UN projects slightly fewer acres impacted overall. The average acres projected vary by decade and do not imply an "even flow" of acres over time. Disturbance estimates have a high level of uncertainty.

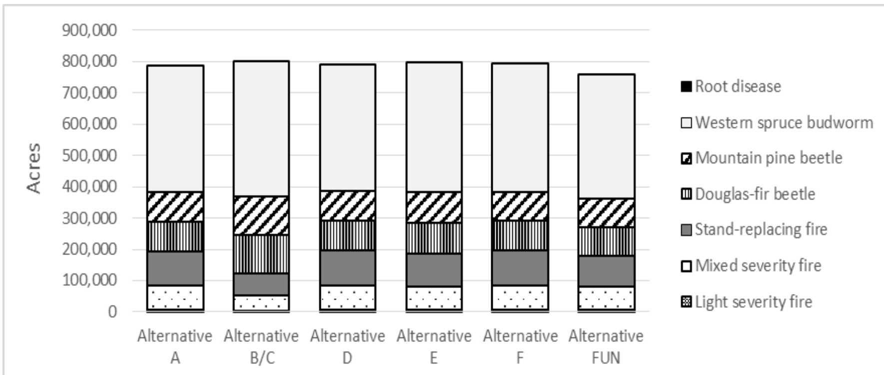


Figure 80. Average acres impacted by disturbance over 50 years, by alternative

Wildfire

Low severity fire does not feature prominently, partly because the model categorizes grass fires as "stand replacing". Alternatives E and F-UN tend to have the least acres burned. The model indicates that that a higher percentage of managed landscapes are burning as compared to unmanaged landscapes (Figure 82). Similarly, a higher % of WUI areas burn as compared to non-WUI areas (Figure 83).

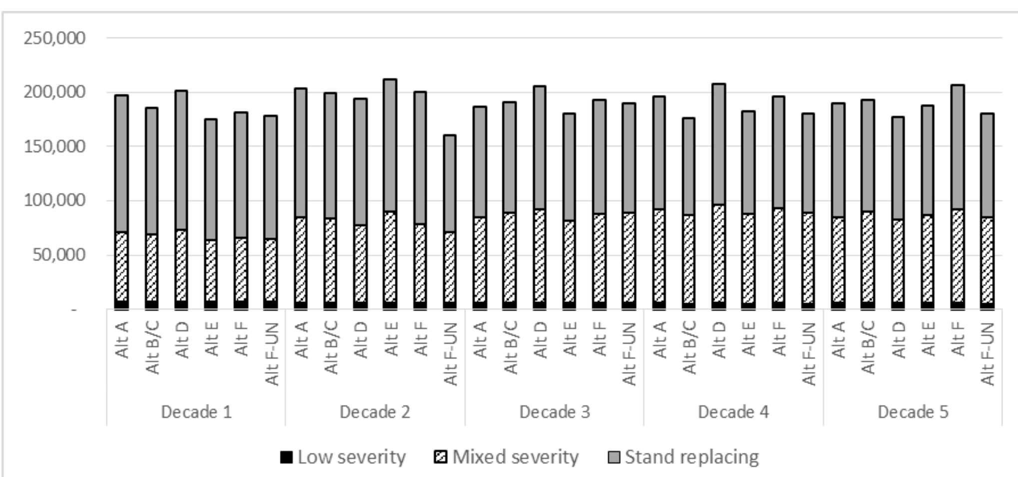


Figure 81. Total wildfire acres burned by type, average for decade, by alternative

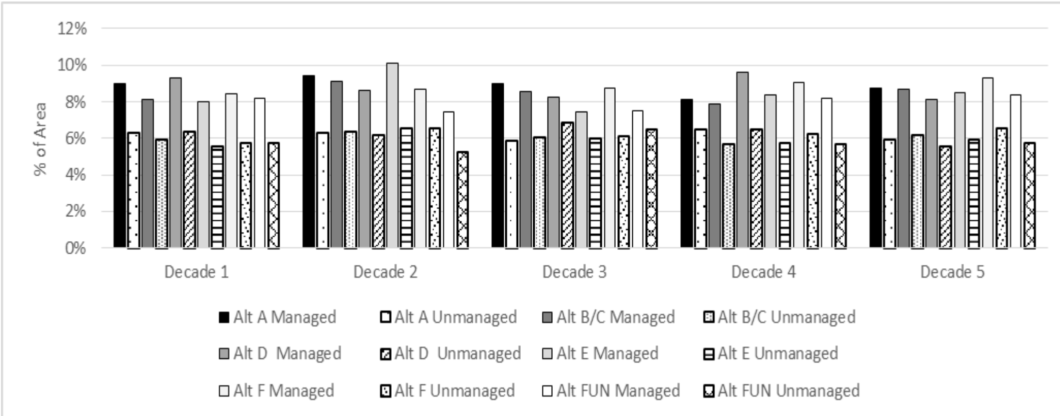


Figure 82. Percent of HLC NF burned by decade and alternative, in managed versus unmanaged landscapes

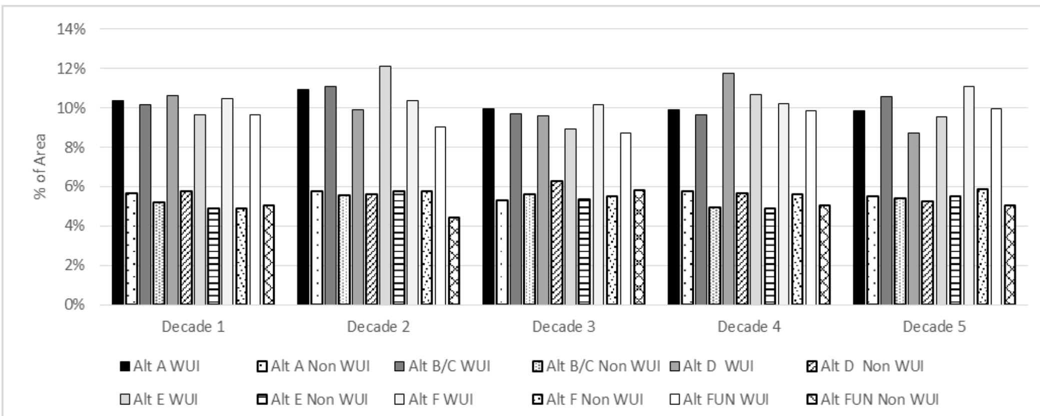


Figure 83. Percent of HLC NF burned by decade and alternative, in WUI versus Non-WUI areas

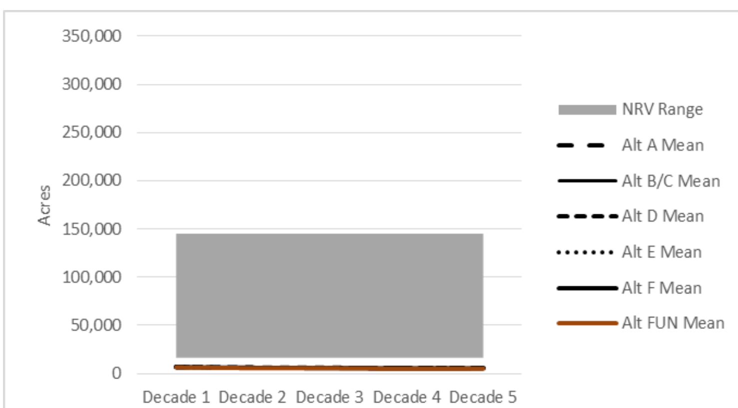


Figure 84. Mean acres per burned with low severity fire forestwide by alternative, compared to NRV

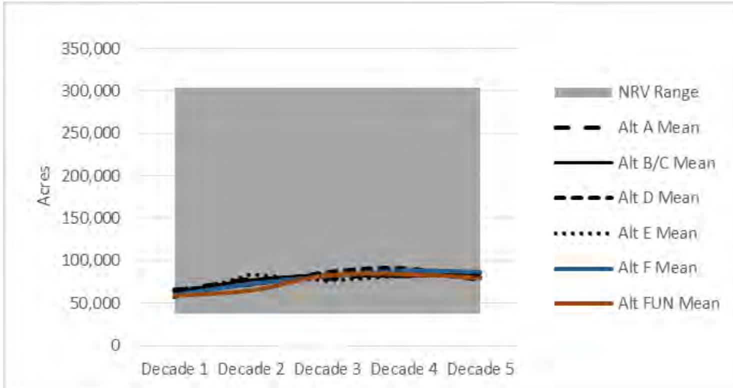


Figure 85. Mean acres burned with mixed severity fire forestwide by alternative, compared to NRV

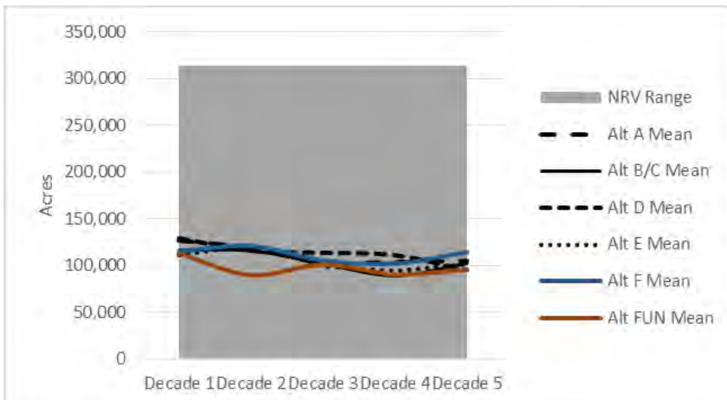


Figure 86. Mean acres burned with stand-replacing fire forestwide by alternative, compared to NRV

The percent of each GA burned (all fire types) by alternative was also assessed:

- 8 to 14% of the Big Belts is predicted to burn each decade.
- 4 to 16% of the Castles is predicted to burn each decade.
- 1 to 3% of the Crazies is predicted to burn each decade.
- 7 to 15% of the Divide GA is predicted to burn each decade.
- 7 to 18% of the Elkhorns is expected to burn each decade.
- 2 to 13% of the Highwoods GA is predicted to burn in each decade.
- While only 3 to 5% of the Little Belts GA is predicted to burn in a given decade, the total acres burned is greater than most other GAs due to the large size of this GA.
- A relatively small percentage of the Rocky Mountain Range GA is predicted to burn in each decade (2-5%), but given its large size it is one of the main contributors to total acres burned.
- 3 to 11% of the Snowies GA is predicted to burn each decade.
- 8 to 13% of the Upper Blackfoot GA is predicted to burn each decade; this along with its relatively large size results in it being one of the major contributors to the overall acres burned on the Forest.

Insects and disease

Root disease is known to occur on the HLC NF, but those that cause substantial damage or mortality (such as Armillaria) are fairly uncommon. While a small proportion of acres affected by root disease were estimated in the NRV and DEIS, no measurable occurrences were projected in the FEIS modeling. This may be due to the minor area affected by root disease. Western spruce budworm is predicted to influence the greatest number of acres over the next 5 decades, although it decreases in Decade 4. Mountain pine beetle remains present but at fairly steady levels, probably in part due to the recent outbreak that has reduced the amount of susceptible forests. An outbreak of Douglas-fir beetle is predicted to occur in Decade 2 and decrease thereafter.

The model projects that a higher percentage of managed landscapes and WUI will being infested as compared to unmanaged landscapes and non-WUI areas, particularly in the earlier decades. All of these pests are also less likely to occur in cold PVT areas, which are most often found in unmanaged and non-WUI areas. In the later decades, the proportions level off and are similar in managed versus unmanaged areas, and in WUI versus non-WUI areas.

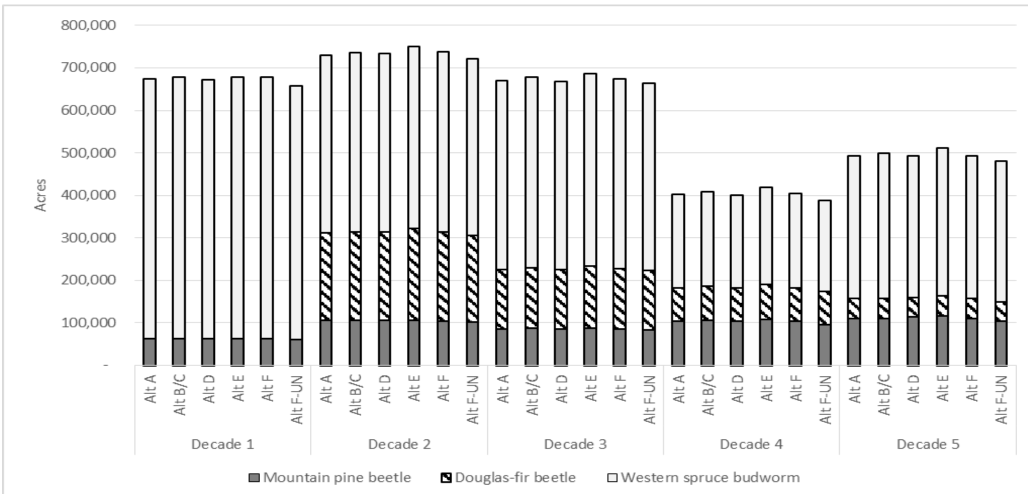


Figure 87. Total acres per decade infested by insects, by alternative, across five decades

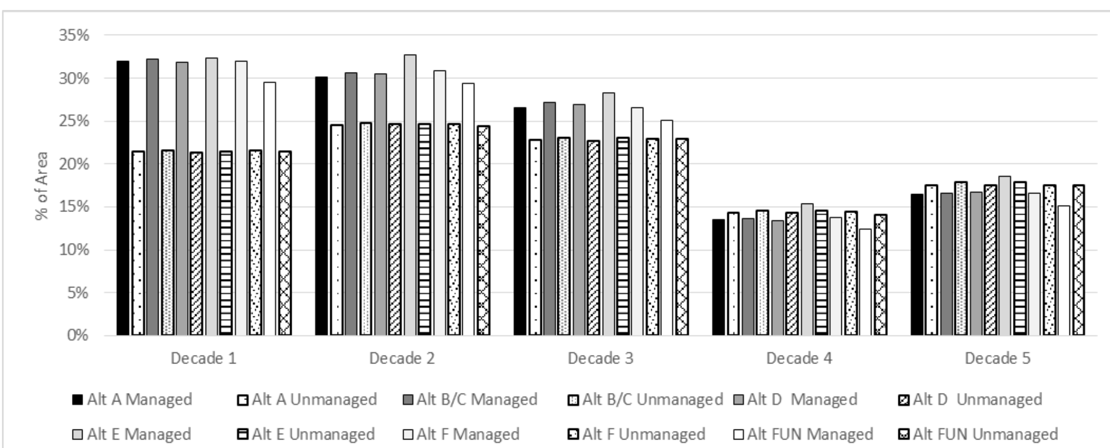


Figure 88. Percent of HLC NF infested by insects by decade and alternative, in managed versus unmanaged landscapes

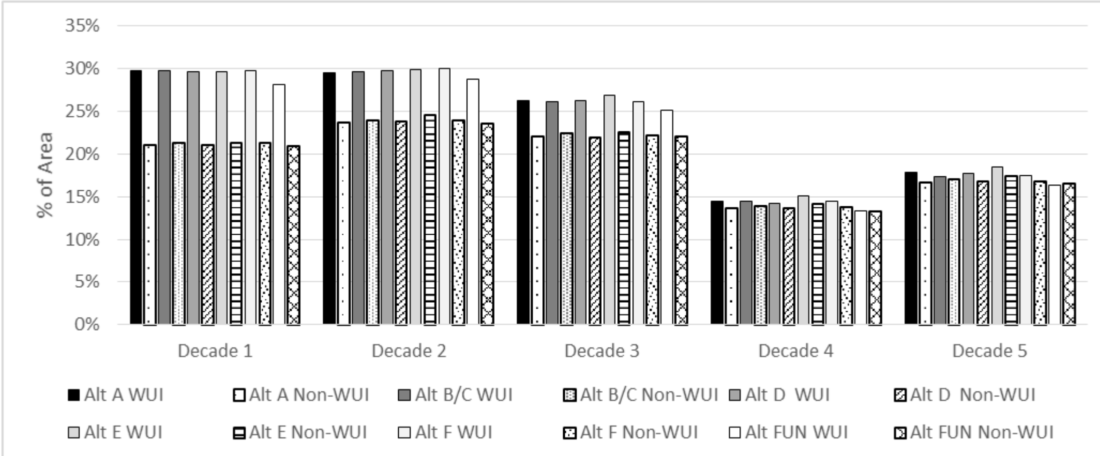


Figure 89. Percent of HLC NF infested by insects, by decade and alternative, in WUI versus Non-WUI lands

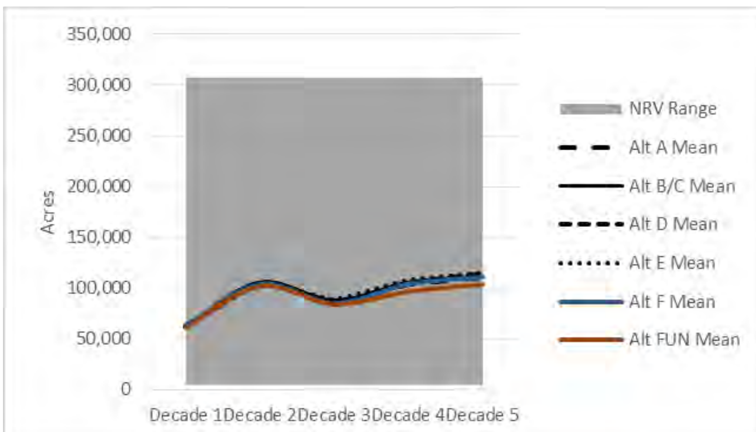


Figure 90. Mean acres infested by mountain pine beetle forestwide by alternative, compared to NRV

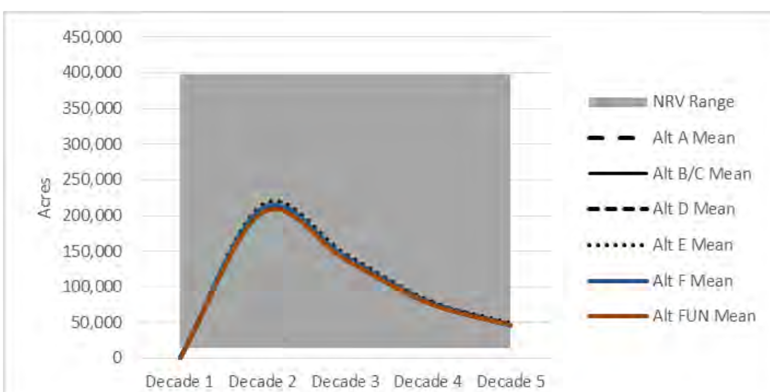


Figure 91. Mean acres infested by Douglas-fir beetle forestwide by alternative, compared to NRV

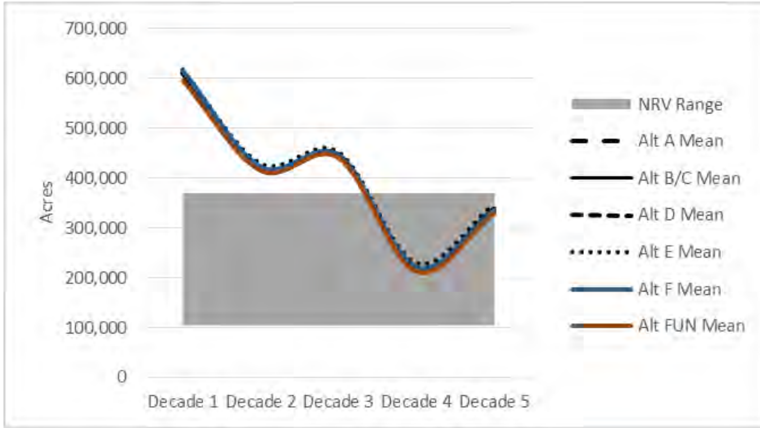


Figure 92. Mean acres infested by Western spruce budworm forestwide by alternative, compared to NRV

The area infested by insects was also assessed by GA; all alternatives are fairly similar:

- The Douglas-fir beetle is projected to be most active on the Big Belts and Little Belts, with some activity on all other GAs as well.
- The mountain pine beetle is expected to be most active in the Castles, with some activity present in all GAs; although the Crazies is expected to have very little.
- Western spruce budworm is prevalent on all GAs, with the Crazies expected to have the least activity and the Big Belts, Castles, Highwoods, Little Belts, and Snowies having the most activity.
- The Crazies is expected to be minimally impacted by insects overall. The GAs expected to be most impacted by insects are the Big Belts, Castles, Highwoods, Little Belts, and Snowies.

Composition and structure summary

The following matrices display the future condition at decade 5 (50 years) compared to the desired condition range for each composition and structural attribute, and each scale of interest. These comparisons are made using the mean modeled values and do not account for the error bars around those means, which in some cases may extend into a different position relative to the desired range. Charts with error bars are available in the project file for all attributes for alternatives A and F. These matrices can be compared to those displayed in the desired condition section of this appendix, which compared the existing condition to the desired ranges, to assess the relative movement over time relative to these goals. All alternatives are substantially similar in this regard.

Table 66. Matrix of projected condition at decade 5 (SIMPPLLE) compared to desired condition– species composition

	Forestwide	Warm Dry	Cool Moist	Cold	Big Belts	Castles	Crazies	Divide	Elkhorns	Highwoods	Little Belts	Rocky Mtn	Snowies	Upper Blackfoot
Nonforested cover type	W	W/A	W/A	W/A	W/A	W/A	W/A	W	W	W	A	A	W	A
Aspen/hardwood cover type	B	B	W/B	N	B	W/B	B	B	W/B	W/B	B	W	B	B
Aspen/cottonwood presence	W	B	W	N	W/B	W/B	B	W	W	W	B	W	B	W/B
Ponderosa pine cover type	W	B	W	N	B	W	W	B	B	W	W	W	W	W/B
Ponderosa pine presence	B	B	N	N	B	B	W/B	B	B	B	B	W/B	W	B
Limber pine presence	W/B	W	W	W/B	W/B	B	B	W/B	W/B	W/B	W/A	W/B	W/A	W
RM Juniper presence	A	W/A	W/B	N	A	A	W/B	W	A	A	W	W	W	W
Douglas-fir cover types	W	B	W	W/A	W	W	A	W	W	B	W	W/B	A	W/A
Douglas-fir presence	W	B	A	W	W/B	A	A	W/B	W	B	W	W	A	W
Lodgepole pine cover type	W/A	A	A	W	W	W	B	A	W	A	A	W/A	B	W/A
Lodgepole pine presence	A	A	A	W/B	W	W	W	A	W	W	A	W/A	B	W/A
Western larch cover type	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Western larch presence	N	N	N	N	N	N	N	N	N	N	N	N	N	B
Spruce/fir cover type	W	N	B	B	W/B	W/B	W/B	W	W/A	W/B	B	B	W	B
Engelmann spruce presence	W	W/A	A	W/B	W/B	W/B	B	W	A	N	W/A	W	A	W
Subalpine fir presence	A	N	W	W	W/A	W	A	W/A	A	W	W/A	W	W	W/A
Whitebark pine cover type	W	N	W/B	W	W	W	A	B	W/B	N	B	W	N	W/B
Whitebark pine presence	W/B	N	W	B	W	W	W	W	W	N	W	W	B	W

W = within the DC range; A = above the DC range; B = below the DC range; N = not present or no DC for that scale. When the existing condition is right at the boundary of the DC range, it is noted as W/A (at the upper end of the range) or W/B (at the lower end of the range). Items shaded in the dark gray tones and white font indicate conditions at the upper bound or above the desired range. Items shaded in light gray tones indicate conditions at the lower bound or below the desired range. Cells with no shading are within the desired ranges, or are not present/applicable.

Table 67. Matrix of projected condition at decade 5 (SIMPPLLE) compared to desired condition– structure and pattern

	Forestwide	Warm Dry	Cool Moist	Cold	Big Belts	Castles	Crazies	Divide	Elkhorns	Highwoods	Little Belts	Rocky Mountain	Snowies	Upper Blackfoot
Seedling/sapling size class	W/A	A	W	W	A	A[2]	W	A	A	W	W/A	W	A	W
Small tree size class	W	W	W	W	W	W/A	A	W	W/B	B	W	W	B	W
Medium tree size class	W/A	A	W	W	W/B	B	B	W	W	W	W/B	A	A	W
Large tree size class	B	W/B	B	B	W/B	W/B	W/B	B	W/B	B	B	B	B	B
Very large tree size class	B	B	B	W/B	B	W/B	W/B	B	B	B	B	B	B	B
Large-tree structure (large)	B	W/B	W	B	N	N	N	N	N	N	N	N	N	N
Large-tree structure (Vlarge)	W/B	B	B	W/B	N	N	N	N	N	N	N	N	N	N
NF/low/med density class	W/A	A	W	W/A	A	A	A	W/A	W	W	A	W/A	W/A	A
Medium/high density class	W/B	W/B	W	B	B	W/B	W/B	W/B	W/B	W	W/B	W/B	W/B	B
High density class	W	W/B	W	W	W/B	B	W/B	W	W	B	W/B	W	W	W/B
Single-storied structure[1]	N	A	W	W	N	N	N	N	N	N	N	N	N	N
2-storied structure[1]	N	A	W	W/A	N	N	N	N	N	N	N	N	N	N
Multi-storied structure[1]	N	B	W/B	B	N	N	N	N	N	N	N	N	N	N
Early successional forests	W	A	W/A	W	N	N	N	N	N	N	N	N	N	N

W = within the DC range; A = above the DC range; B = below the DC range; N = not present or no DC for that scale.
When the existing condition is right at the boundary of the DC range, it is noted as W/A (at the upper end of the range) or W/B (at the lower end of the range).
[1]Vertical structure is shown relative to the NRV; there are no quantitative DCs for this; rather, it is addressed qualitatively as it relates to density class.
[2] There is some separation of alternatives for seedling/sapling size class in the Castles. Alt E results in conditions within the desired range; all other alternatives are above the desired range, with alt F-UN the highest. Items shaded in the dark gray tones and white font indicate conditions at the upper bound or above the desired range. Items shaded in light gray tones indicate conditions at the lower bound or below the desired range. Cells with no shading are within the desired ranges, or are not present/applicable.

Vegetation composition

The following section is organized by cover type. Each cover type section includes the trends for the cover type, and the presence of the individual species that may be dominant within that cover type.

Nonforested cover type

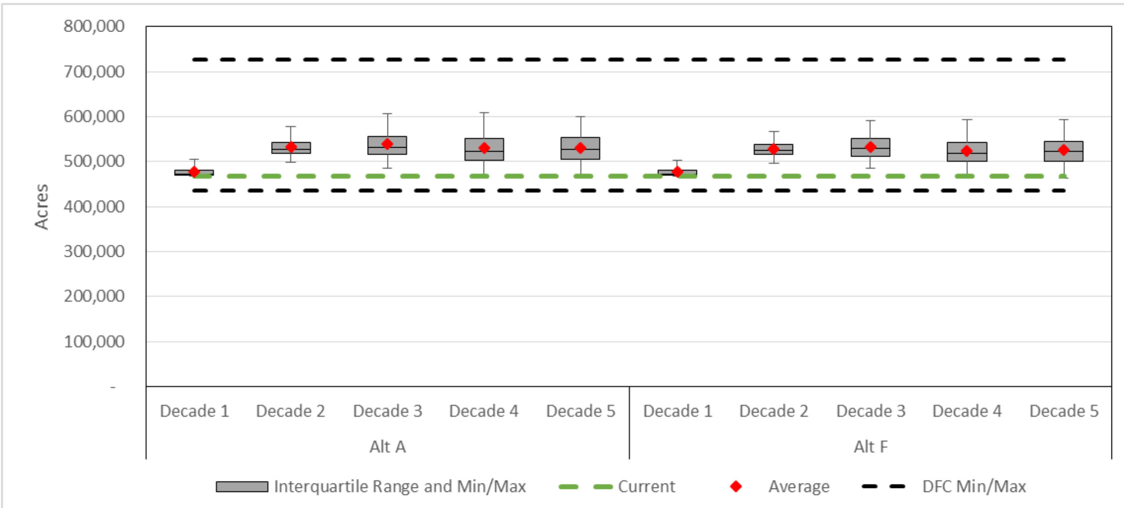


Figure 93. Nonforested cover type abundance (total acres) over 5 decades, alternatives A and F

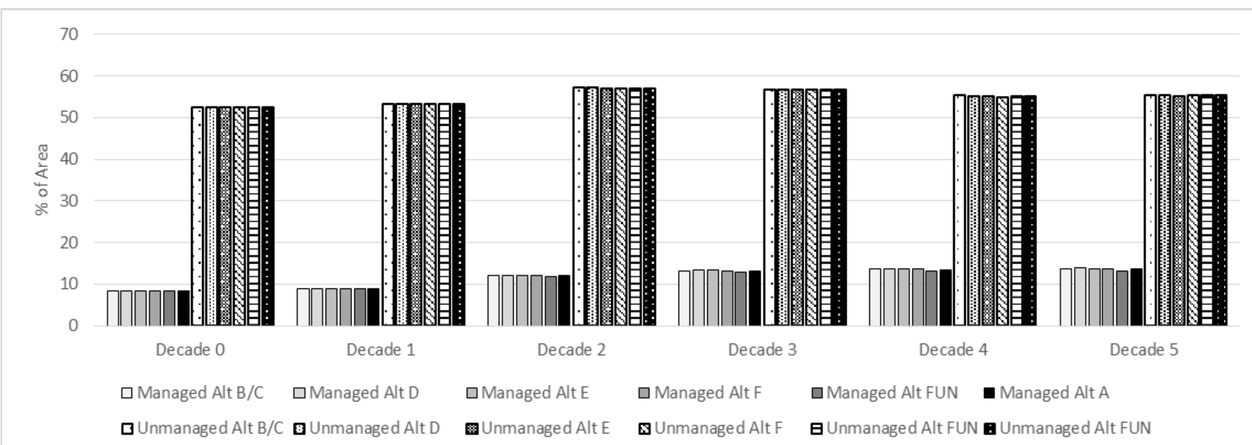


Figure 94. Nonforested cover type abundance in managed versus unmanaged landscapes, forestwide

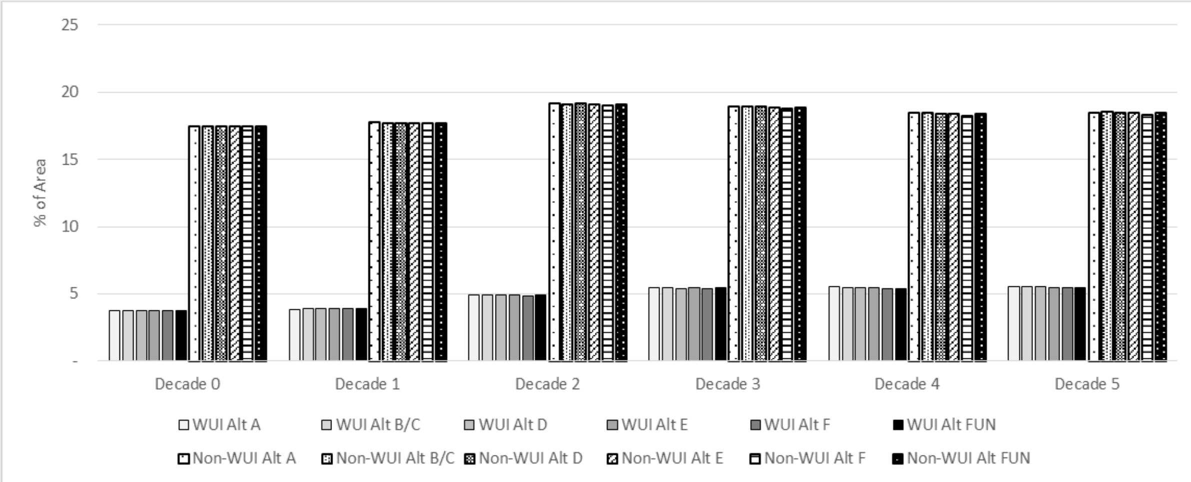


Figure 95. Nonforested cover type abundance in WUI versus Non-WUI areas, forestwide

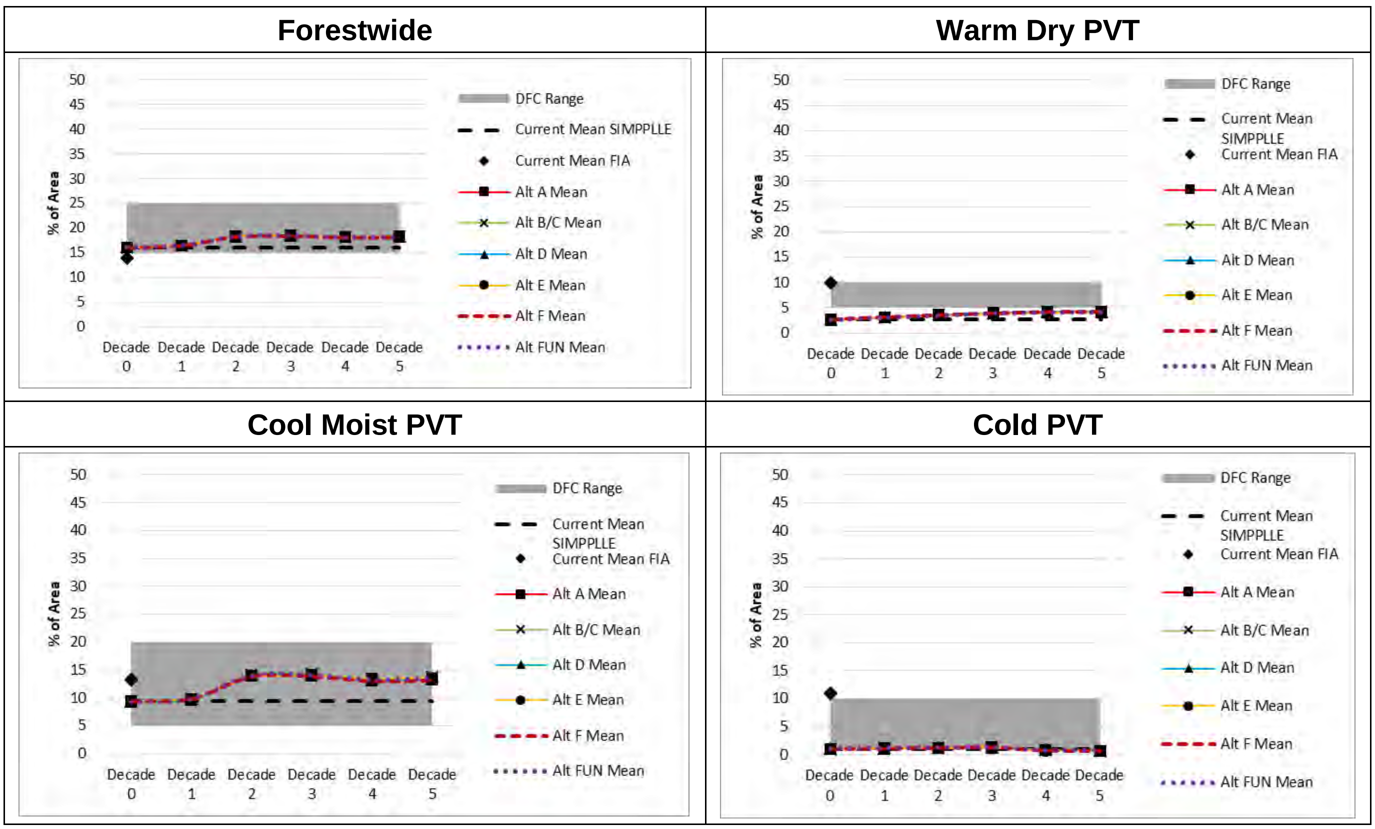
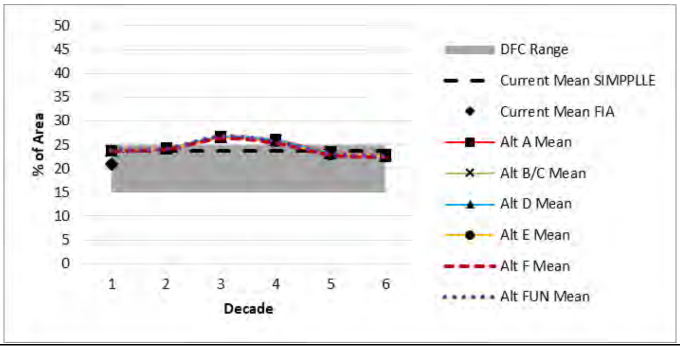


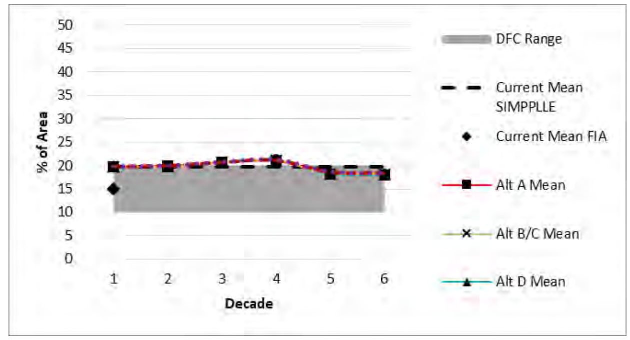
Figure 96. Nonforested cover type abundance (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 97. Nonforested cover type abundance (% of total area) over 5 decades by alternative, by GA

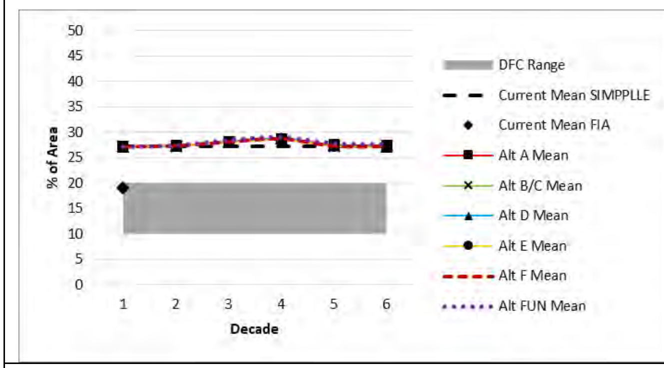
Big Belts



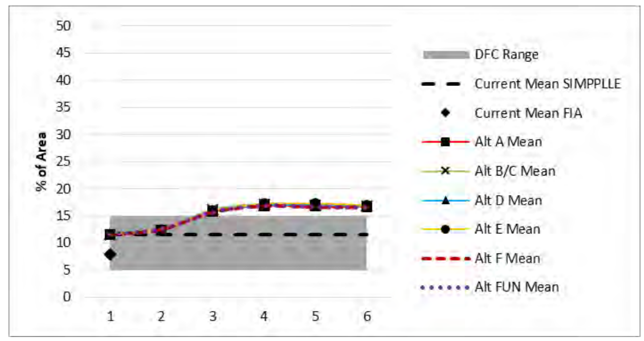
Castles



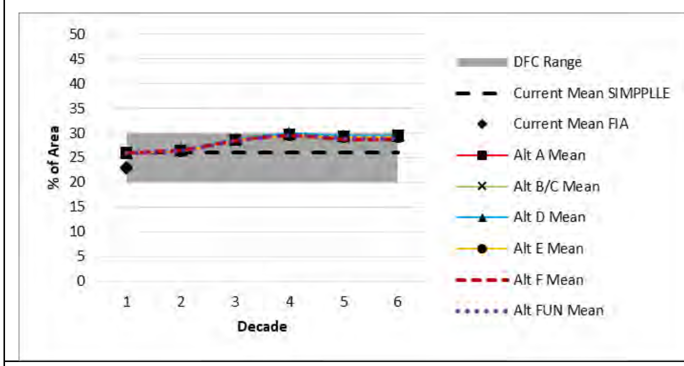
Crazies



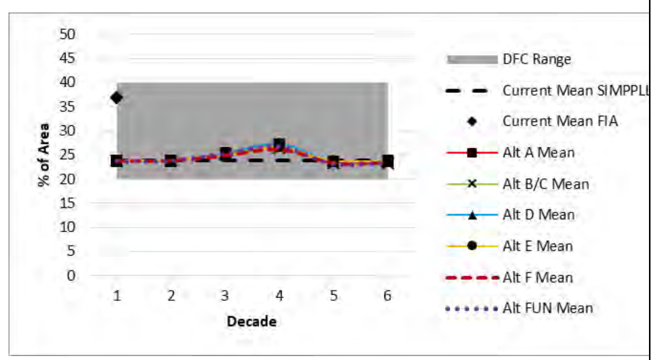
Divide



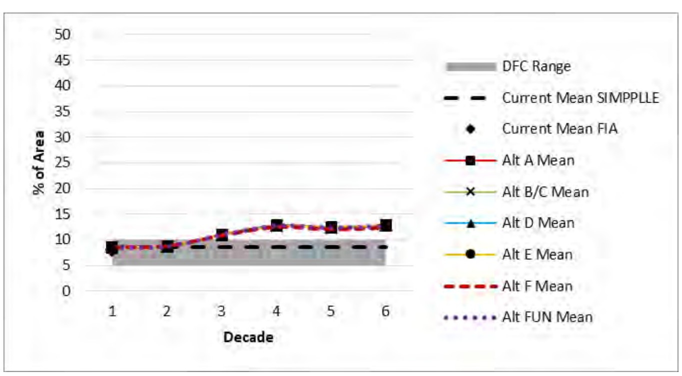
Elkhorns



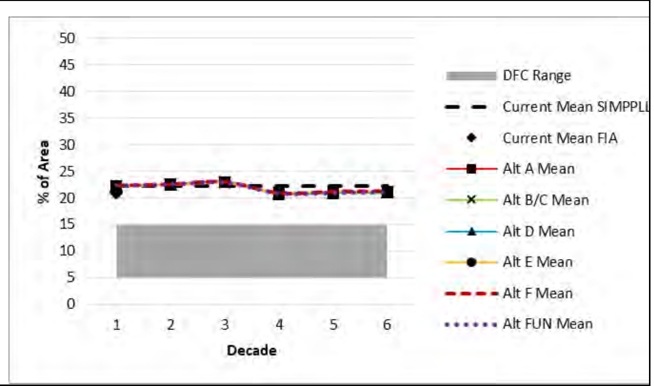
Highwoods

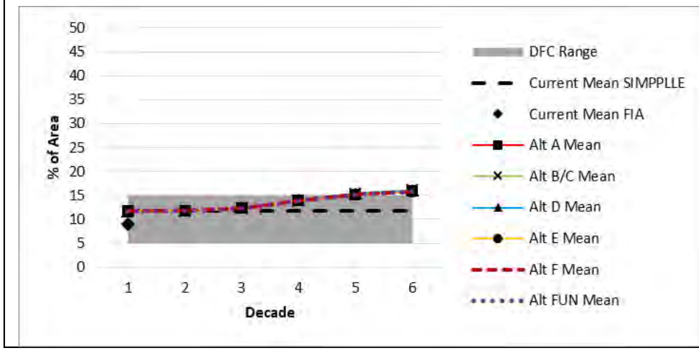
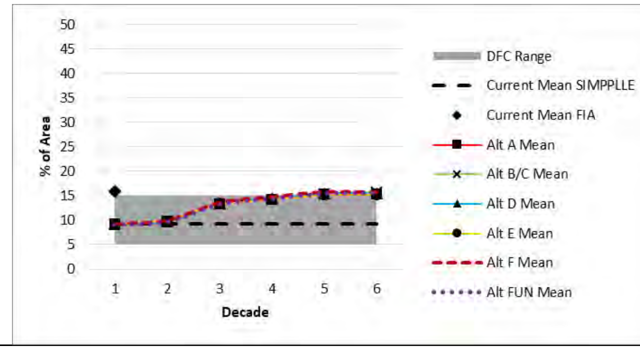


Little Belts



Rocky Mountain Range



Snowies	Upper Blackfoot
	

Ponderosa pine cover type and presence of associated species (ponderosa pine, limber pine, Rocky Mountain juniper)

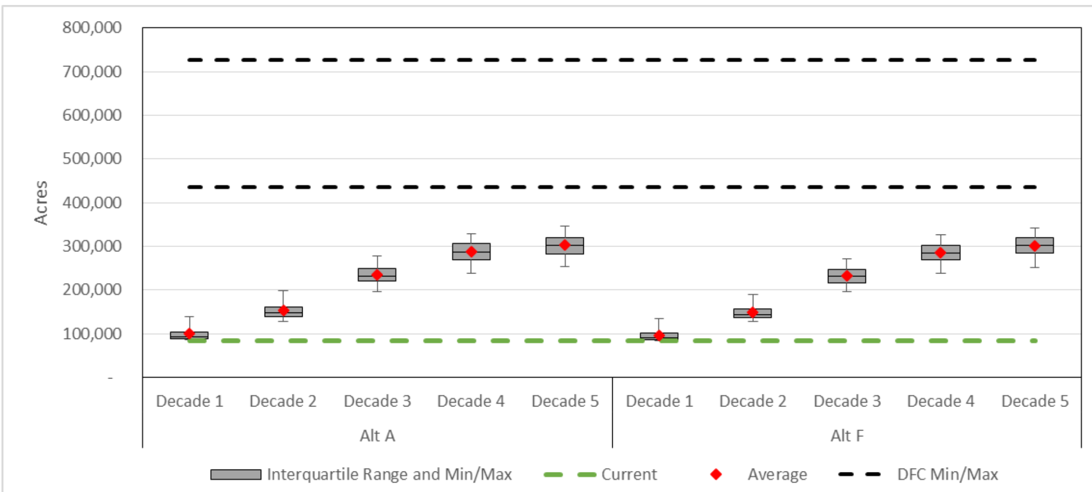


Figure 98. Ponderosa pine cover type abundance (total acres) over 5 decades, alternatives A and F

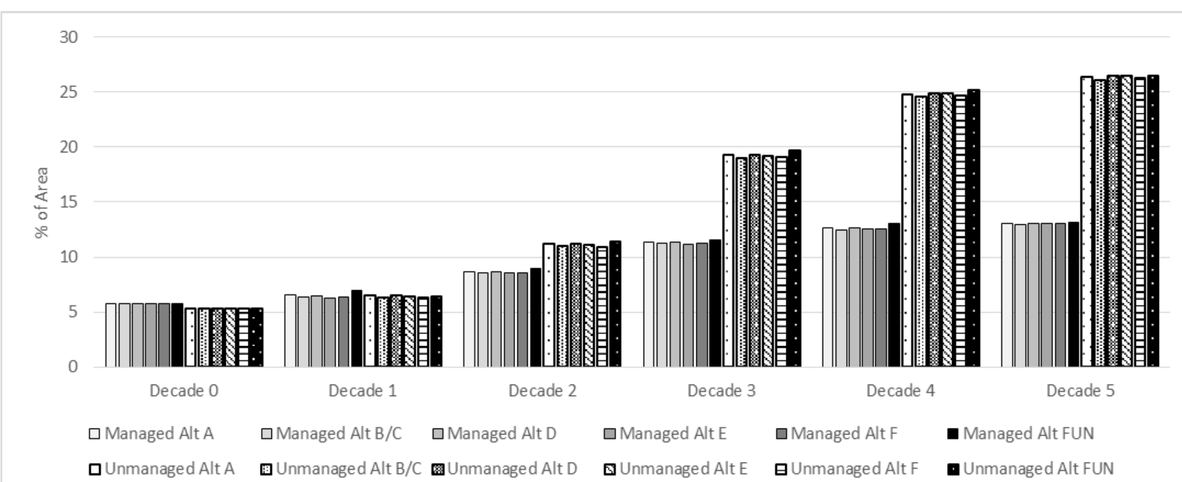


Figure 99. Ponderosa pine cover type abundance in managed versus unmanaged landscapes, forestwide

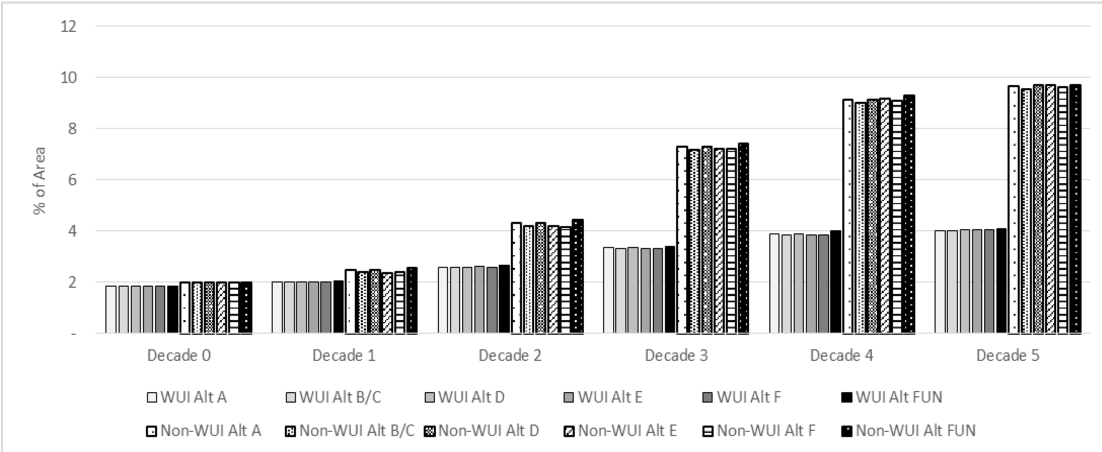


Figure 100. Ponderosa pine cover type abundance in WUI versus non-WUI areas, forestwide

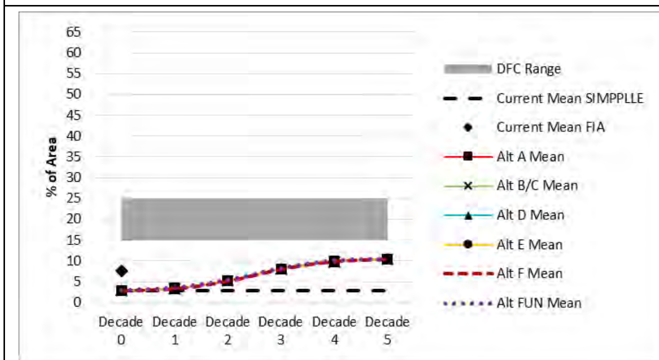
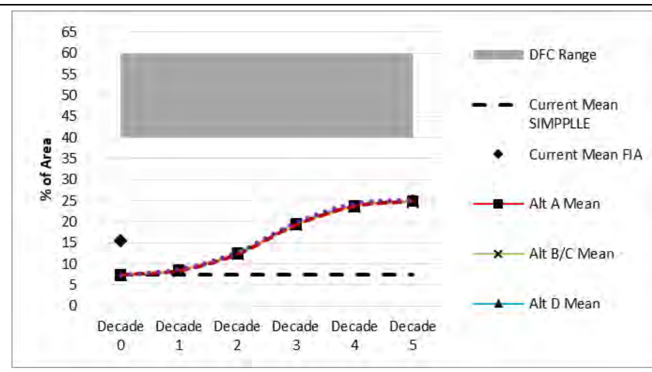
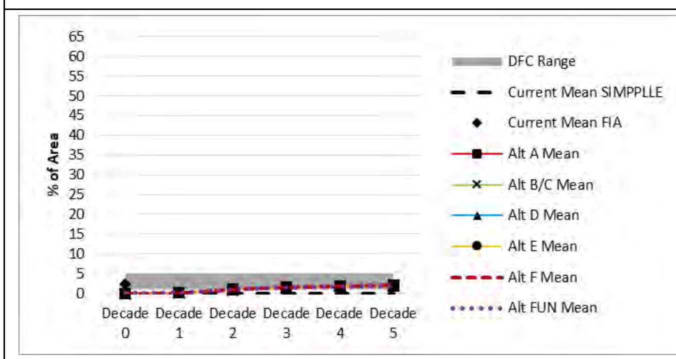
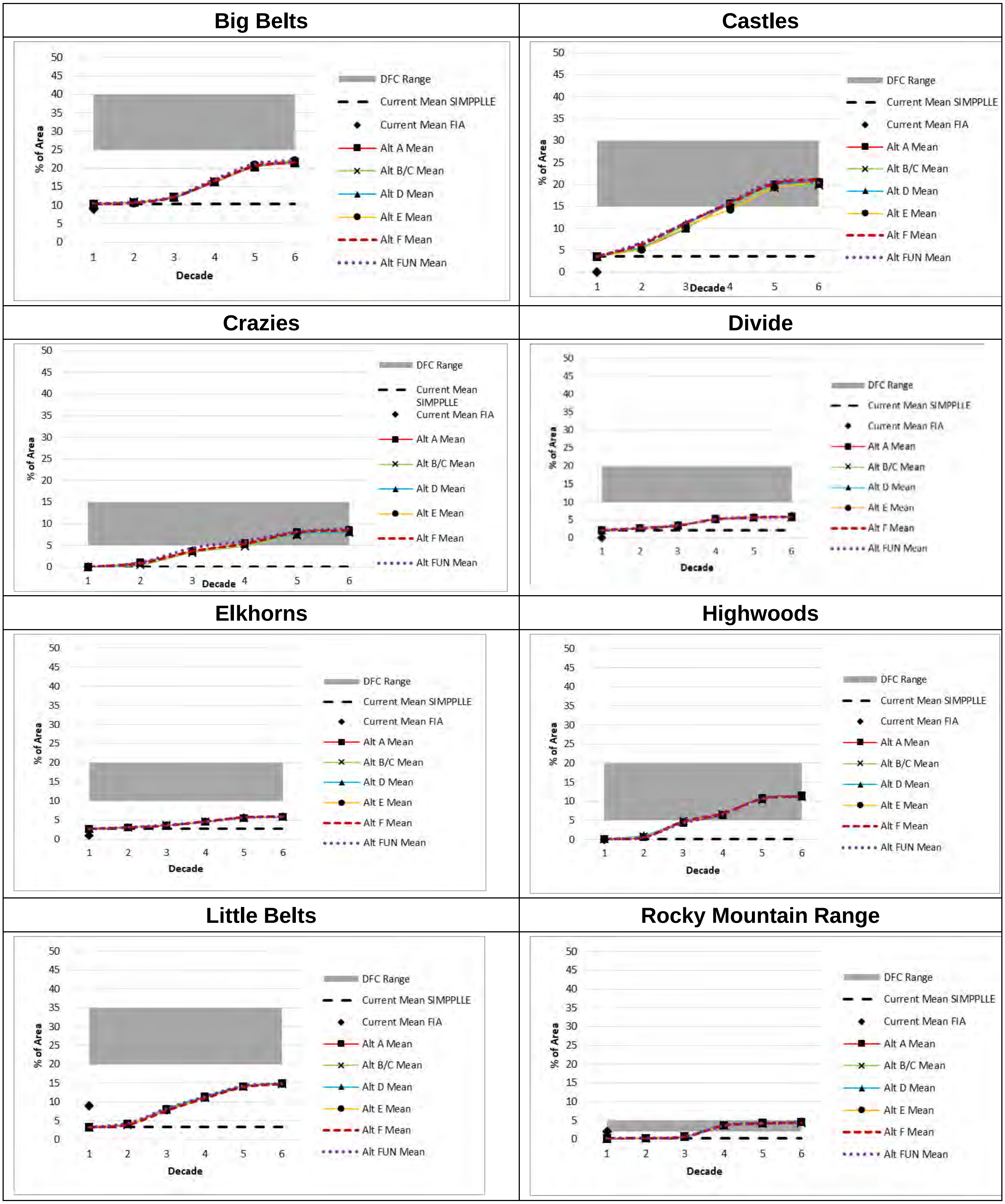
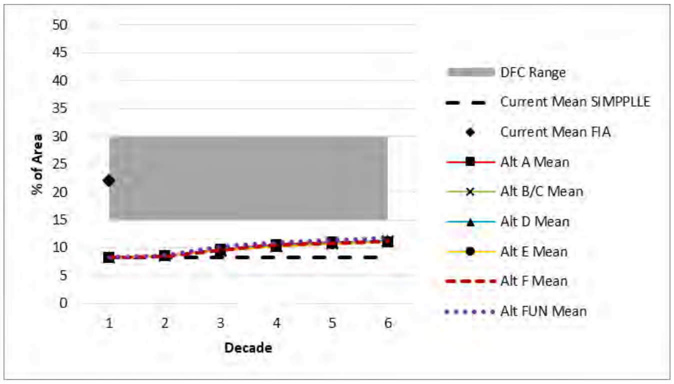
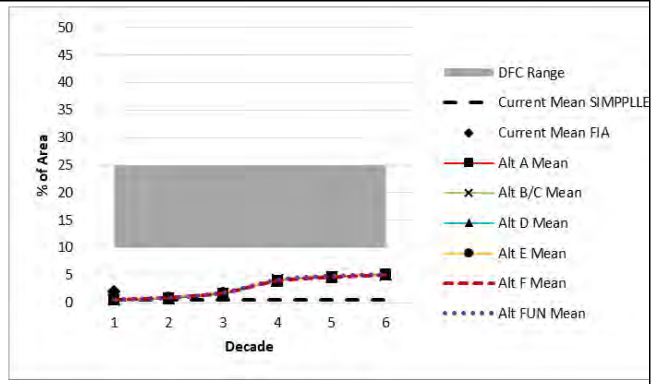
Forestwide	Warm Dry PVT
	
Cool Moist PVT	**Cold PVT**
	N/A

Figure 101. Ponderosa pine cover type abundance (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 102. Ponderosa pine cover type abundance (% of total area) over 5 decades by alternative, by GA



Snowies	Upper Blackfoot
	

Ponderosa pine presence

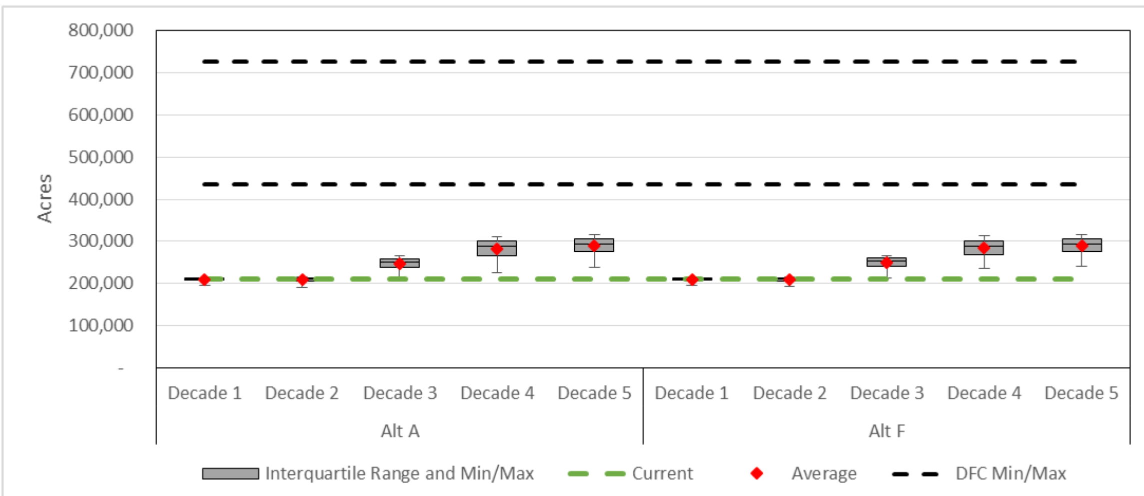


Figure 103. Ponderosa pine presence (total acres) over 5 decades, alternatives A and F

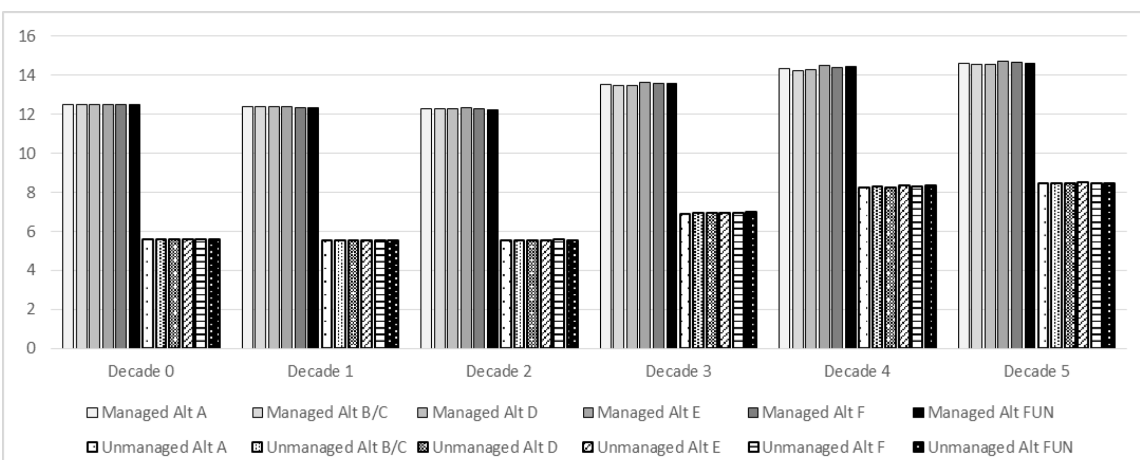


Figure 104. Ponderosa pine presence in managed versus unmanaged landscapes, forestwide

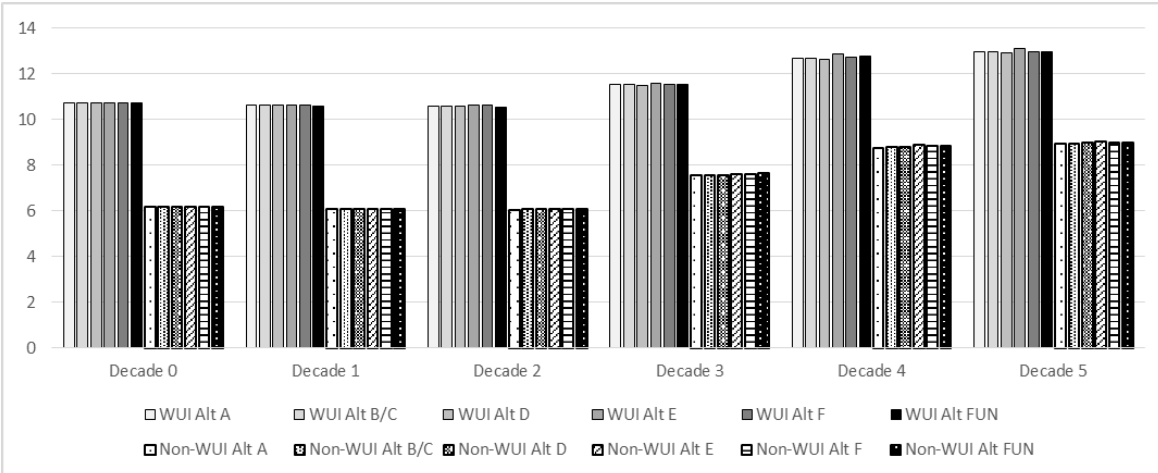


Figure 105. Ponderosa pine presence in WUI versus non-WUI areas, forestwide

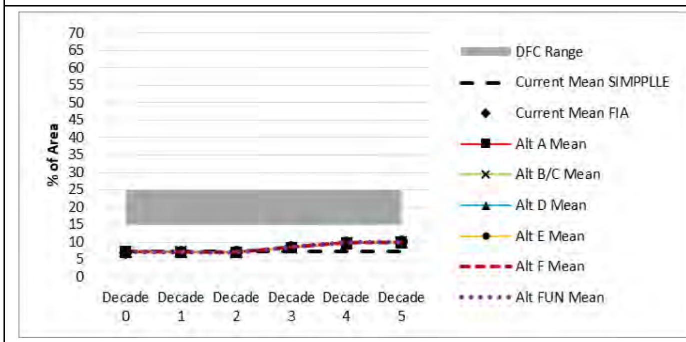
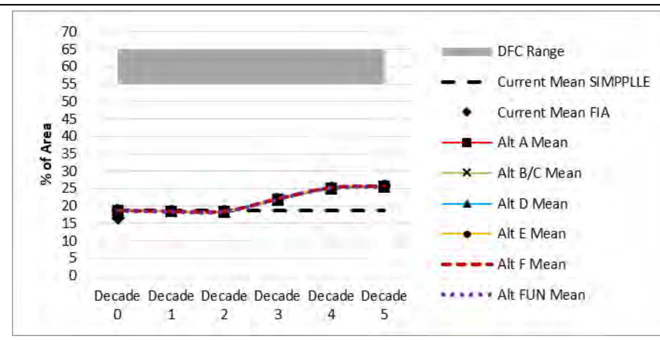
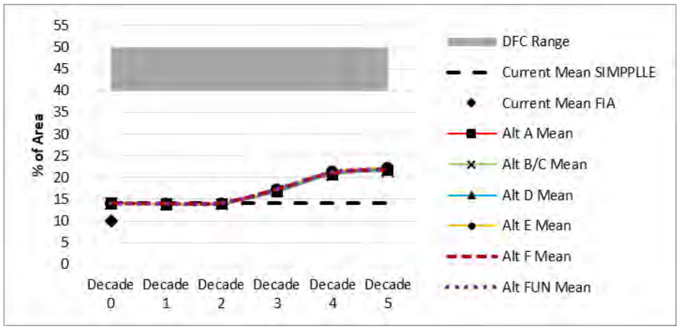
Forestwide	Warm dry PVT
	
Cool Moist PVT	**Cold PVT**
N/A	**N/A**

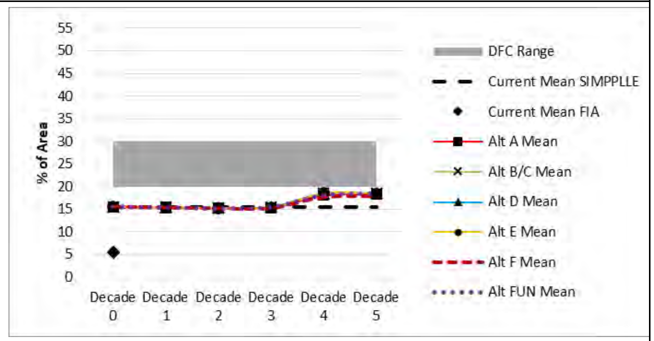
Figure 106. Ponderosa pine presence (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 107. Ponderosa pine presence (% of total area) over 5 decades by alternative, by GA

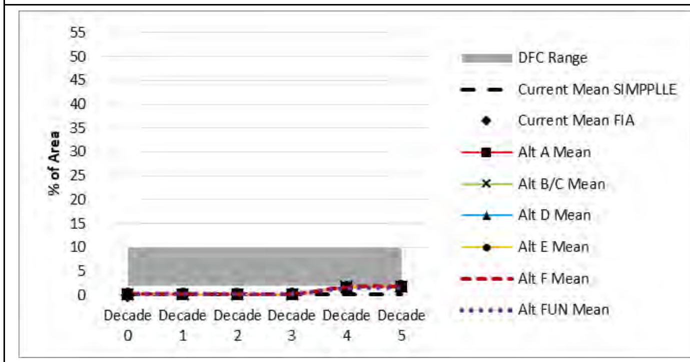
Big Belts



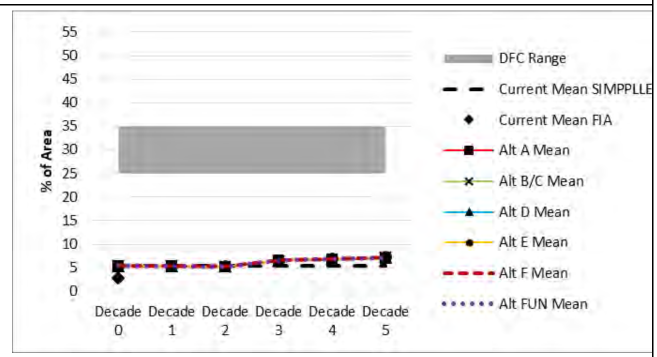
Castles



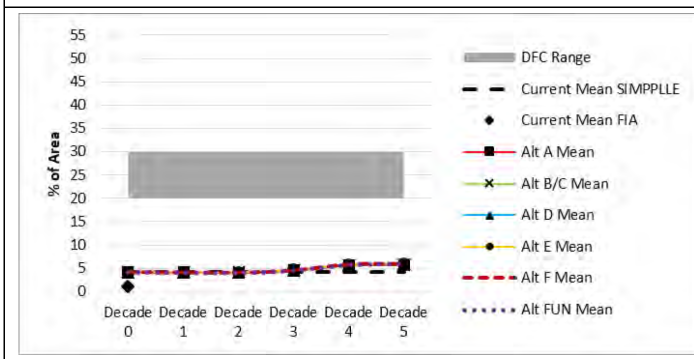
Crazies



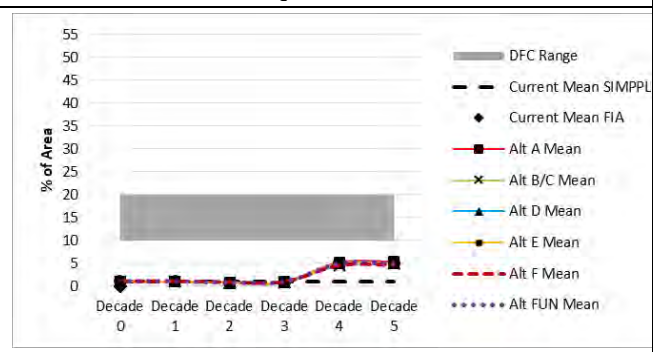
Divide



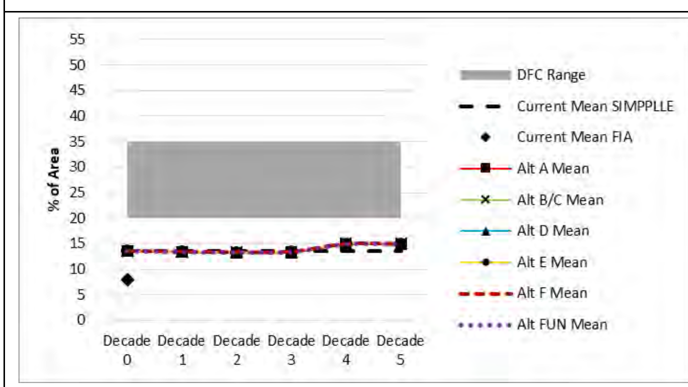
Elkhorns



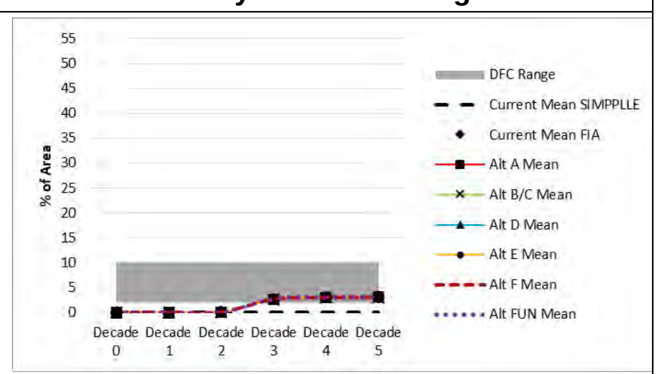
Highwoods



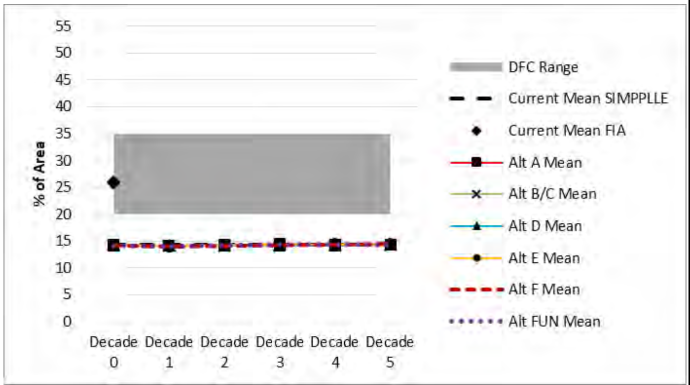
Little Belts



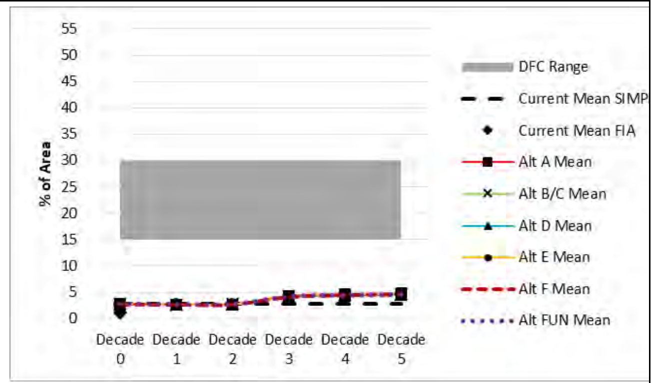
Rocky Mountain Range



Snowies



Upper Blackfoot



Limber pine presence

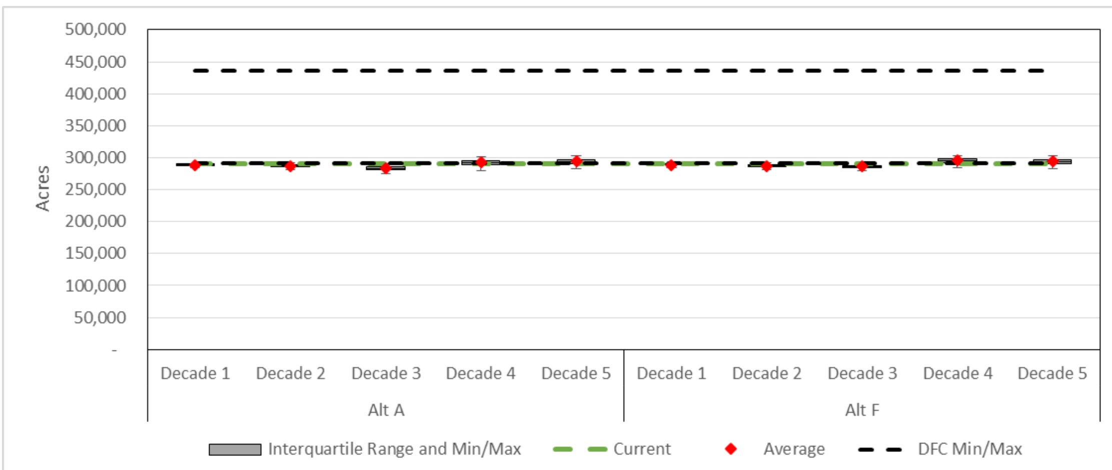


Figure 108. Limber pine presence (total acres) over 5 decades, alternatives A and F

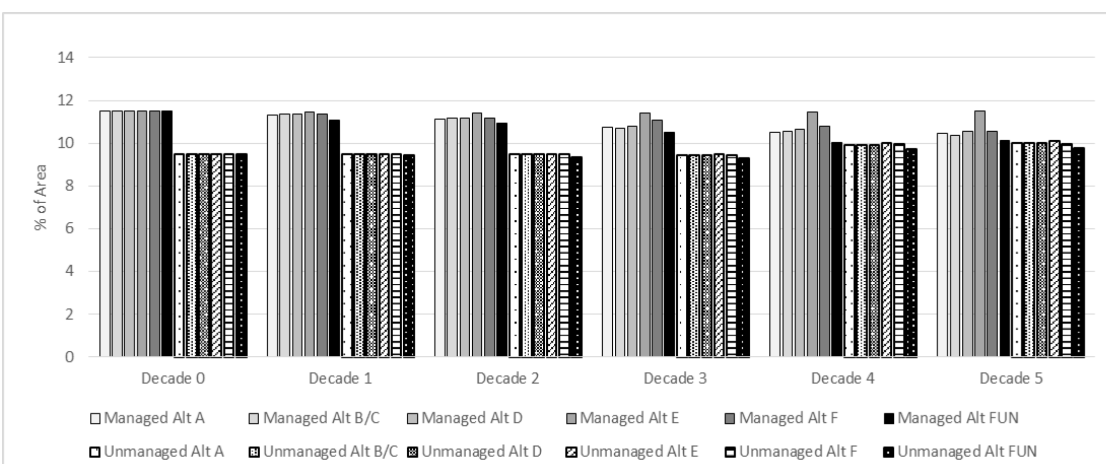


Figure 109. Limber pine presence in managed versus unmanaged landscapes, forestwide

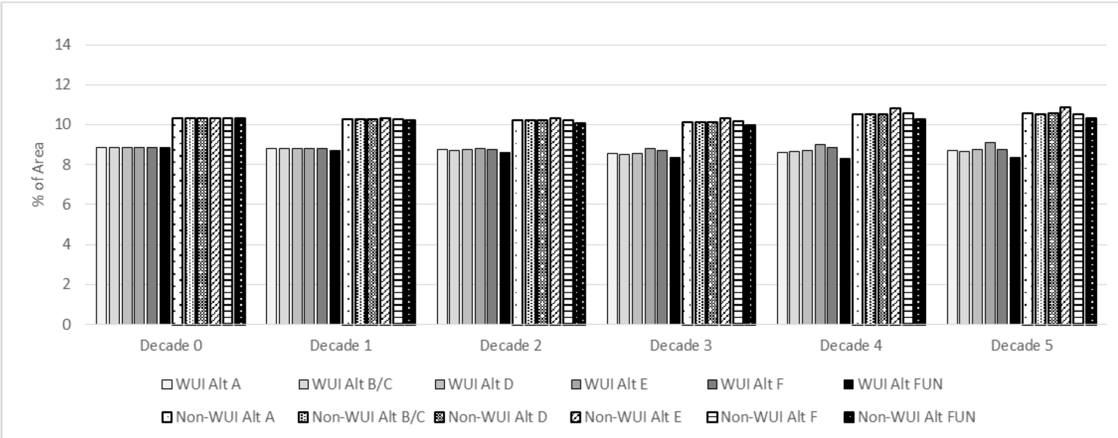


Figure 110. Limber pine presence in WUI versus Non-WUI areas, forestwide

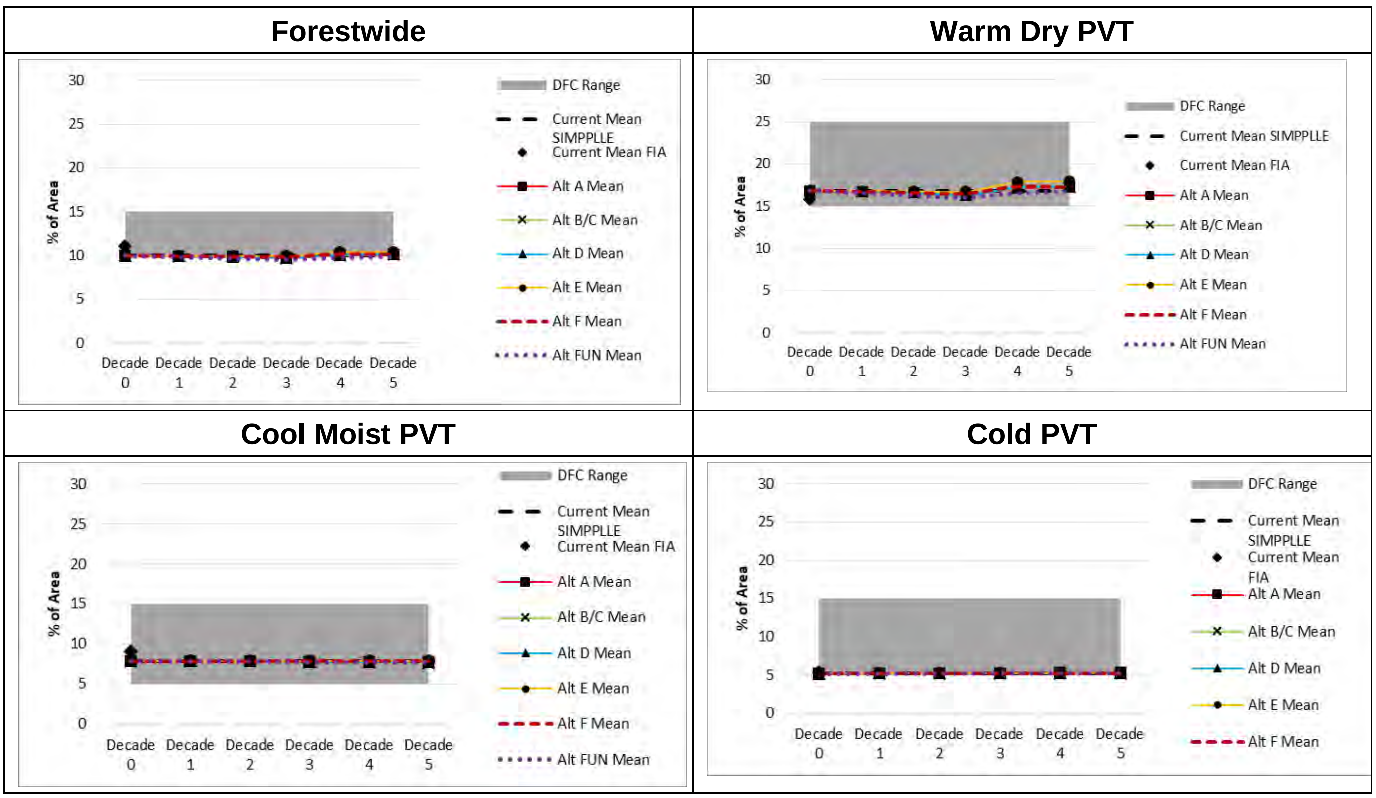
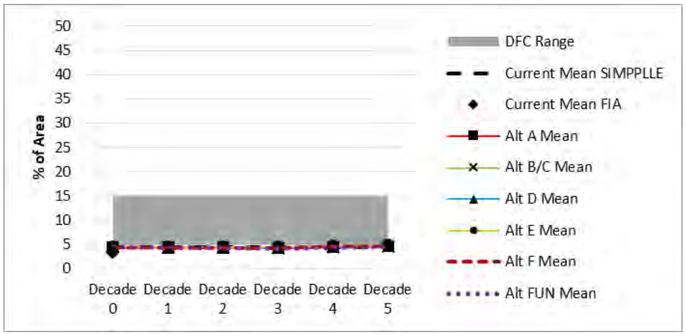


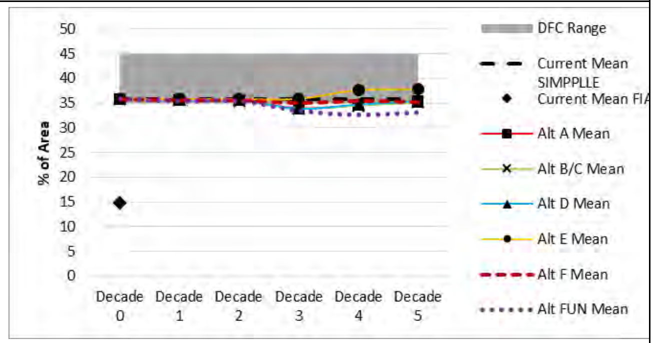
Figure 111. Limber pine presence (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 112. Limber pine presence (% of total area) over 5 decades by alternative, by GA

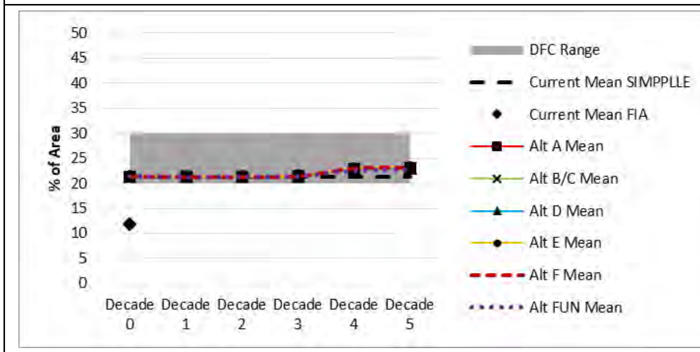
Big Belts



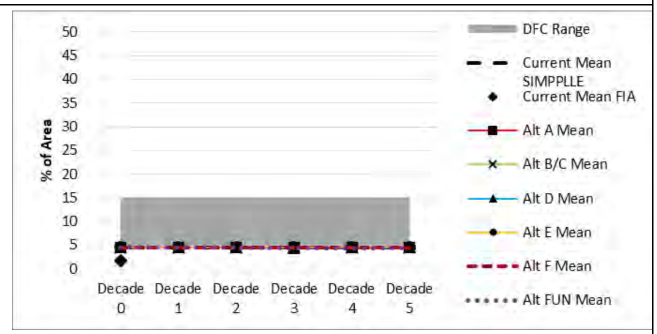
Castles



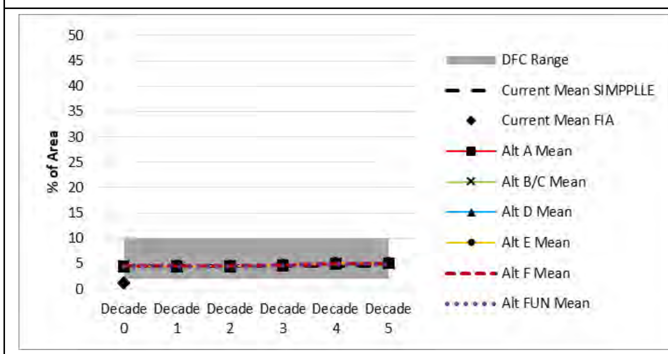
Crazies



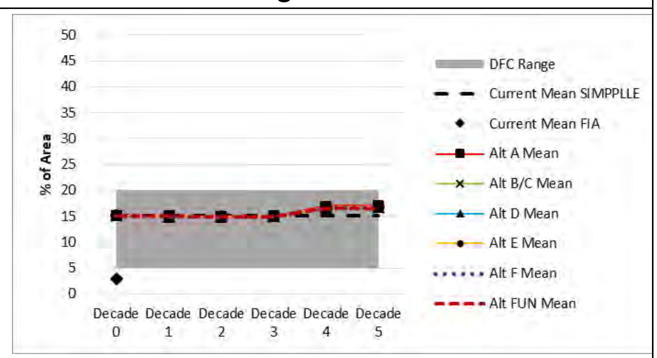
Divide



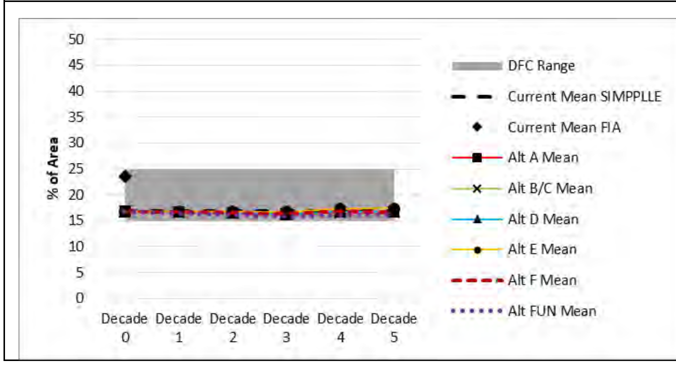
Elkhorns



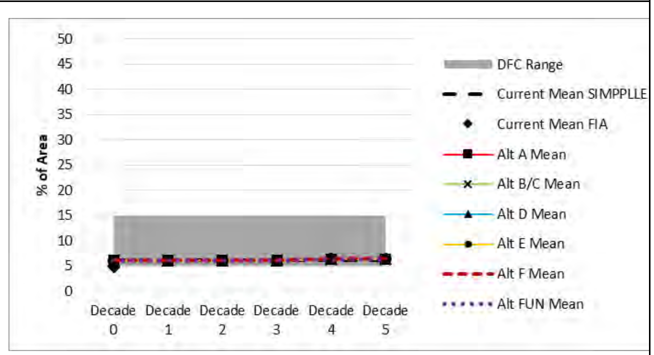
Highwoods

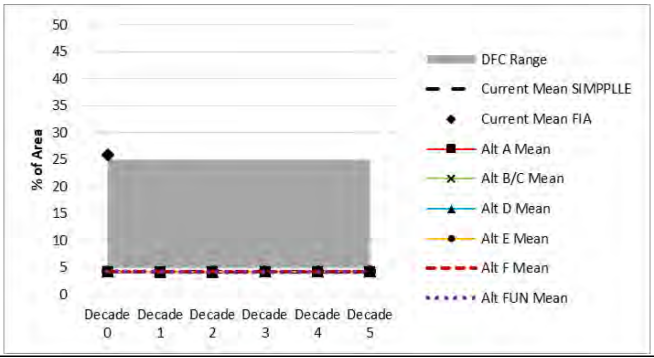
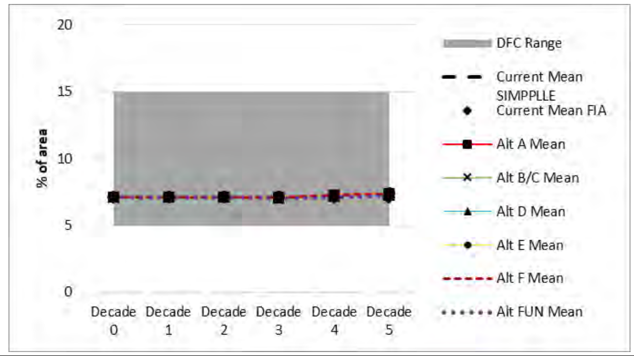


Little Belts



Rocky Mountain Range



Snowies	Upper Blackfoot
	

Rocky mountain juniper presence

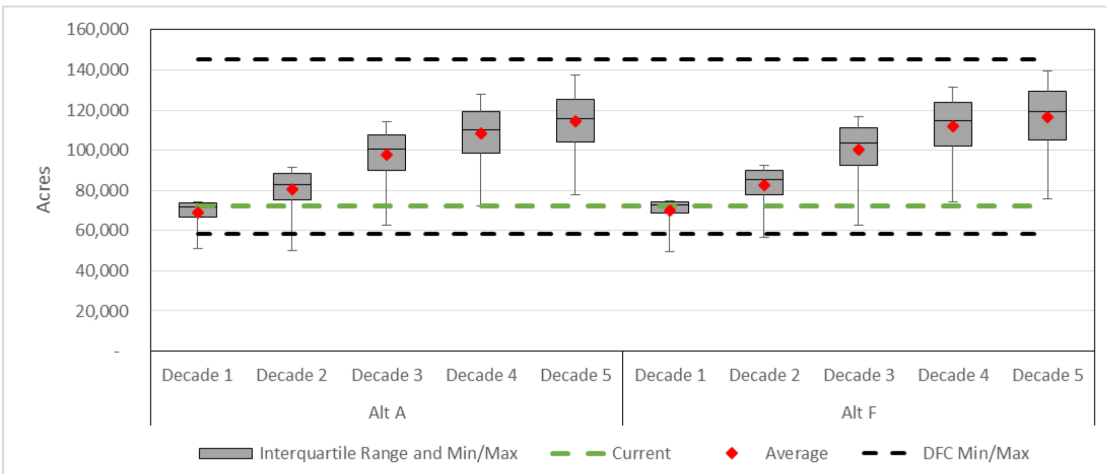


Figure 113. Rocky Mountain juniper presence (total acres) over 5 decades, alternatives A and F

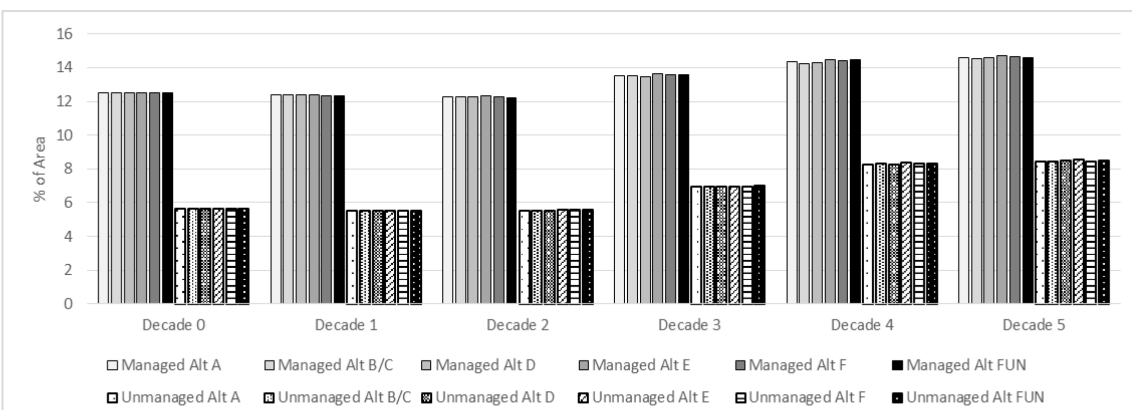


Figure 114. Rocky Mountain juniper presence in managed versus unmanaged landscapes, forestwide

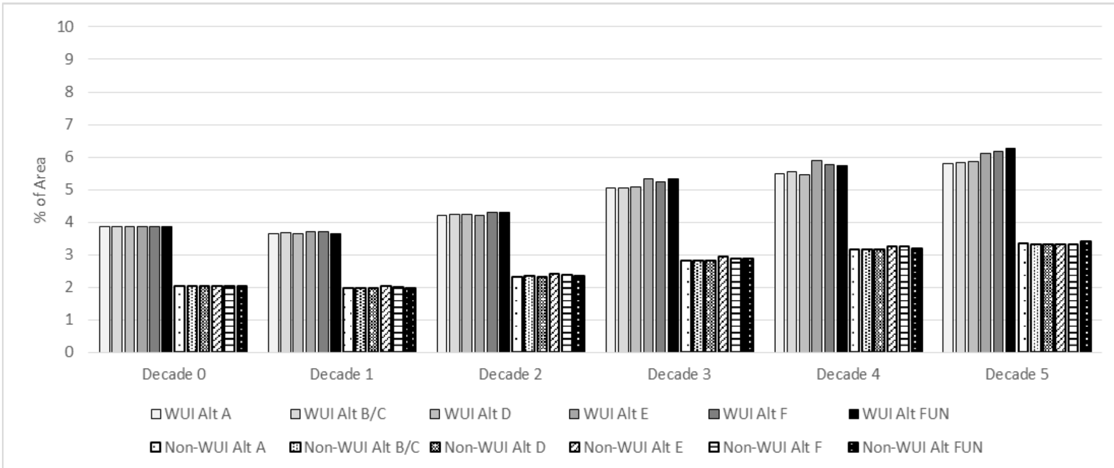


Figure 115. Rocky Mountain juniper presence in WUI versus Non-WUI areas, forestwide

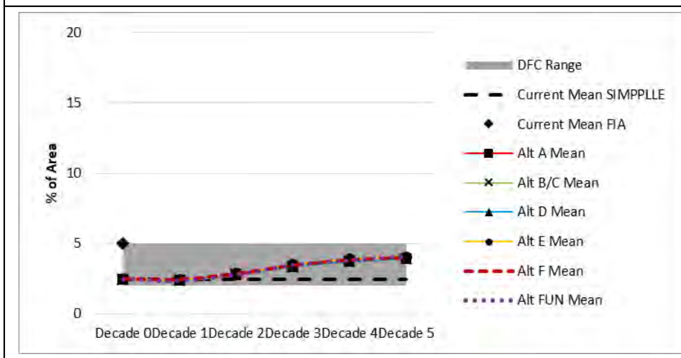
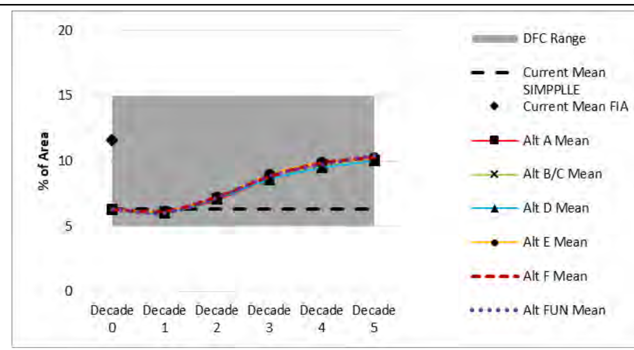
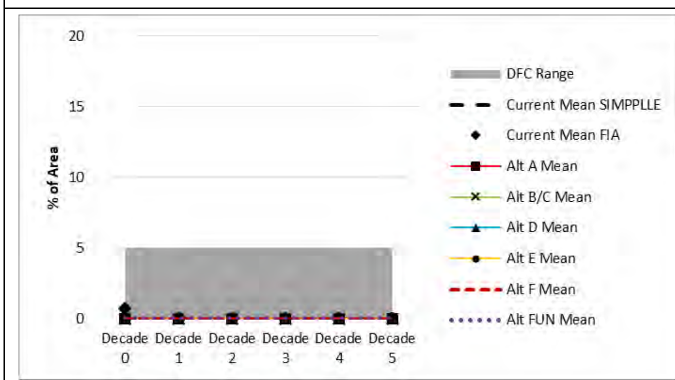
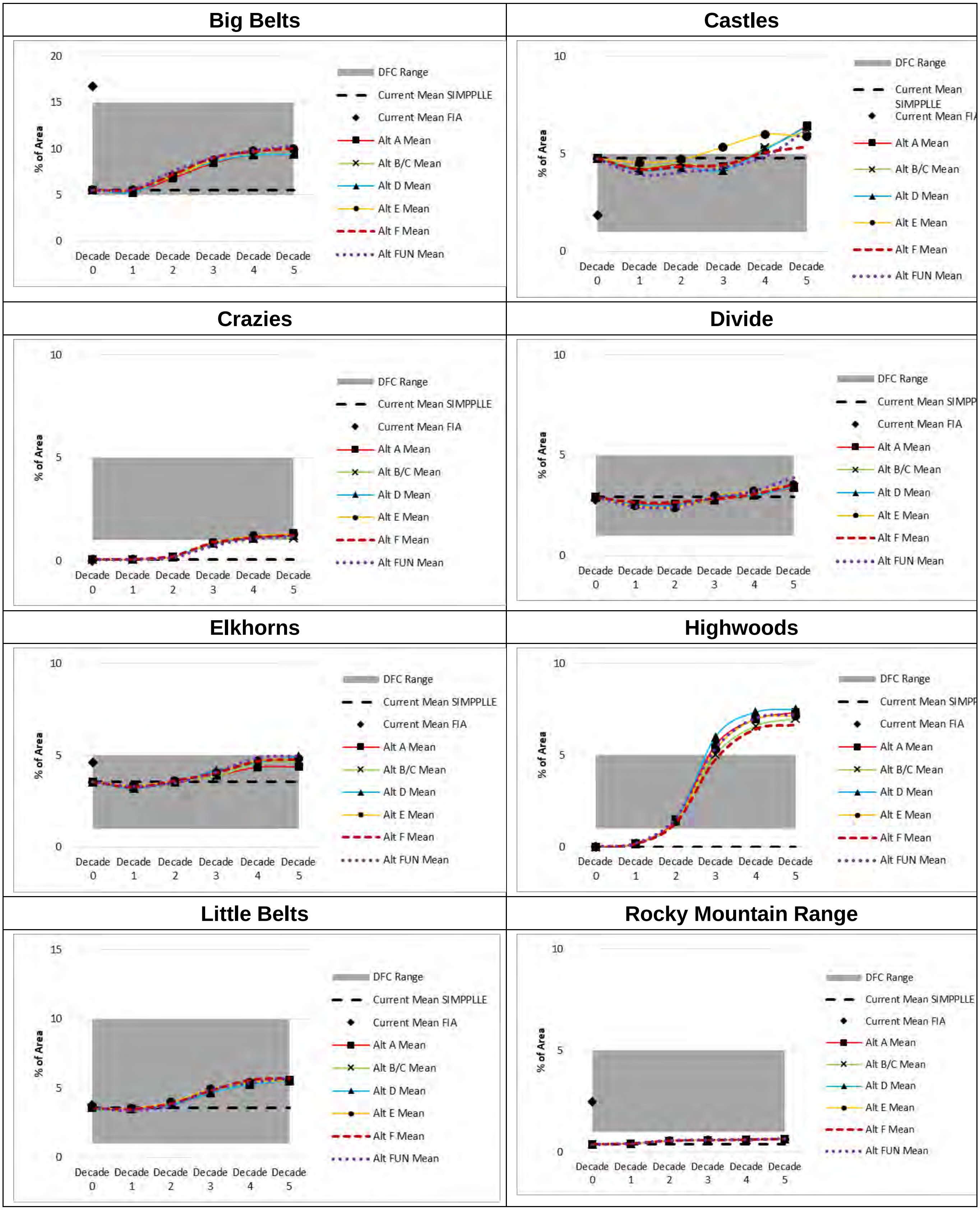
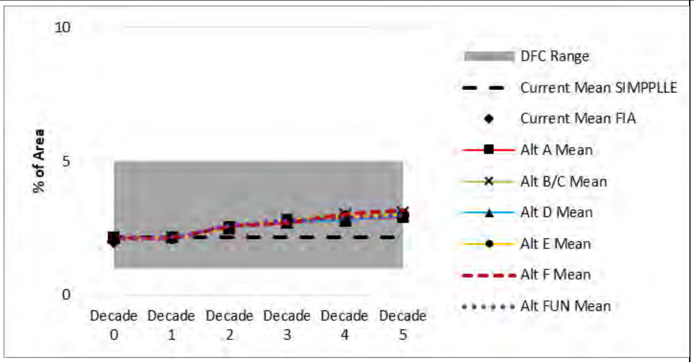
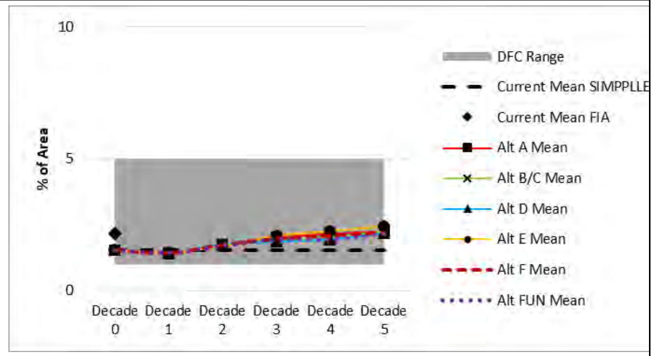
Forestwide	Warm Dry PVT
	
Cool Moist PVT	**Cold PVT**
	N/A

Figure 116. Rocky Mountain juniper presence (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 117. Rocky Mountain juniper presence (% of total area) over 5 decades by alternative, by GA



Snowies	Upper Blackfoot
	

Aspen/hardwood cover type and presence of aspen

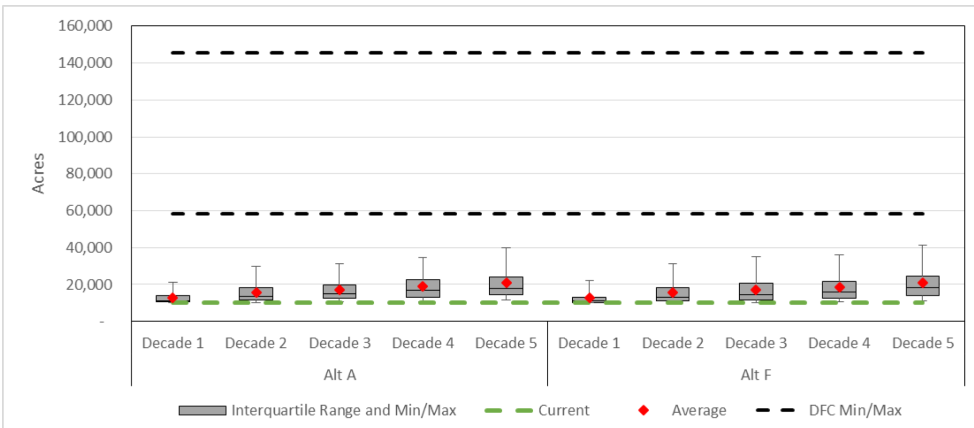


Figure 118. Aspen/hardwood cover type (total acres) over 5 decades, alternatives A and F

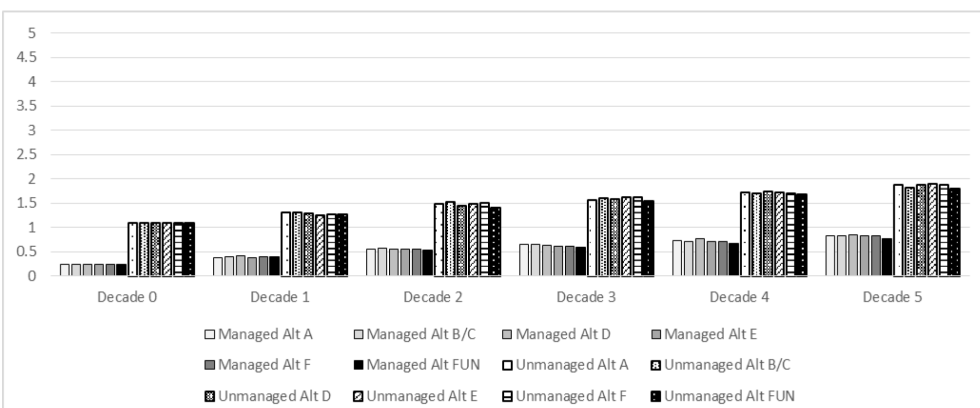


Figure 119. Aspen/hardwood cover type in managed versus unmanaged landscapes, forestwide

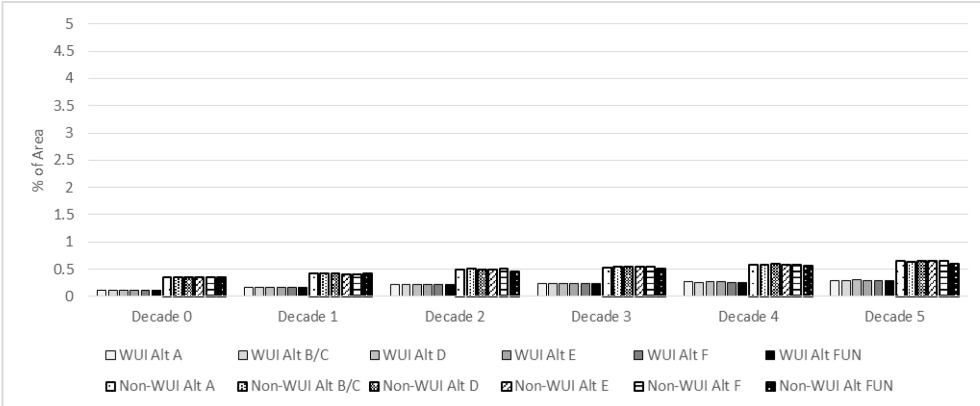


Figure 120. Aspen/ hardwood cover type in WUI versus non-WUI areas, forestwide

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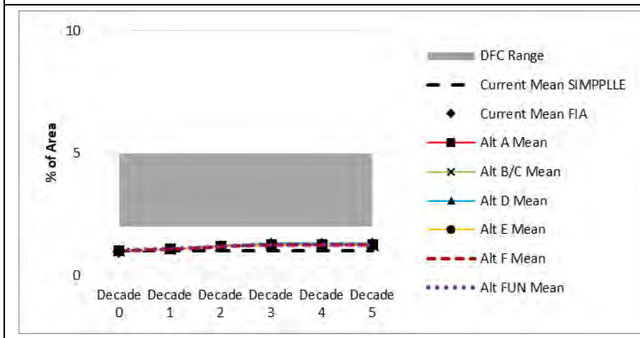
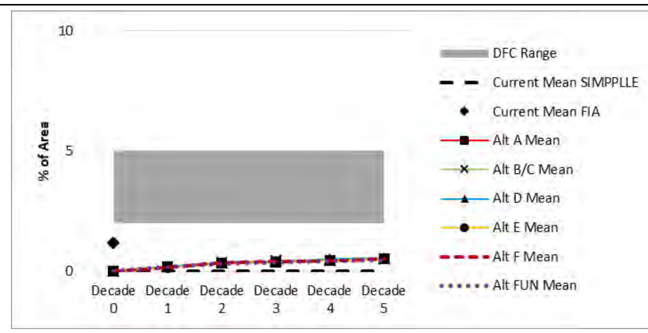
<tr><td>
</td><td>
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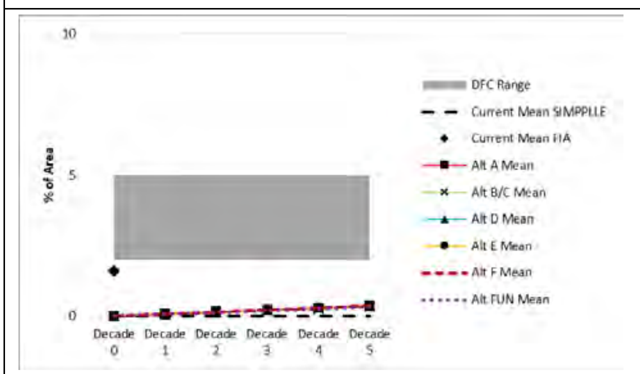
<tr><th>Cool Moist PVT</th><th>Cold PVT</th></tr>
<tr><td>
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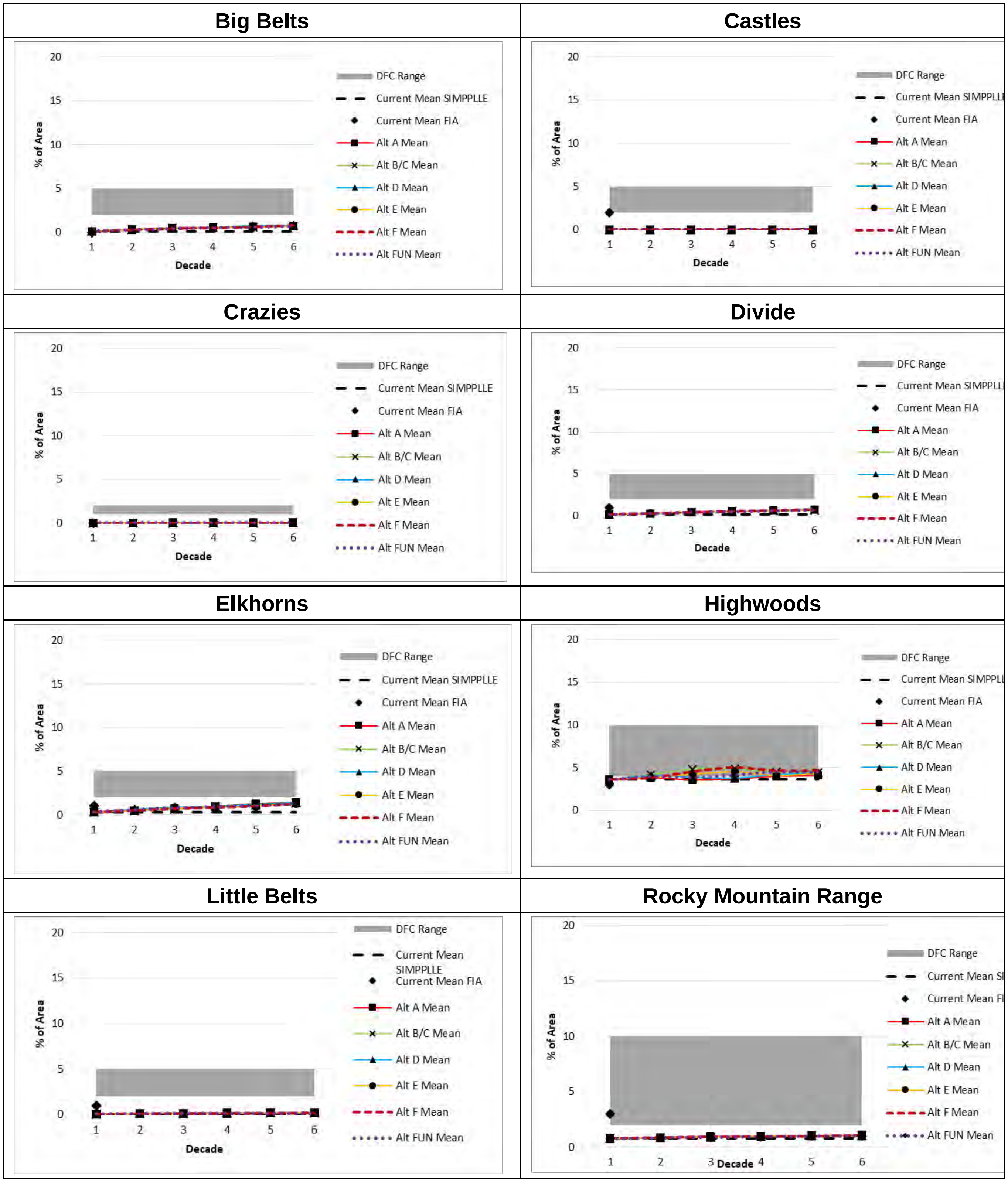
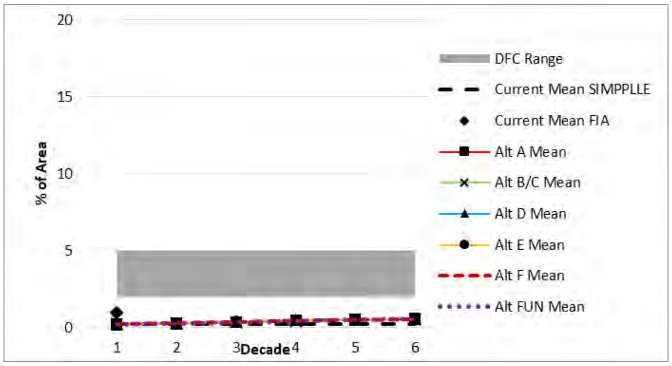
Figure 121. Aspen/hardwood cover type (% of total area) over 5 decades by alternative, forestwide and by PVT

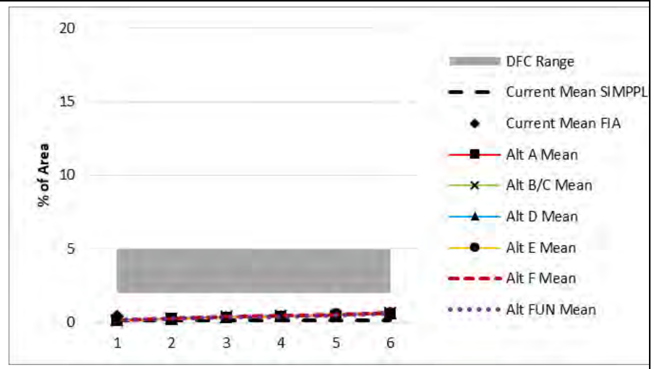
Figure 122. Aspen/hardwood cover type (% of total area) over 5 decades by alternative, by GA



Snowies



Upper Blackfoot



Aspen or cottonwood presence

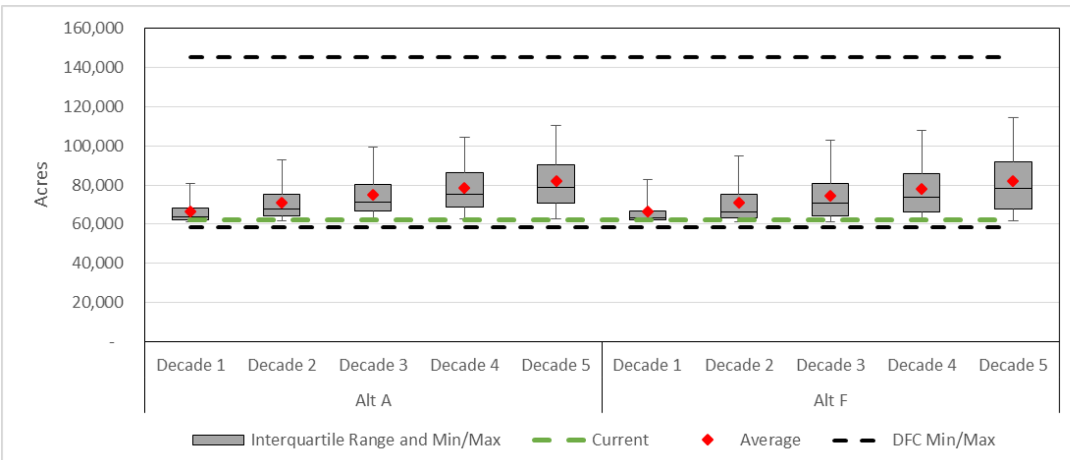


Figure 123. Aspen presence (total acres) over 5 decades, alternatives A and F

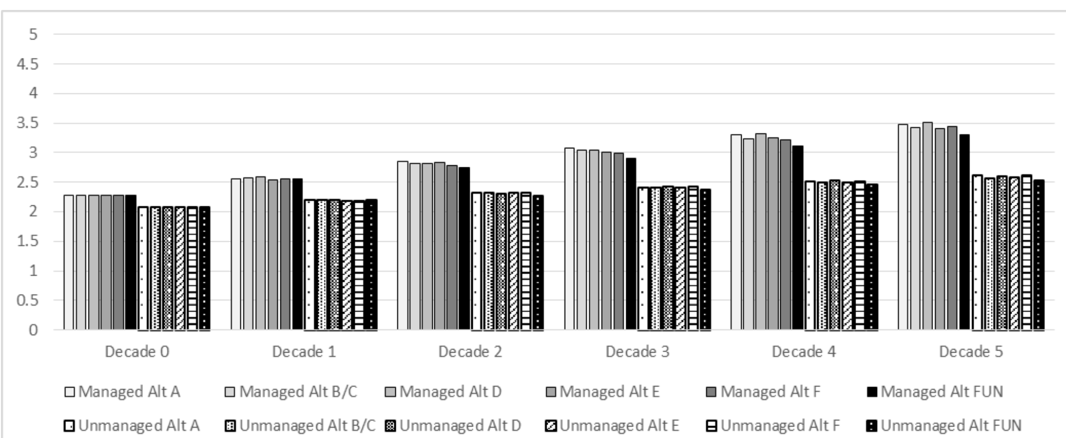


Figure 124. Aspen presence in managed versus unmanaged landscapes, forestwide

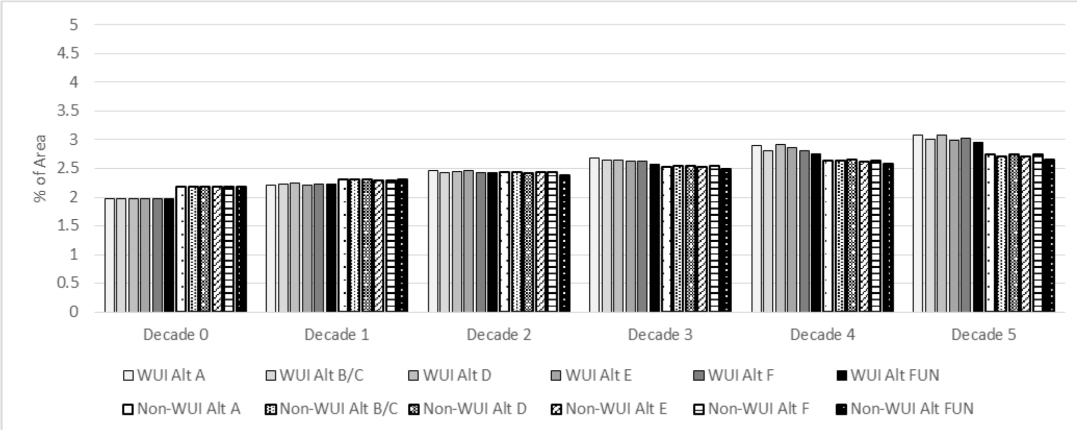


Figure 125. Aspen presence in WUI versus Non-WUI areas, forestwide

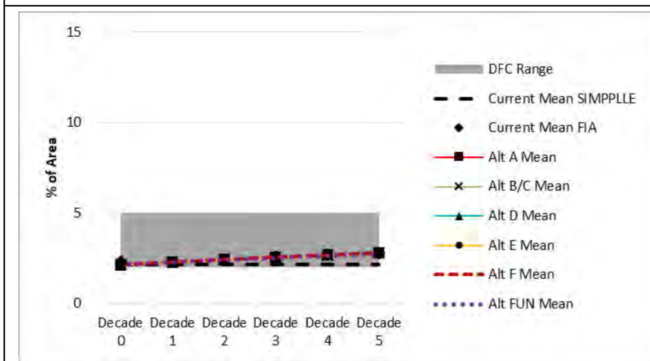
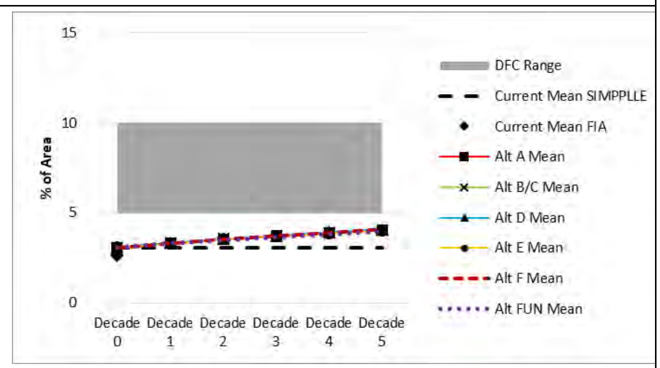
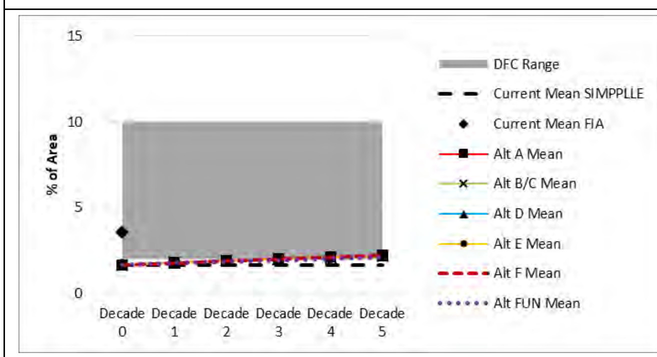
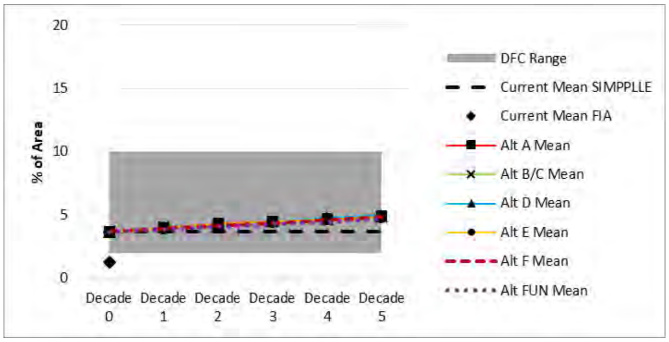
Forestwide	Warm Dry PVT
	
Cool Moist PVT	**Cold PVT**
	N/A

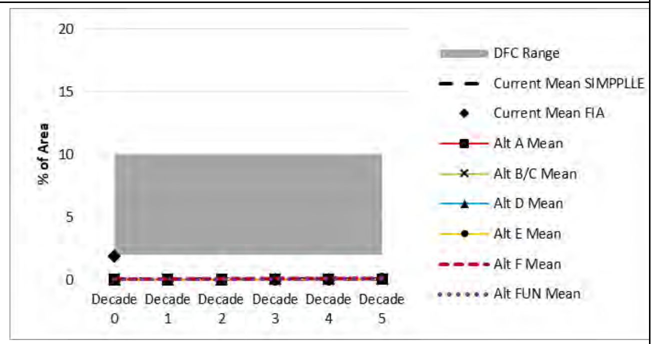
Figure 126. Aspen presence (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 127. Aspen presence (% of total area) over 5 decades by alternative, by GA

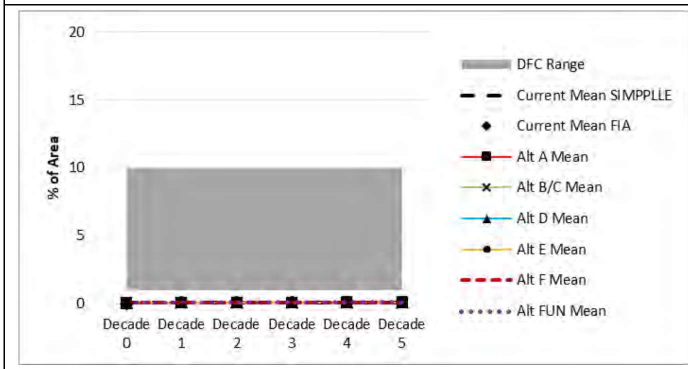
Big Belts



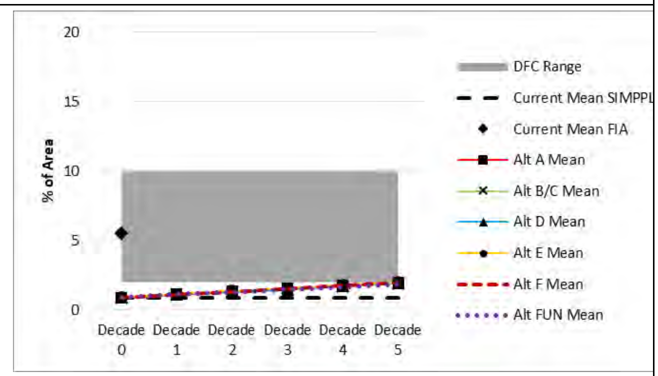
Castles



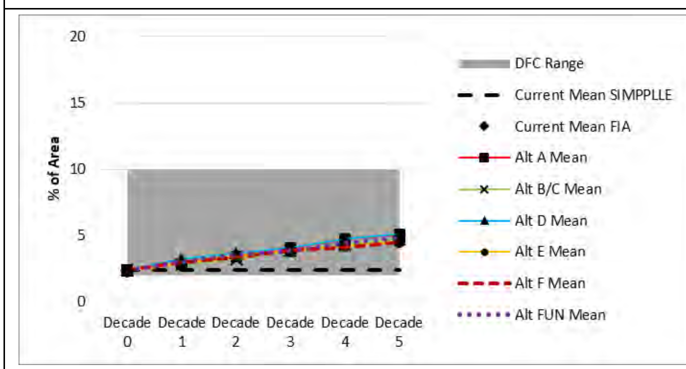
Crazies



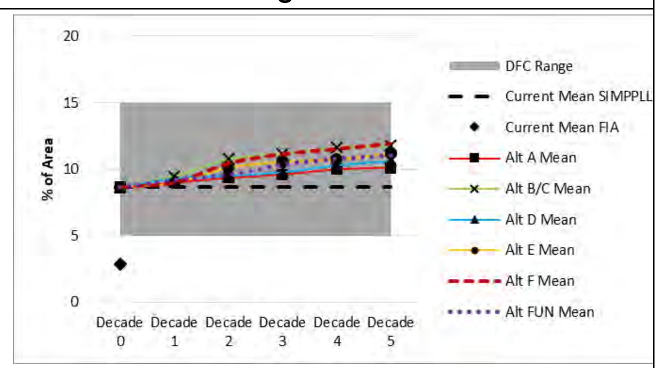
Divide



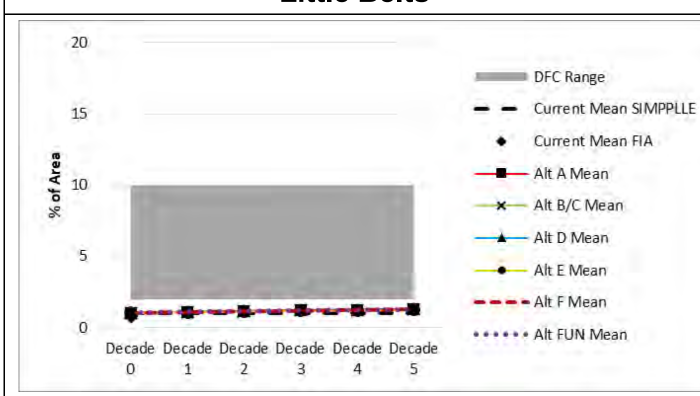
Elkhorns



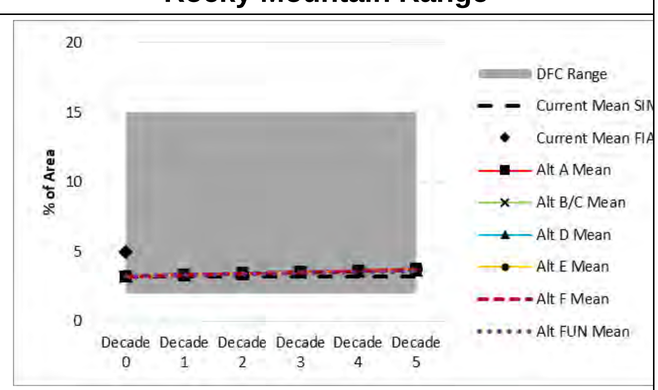
Highwoods

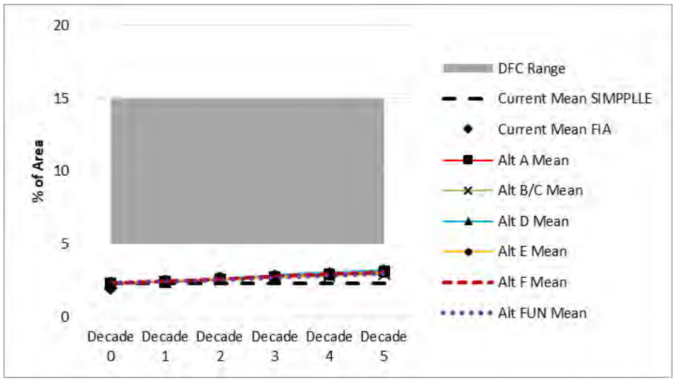
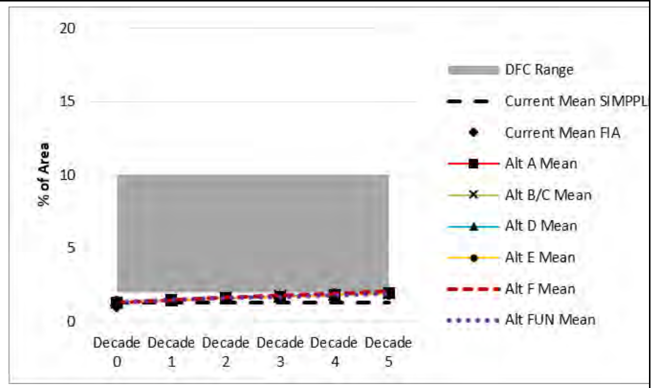


Little Belts



Rocky Mountain Range



Snowies	Upper Blackfoot
	

Douglas fir cover type and presence of Douglas-fir

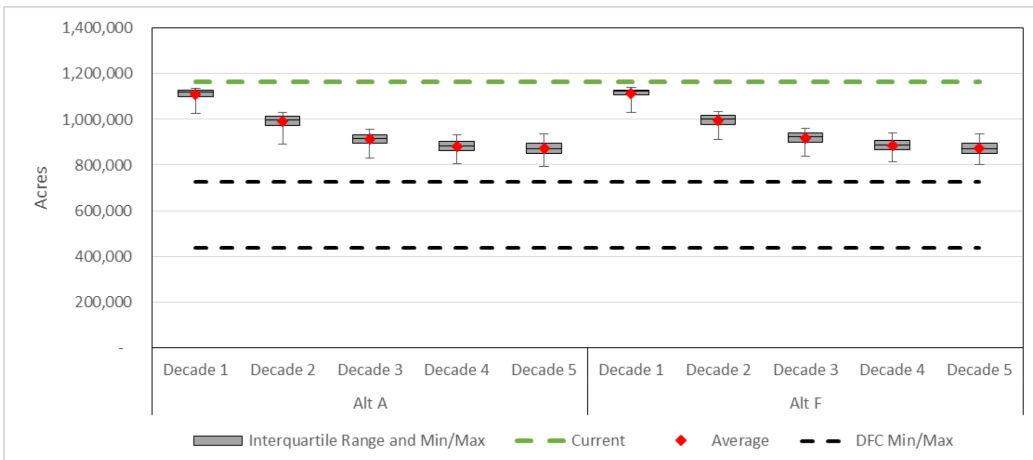


Figure 128. Douglas-fir cover type (total acres) over 5 decades, alternatives A and F

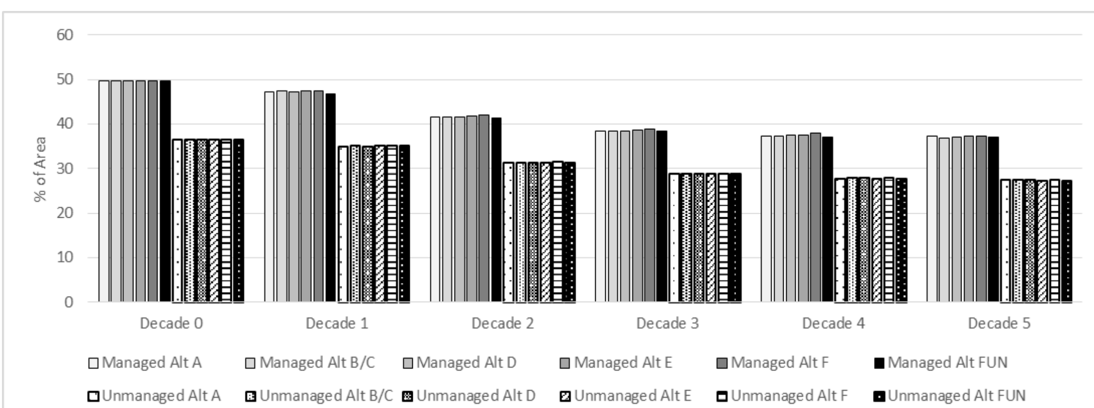


Figure 129. Douglas-fir cover type in managed versus unmanaged landscapes, forestwide

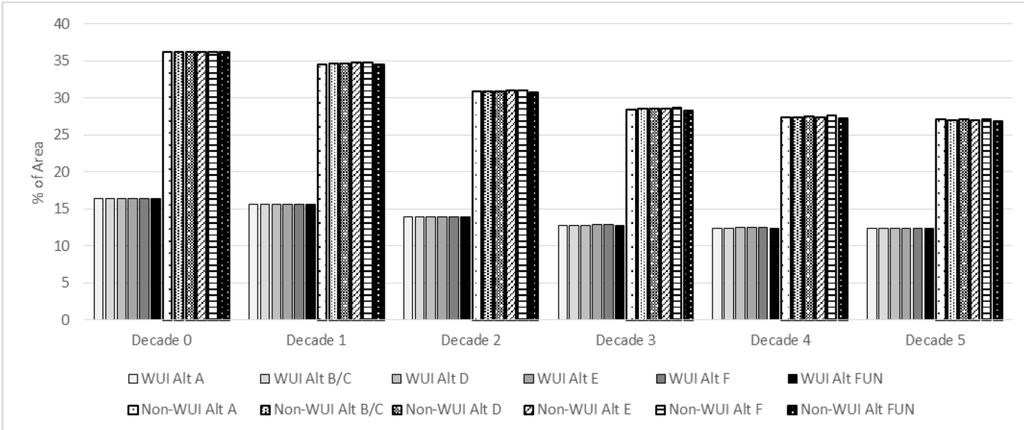


Figure 130. Douglas-fir cover type in WUI versus non-WUI areas, forestwide

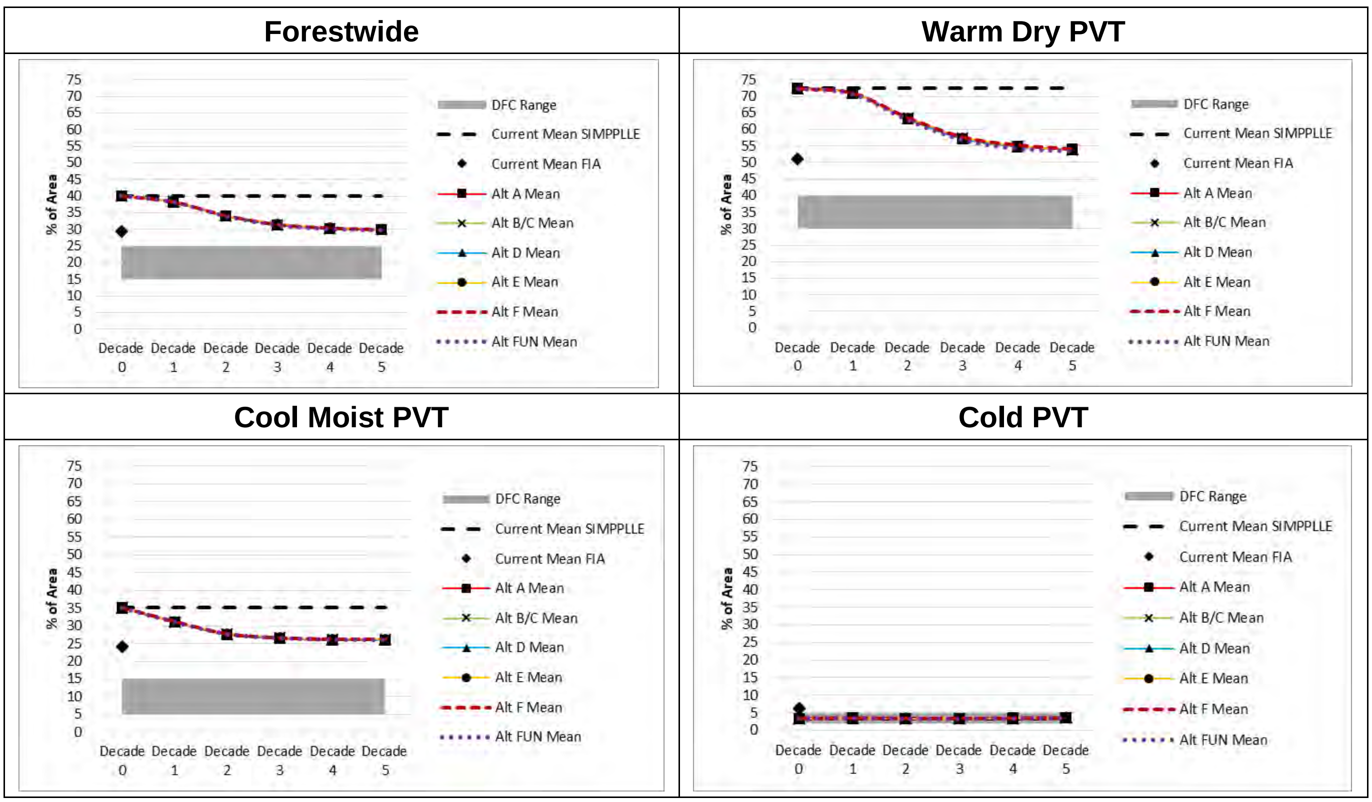
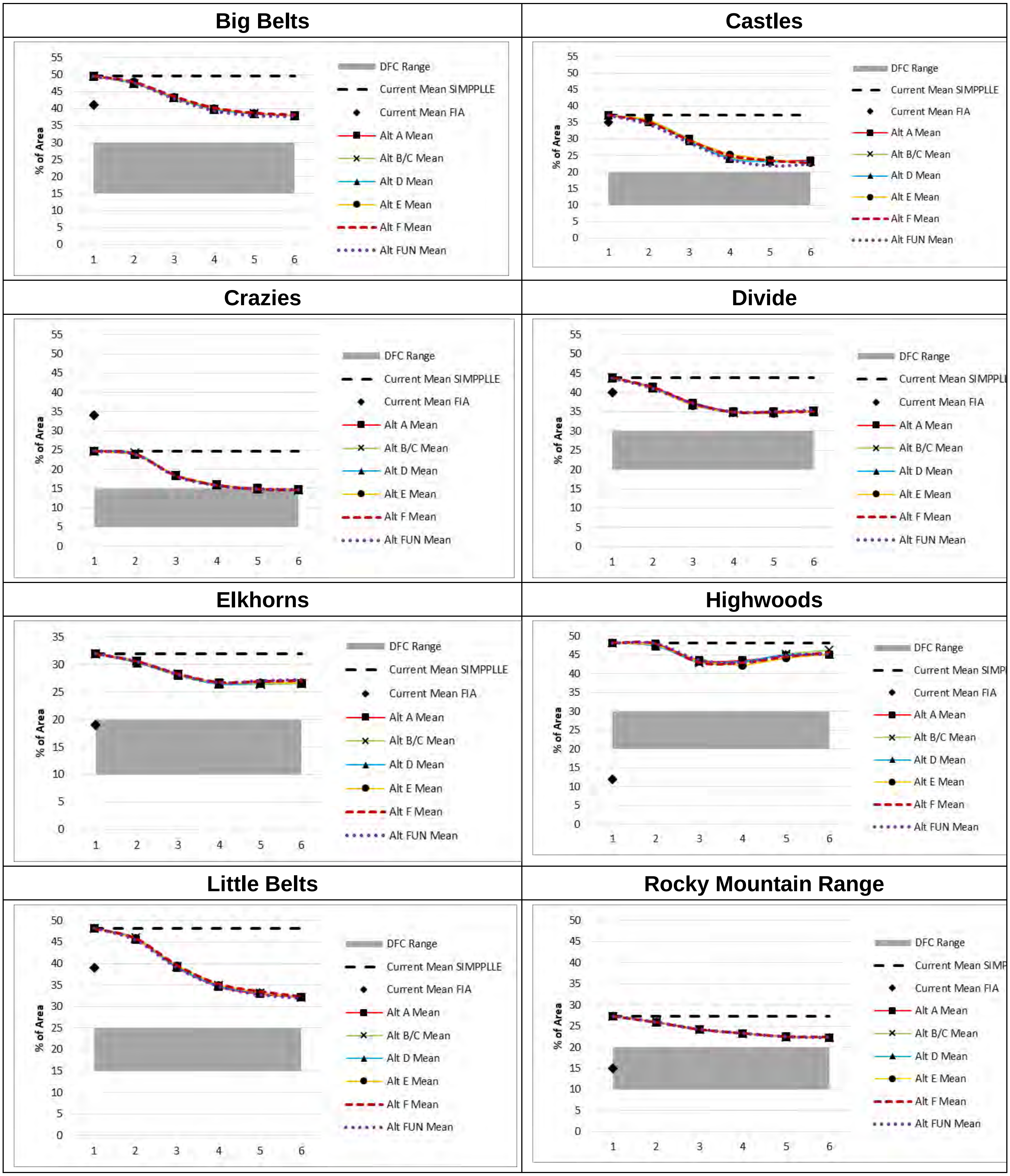
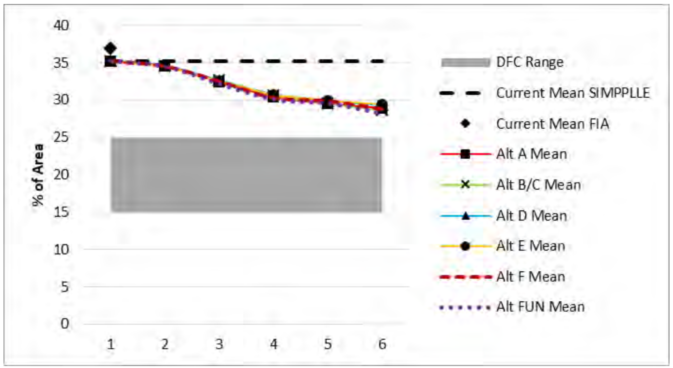
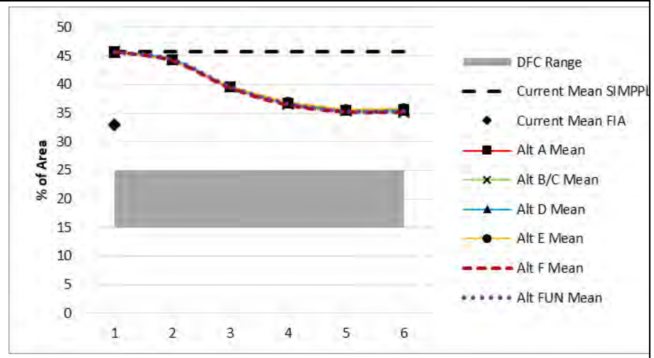


Figure 131. Douglas-fir cover type (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 132. Douglas-fir cover type (% of total area) over 5 decades by alternative, by GA



Snowies	Upper Blackfoot
	

Douglas-fir presence

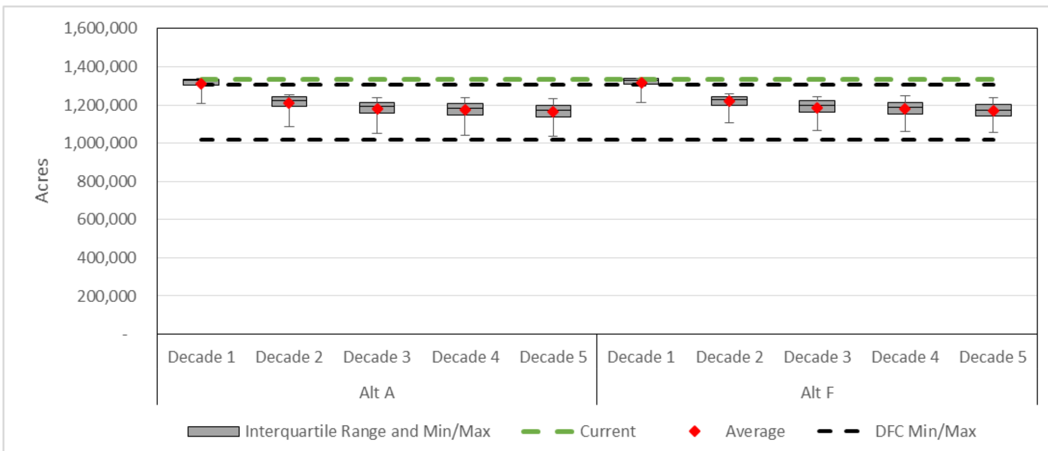


Figure 133. Douglas-fir presence (total acres) over 5 decades, alternatives A and F

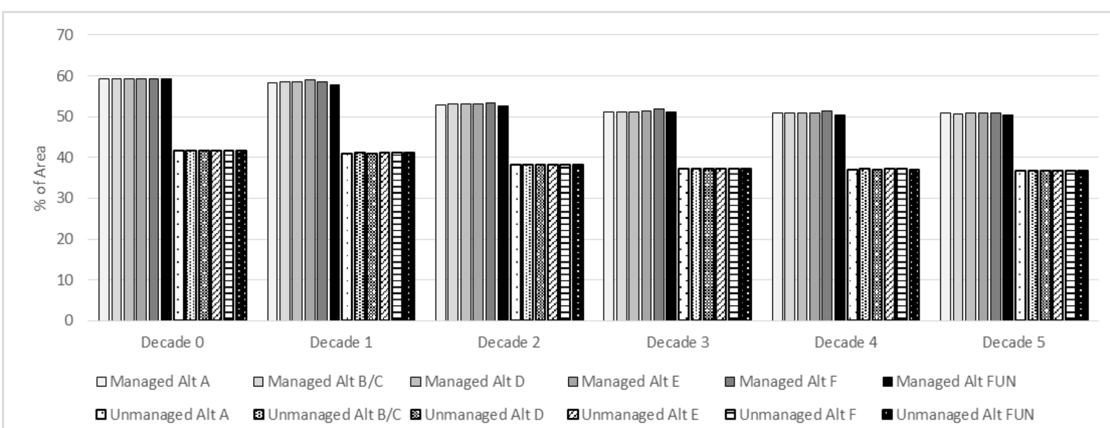


Figure 134. Douglas-fir presence in managed versus unmanaged landscapes, forestwide

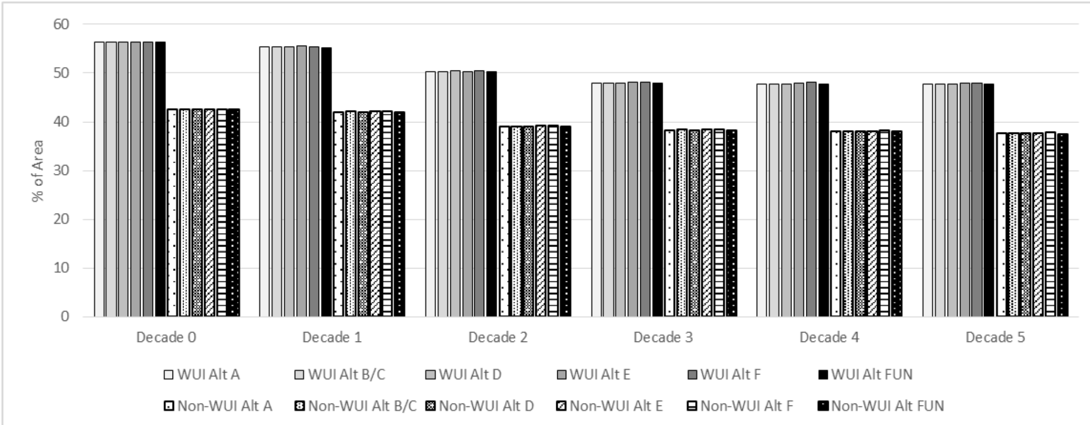


Figure 135. Douglas-fir presence in WUI versus Non-WUI areas, forestwide

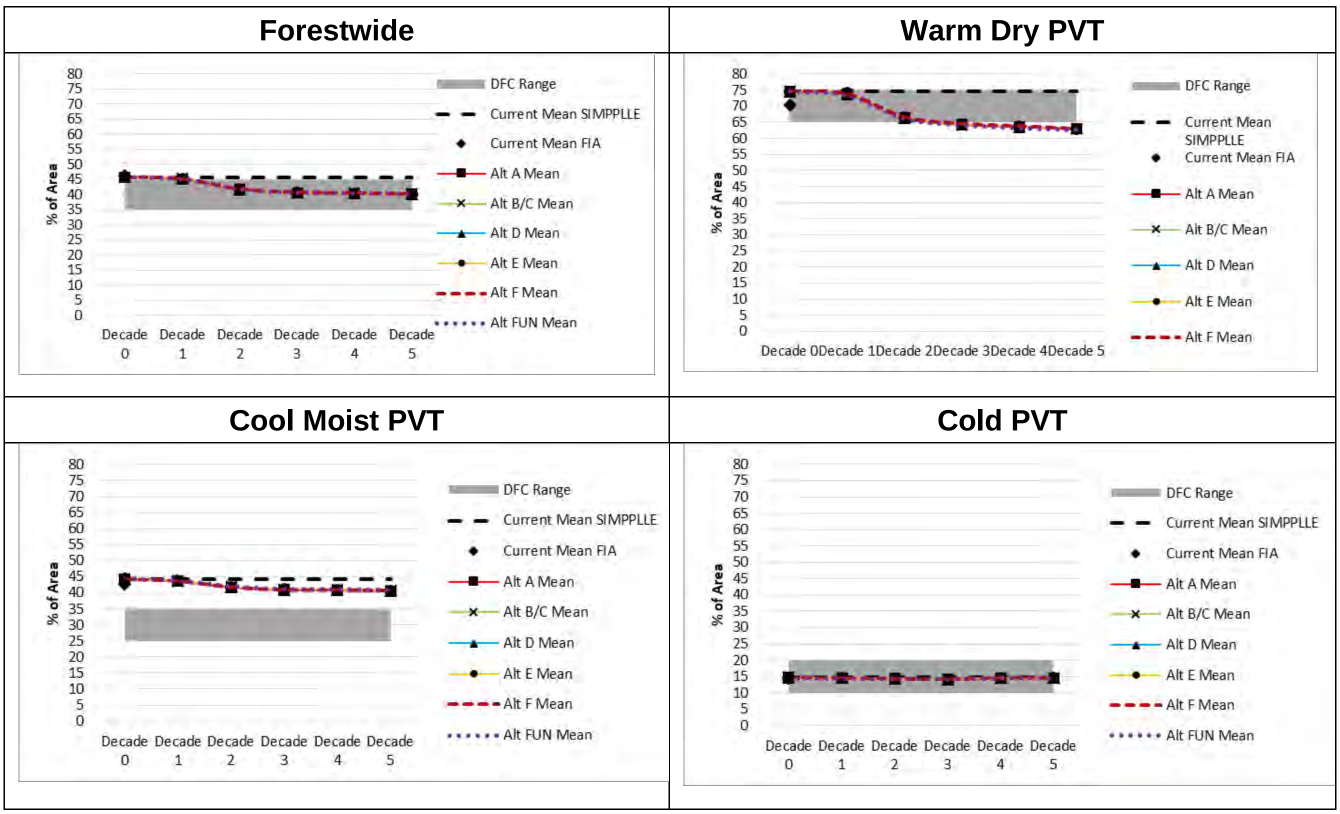
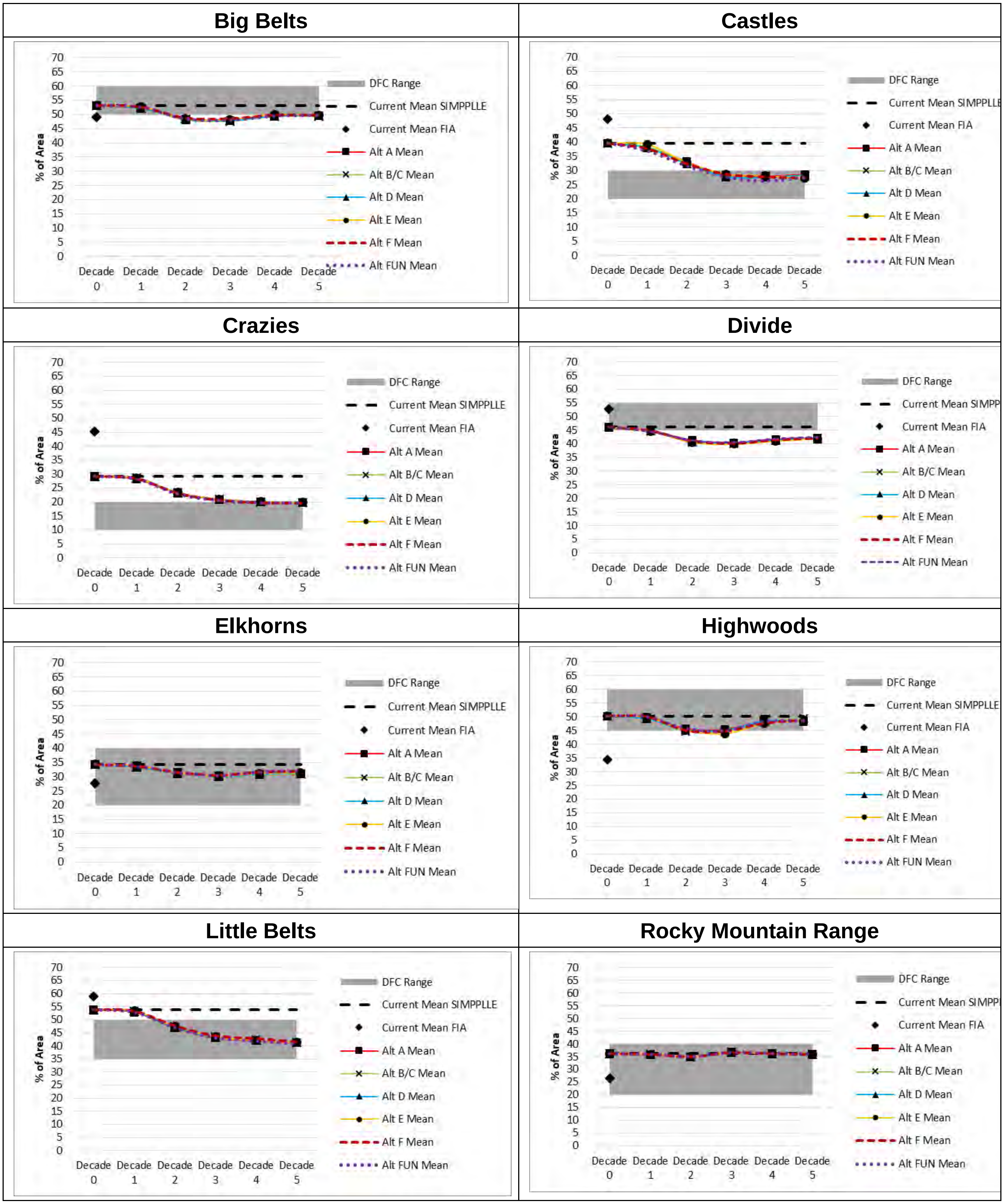
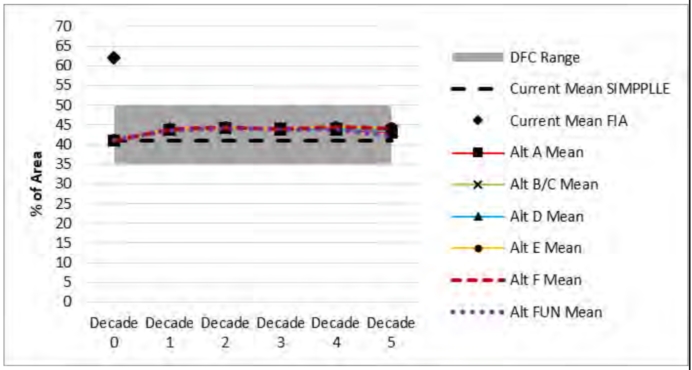
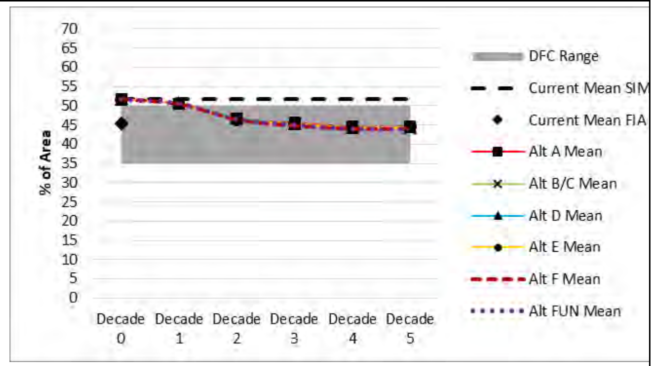


Figure 136. Douglas-fir presence (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 137. Douglas-fir presence (% of total area) over 5 decades by alternative, by GA



Snowies	Upper Blackfoot
	

Lodgepole pine cover type and presence of lodgepole pine

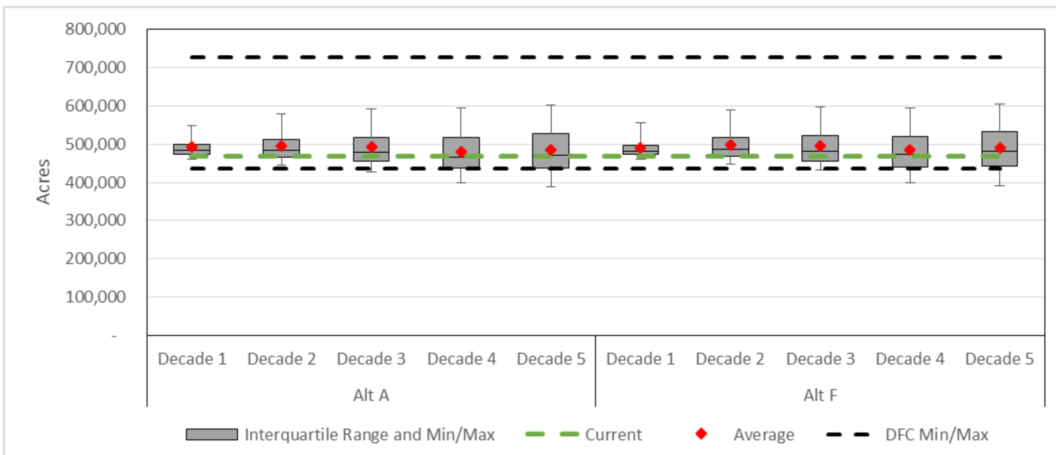


Figure 138. Lodgepole pine cover type (total acres) over 5 decades, alternatives A and F

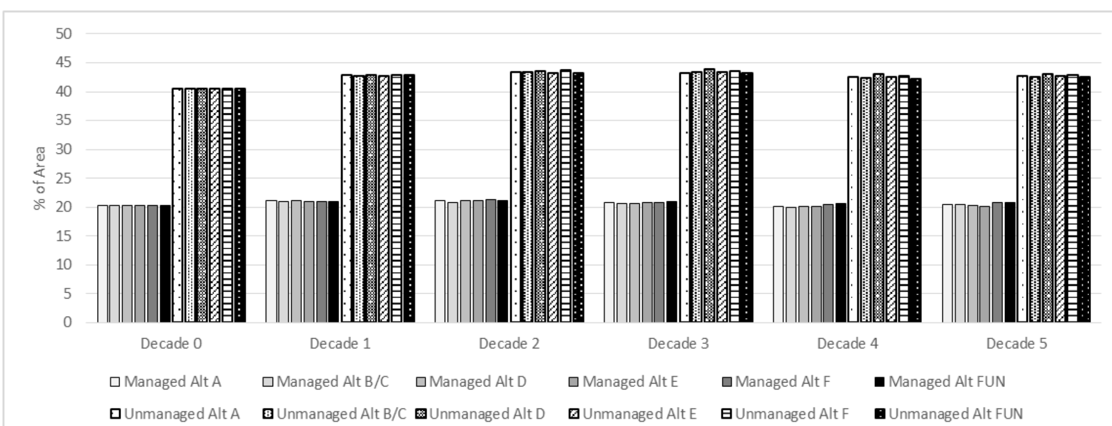


Figure 139. Lodgepole pine cover type in managed versus unmanaged landscapes, forestwide

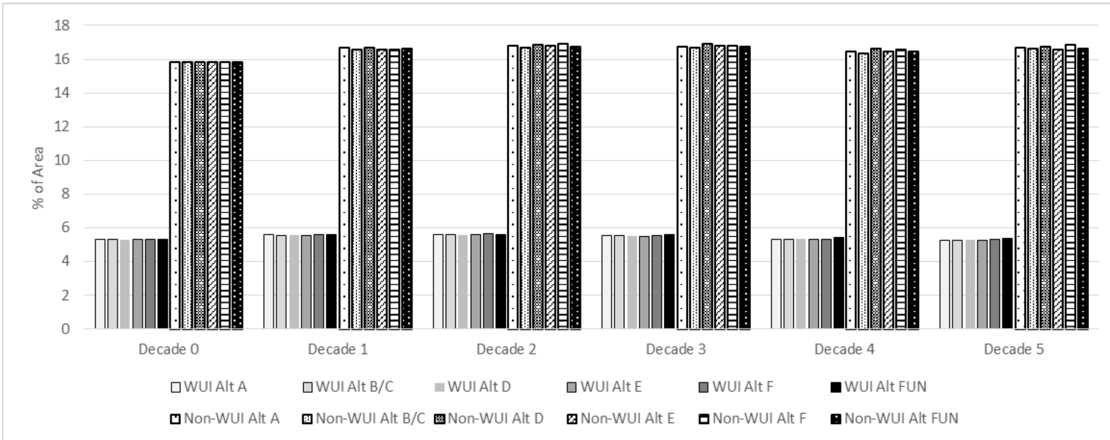


Figure 140. Lodgepole pine cover type in WUI versus non-WUI areas, forestwide

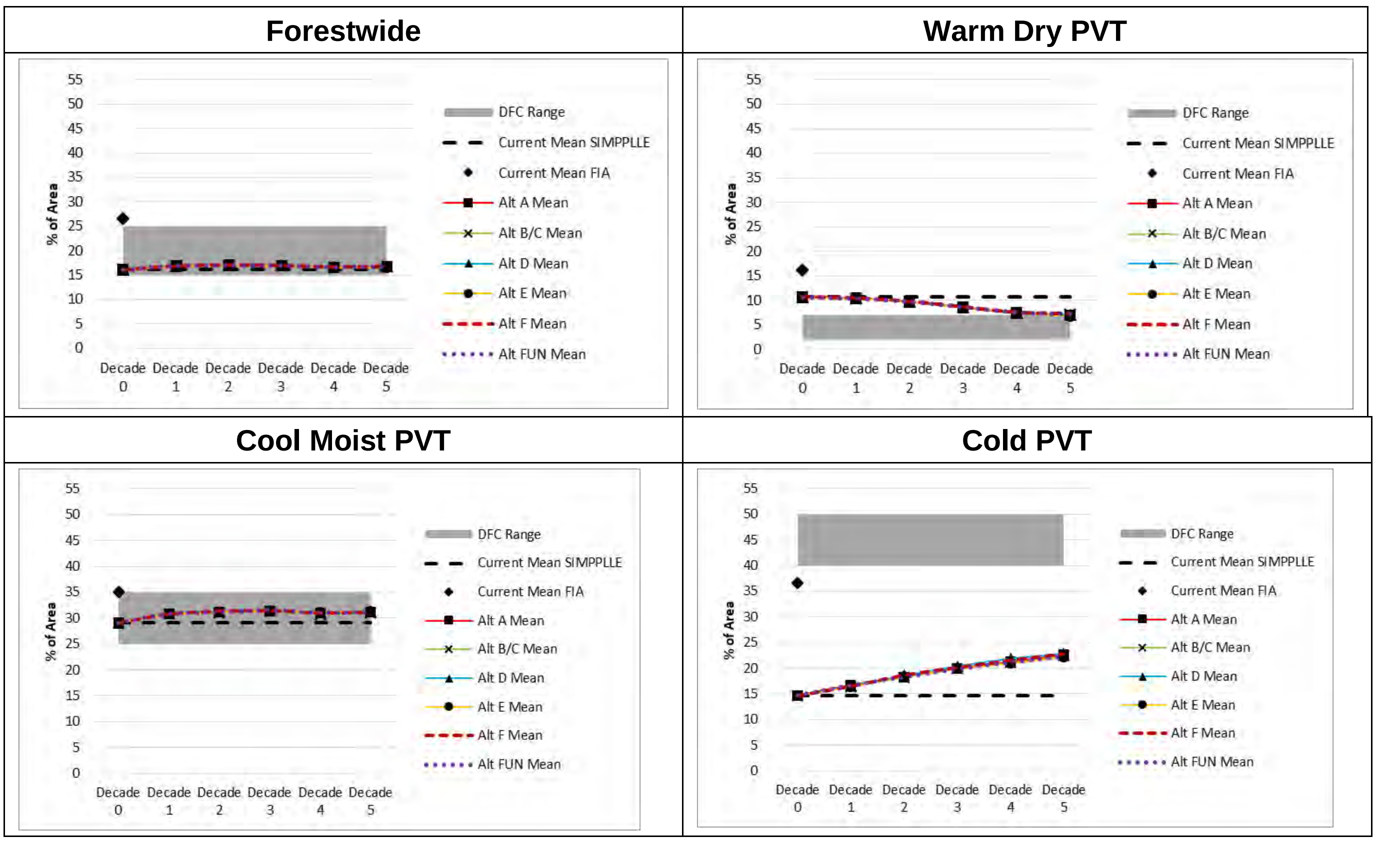
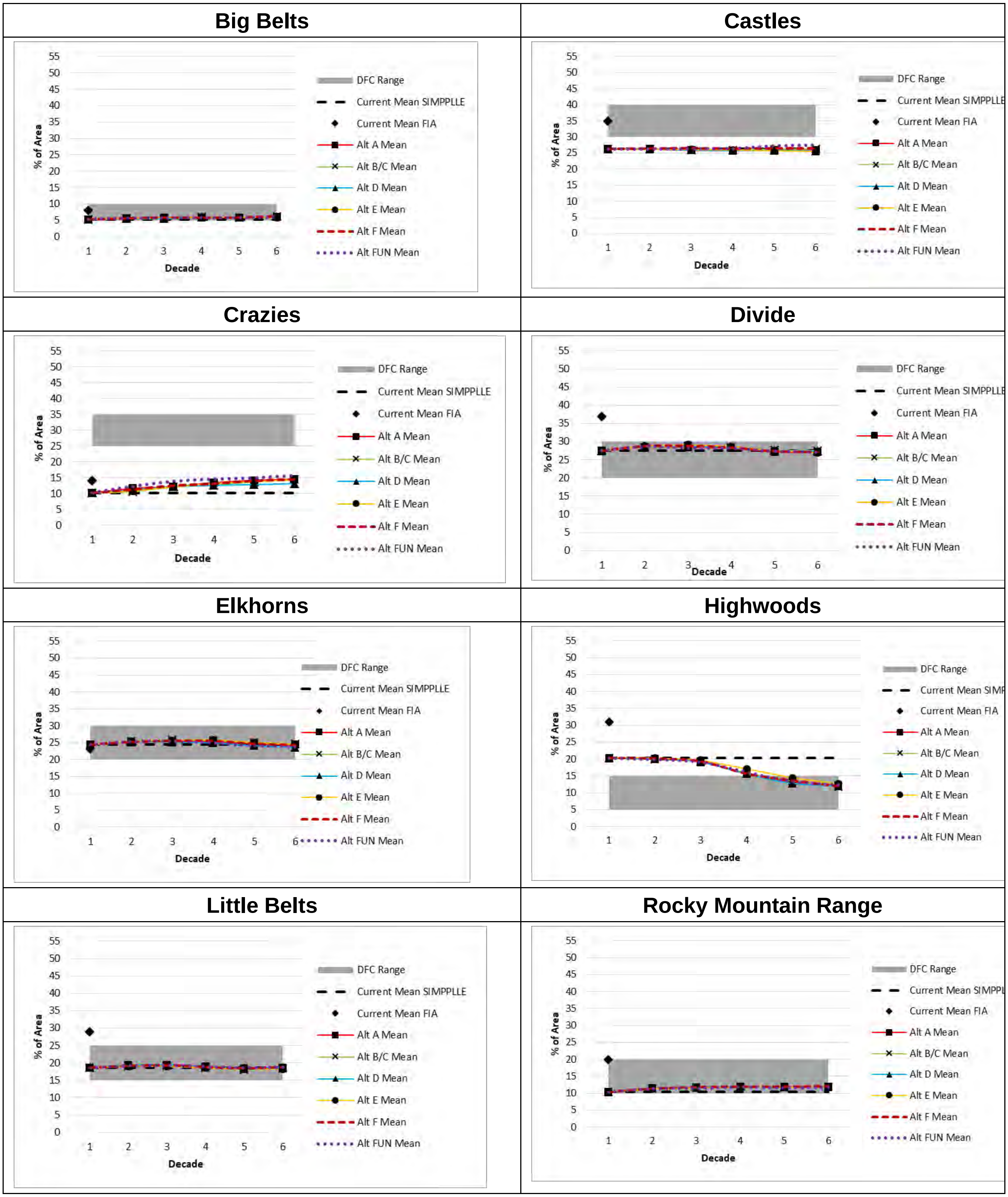
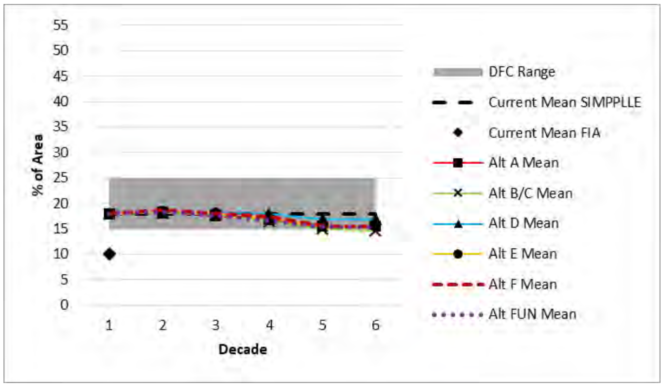
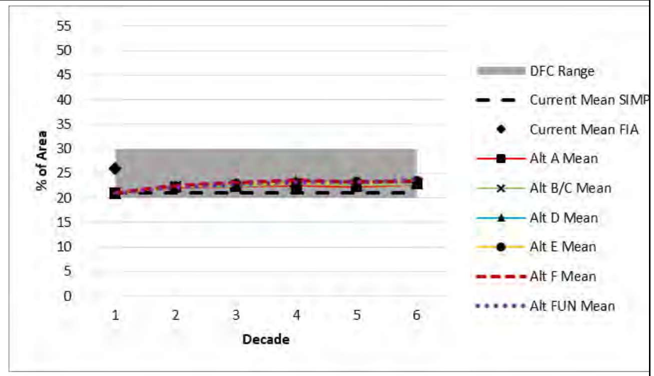


Figure 141. Lodgepole pine cover type (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 142. Lodgepole pine cover type (% of total area) over 5 decades by alternative, by GA



Snowies	Upper Blackfoot
	

Lodgepole pine presence

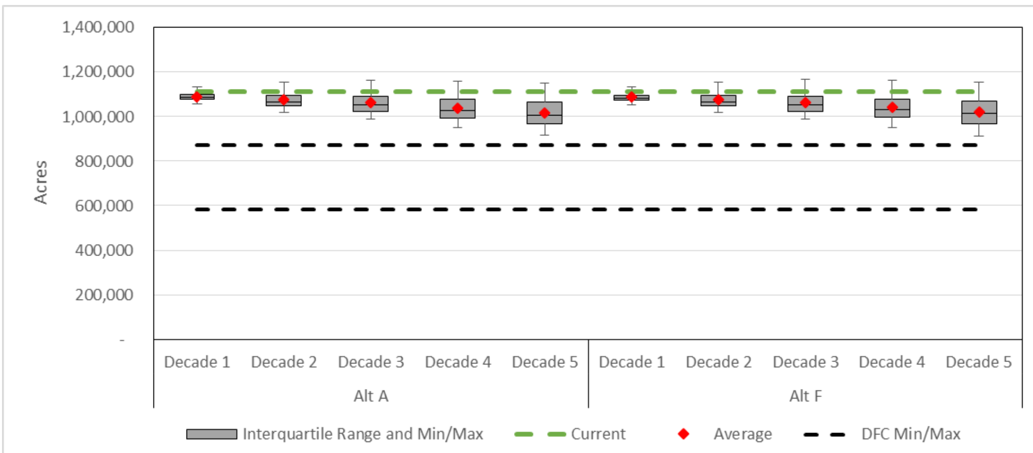


Figure 143. Lodgepole pine presence (total acres) over 5 decades, alternatives A and F

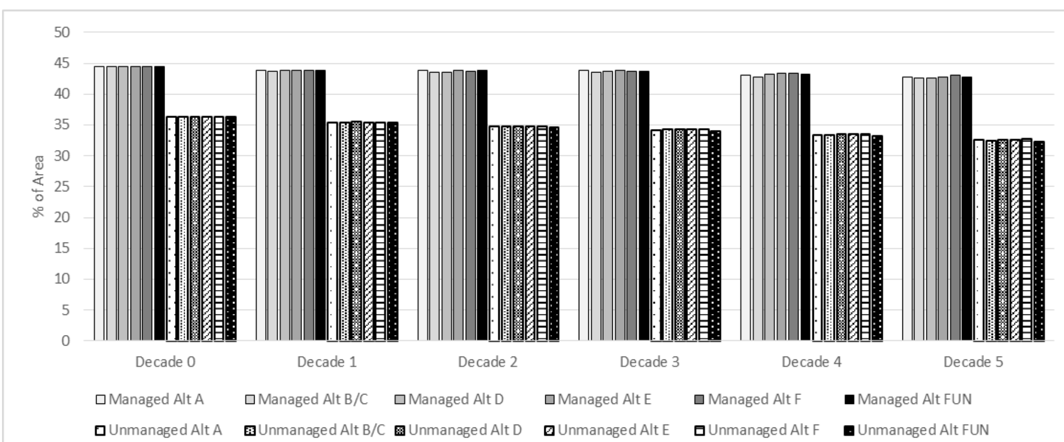


Figure 144. Lodgepole pine presence in managed versus unmanaged landscapes, forestwide

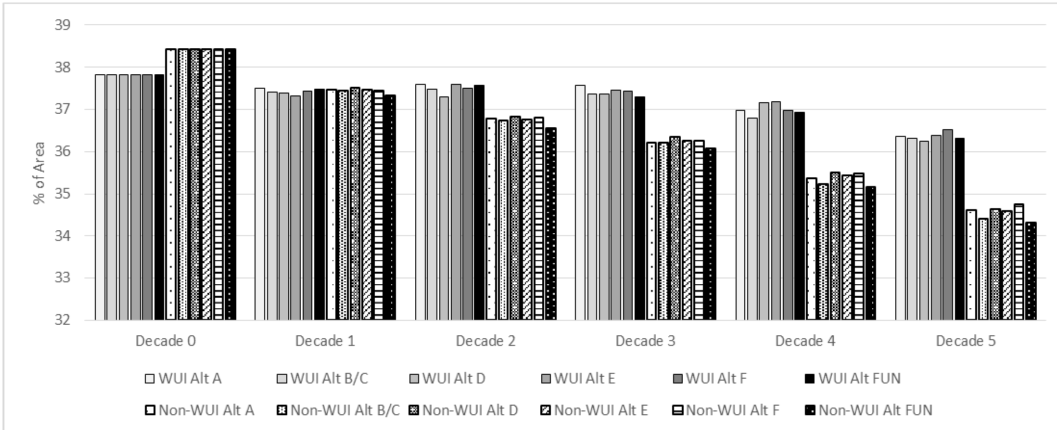


Figure 145. Lodgepole pine presence in WUI versus non-WUI areas, forestwide

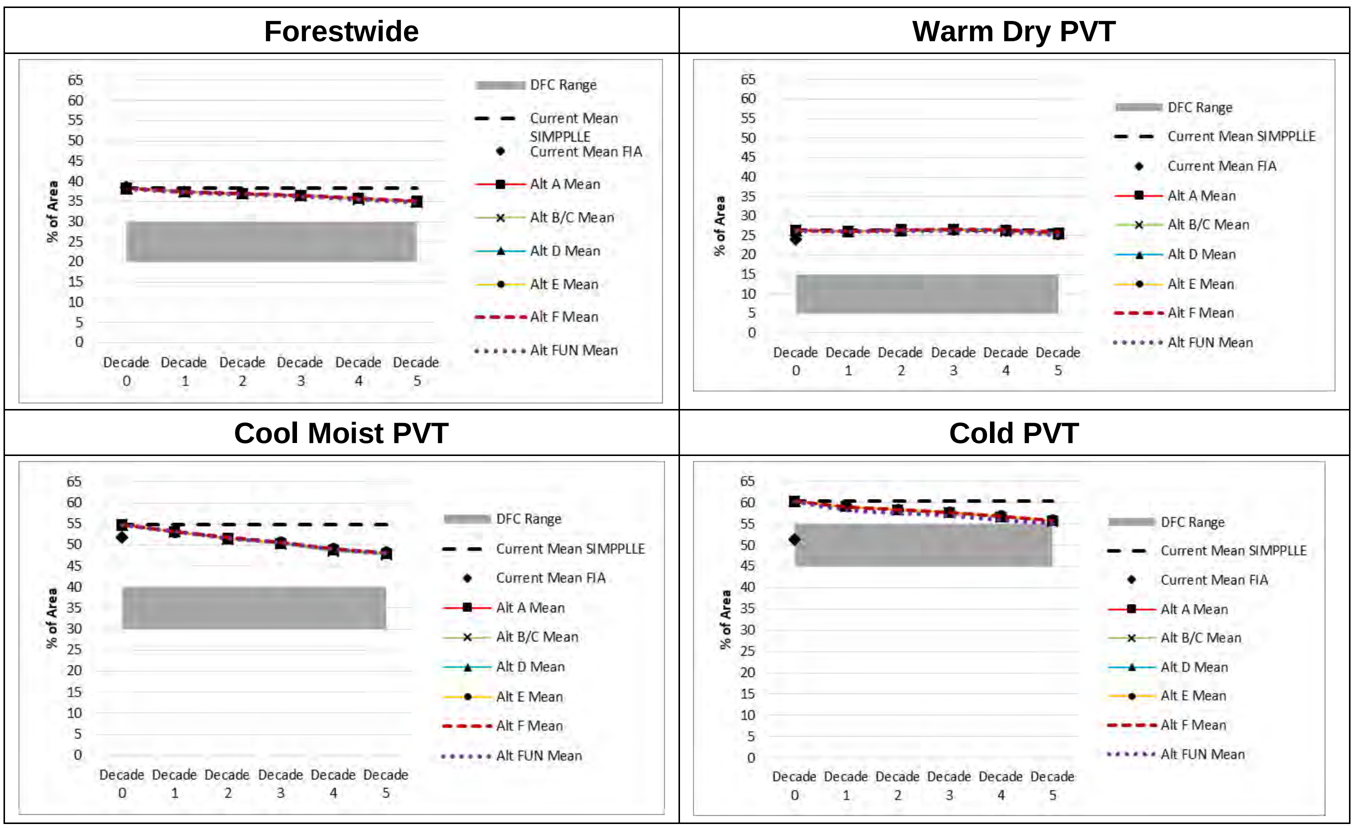
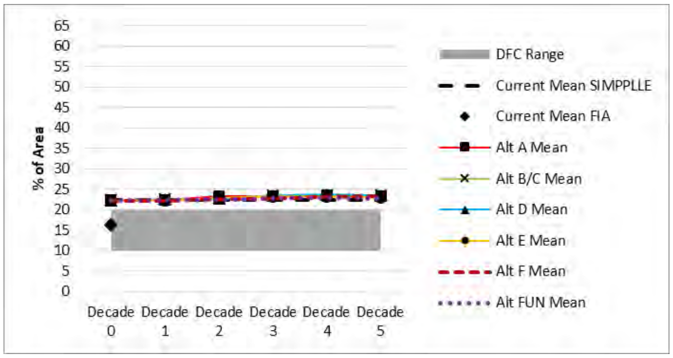


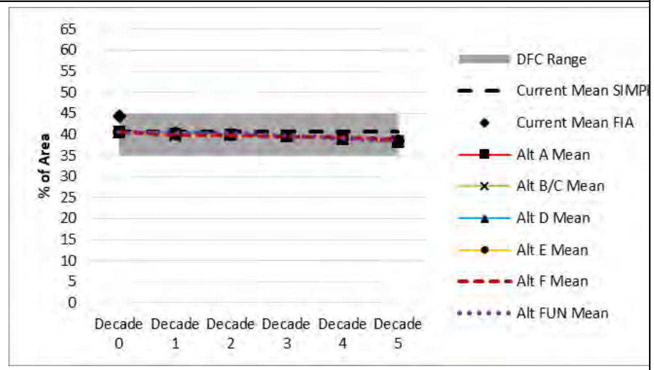
Figure 146. Lodgepole pine presence (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 147. Lodgepole pine presence (% of total area) over 5 decades by alternative, by GA

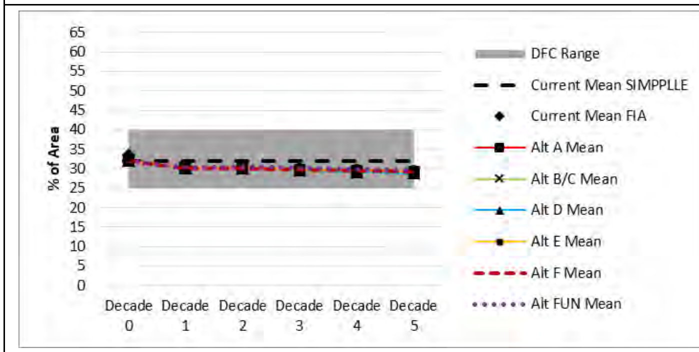
Big Belts



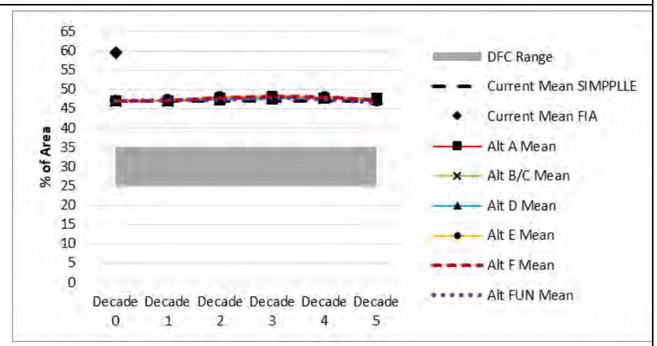
Castles



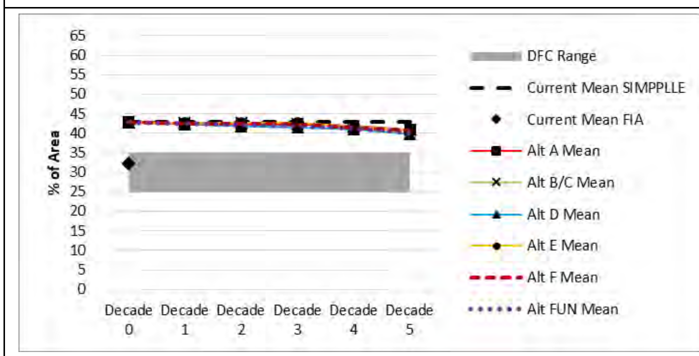
Crazies



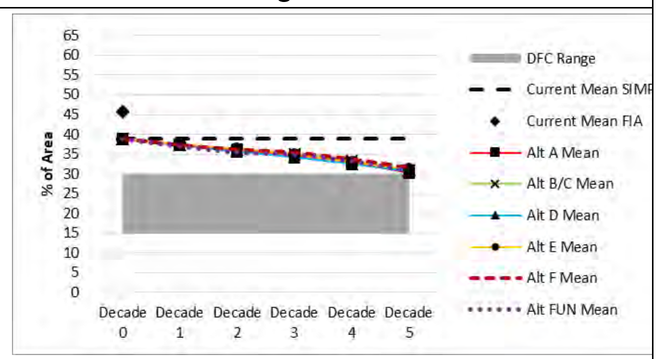
Divide



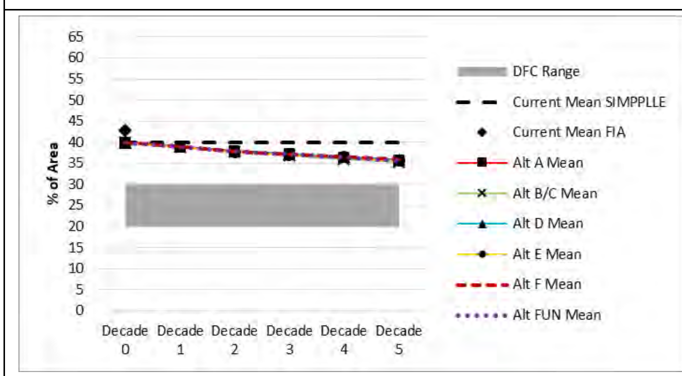
Elkhorns



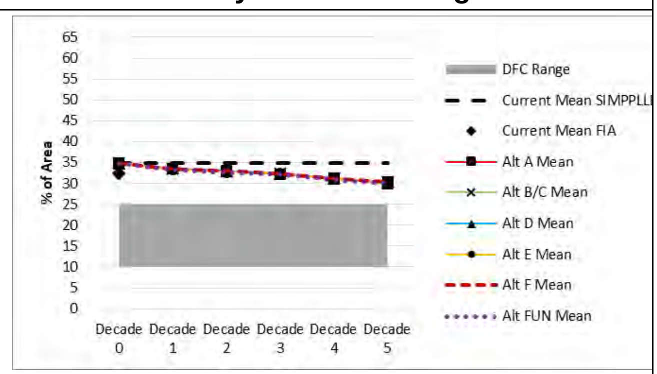
Highwoods



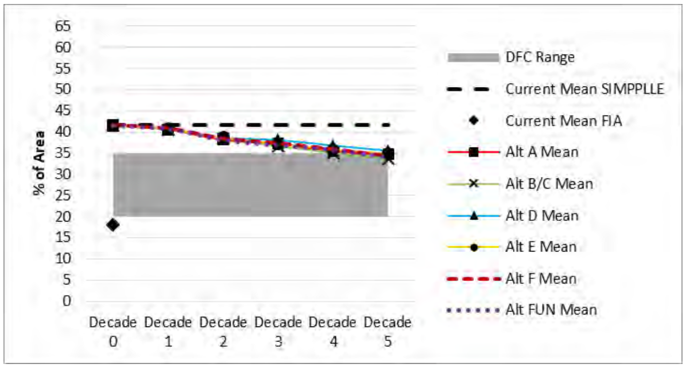
Little Belts



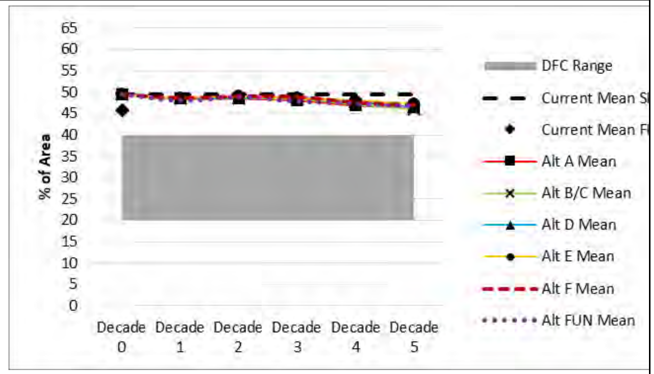
Rocky Mountain Range



Snowies



Upper Blackfoot



Western larch cover type and presence of western larch

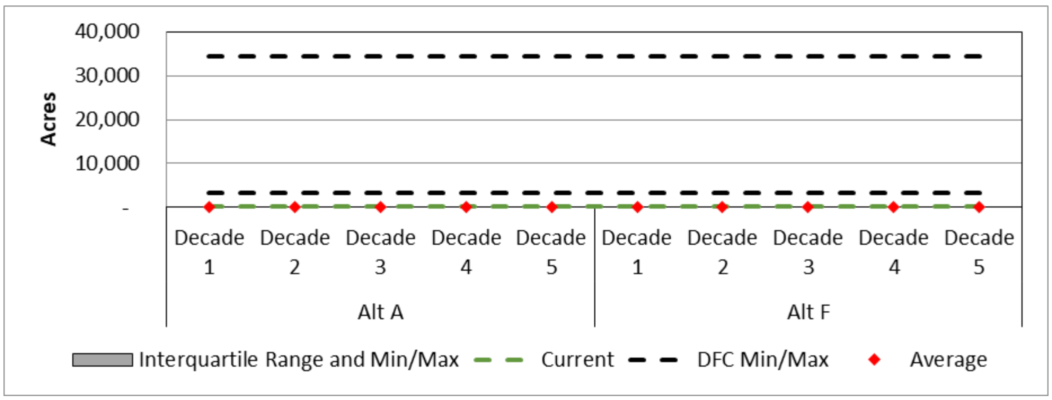


Figure 148. Western larch presence (total acres) over 5 decades, alternatives A and F

Upper Blackfoot

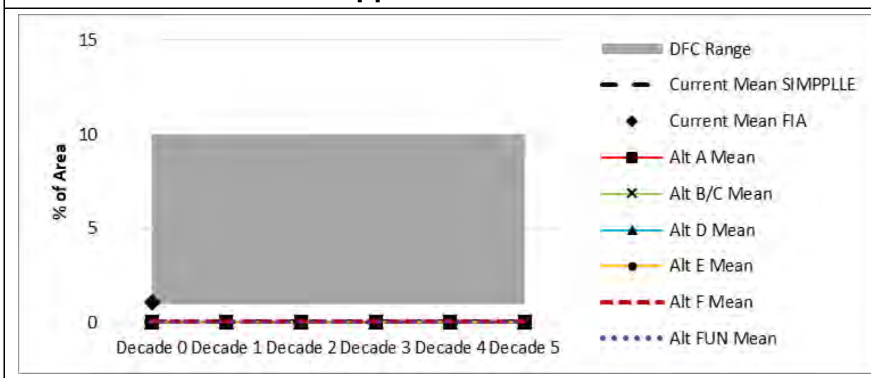


Figure 149. Western larch presence (% of total area) over 5 decades by alternative, in the Upper Blackfoot GA (not present in any other GA)

Spruce/fir cover type and presence of associated species (Engelmann spruce and subalpine fir)

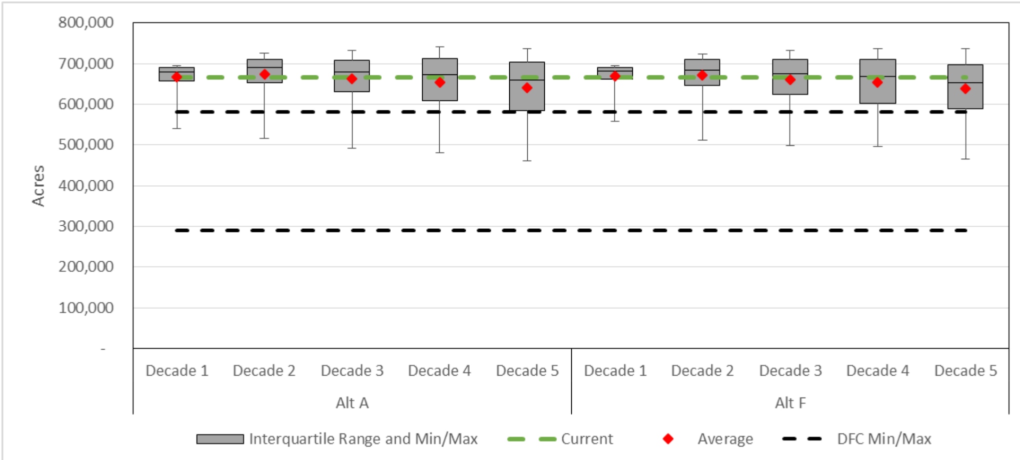


Figure 150. Spruce/fir cover type (total acres) over 5 decades, alternatives A and F

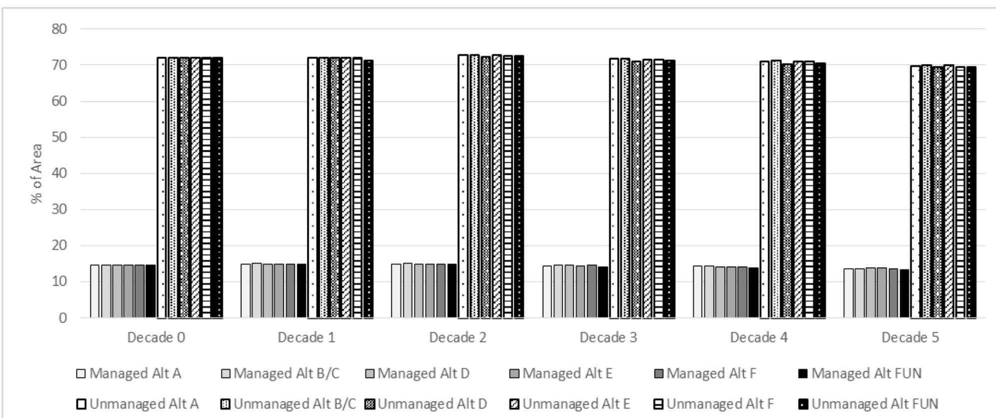


Figure 151. Spruce/fir cover type in managed versus unmanaged landscapes, forestwide

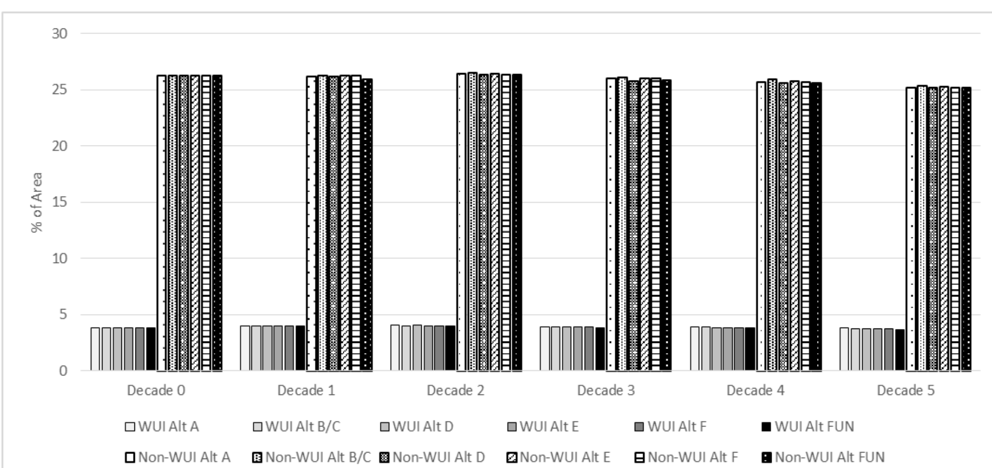


Figure 152. Spruce/fir cover type in WUI versus Non-WUI areas, forestwide

Figure 153.

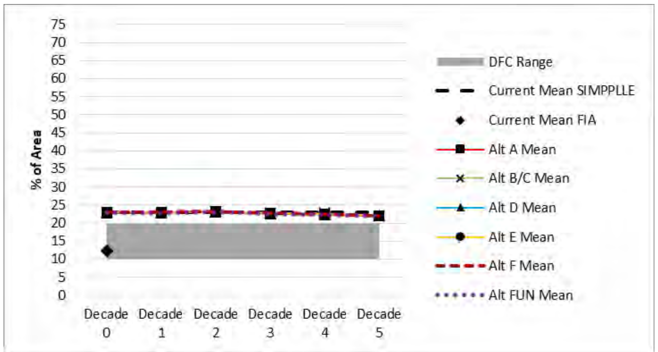
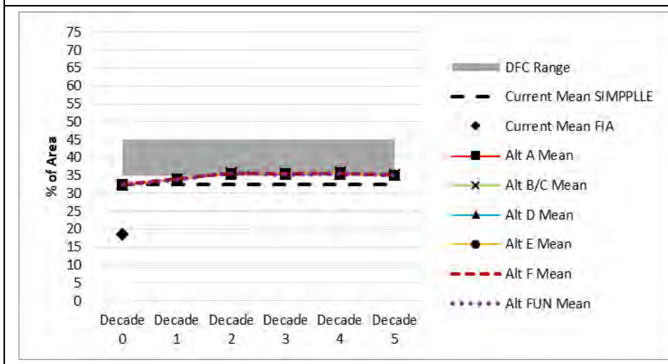
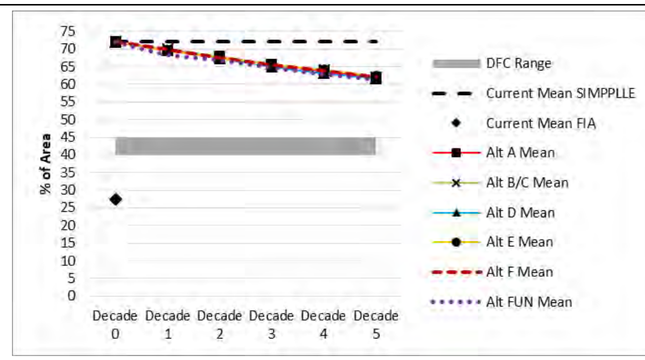
<table>
<tr><th>Forestwide</th><th>Warm Dry PVT</th></tr>
<tr><td>
</td><td>N/A</td></tr>
<tr><th>Cool Moist PVT</th><th>Cold PVT</th></tr>
<tr><td>
</td><td>
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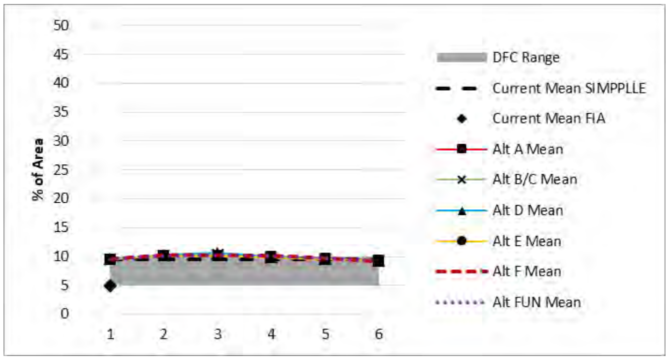
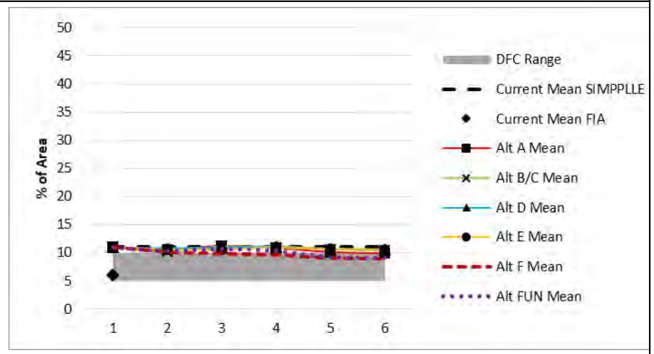
Figure 154. Spruce/fir cover type (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 155. Spruce/fir cover type (% of total area) over 5 decades by alternative, by GA

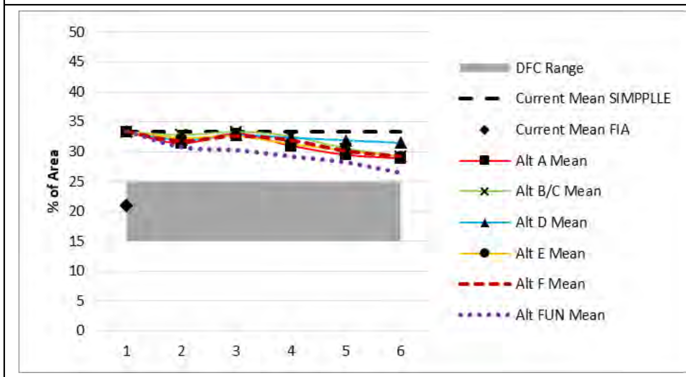
Big Belts



Castles



Crazies



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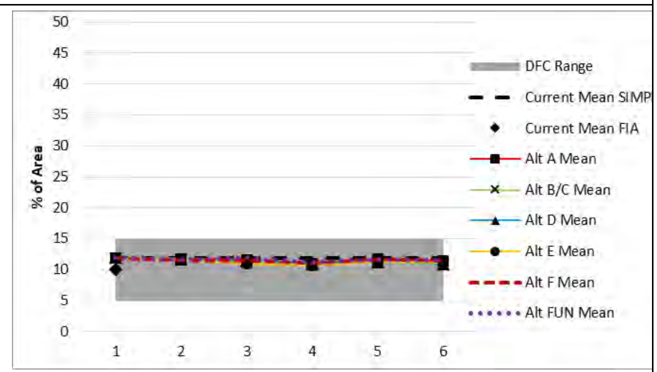
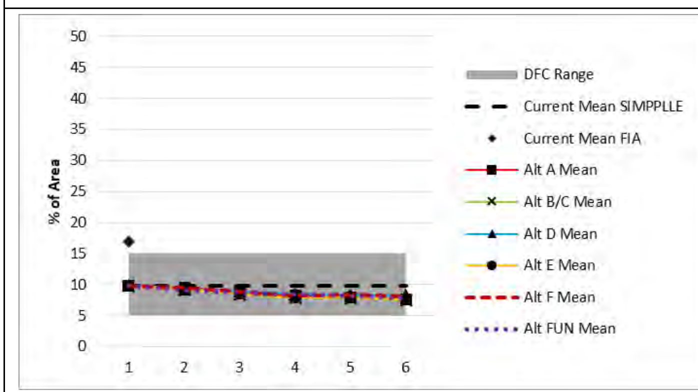
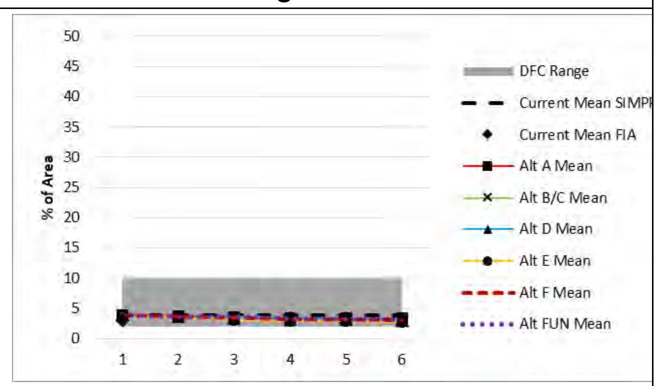
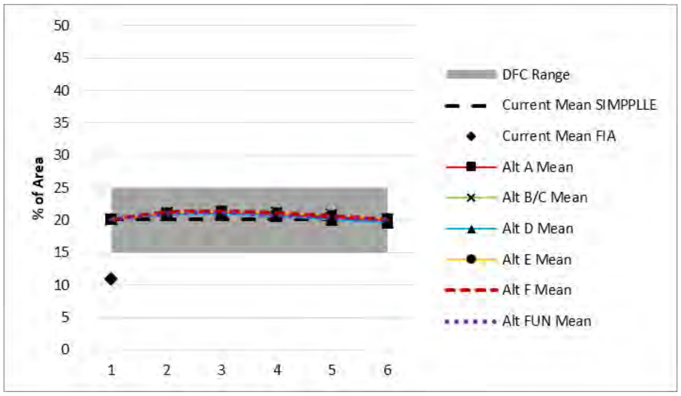
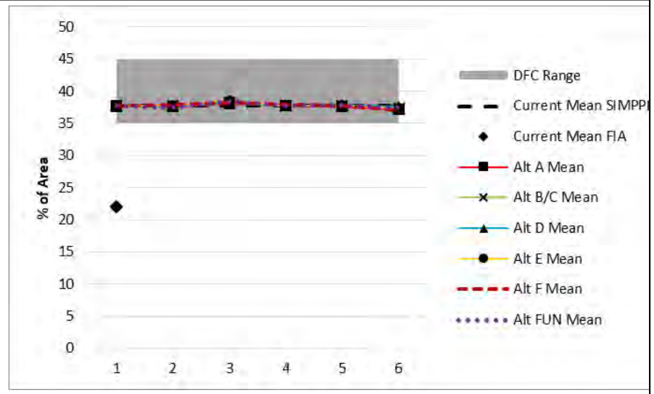
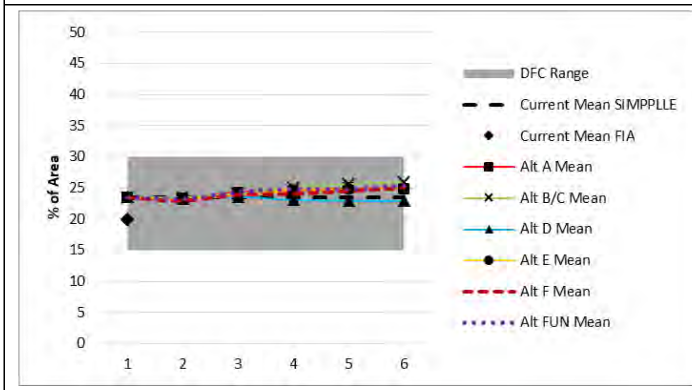
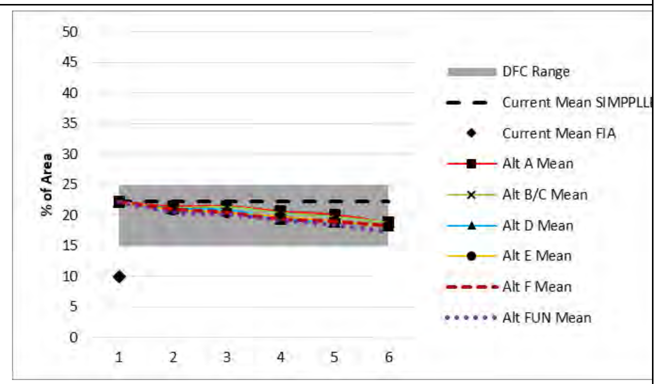


Elkhorns



Highwoods



Little Belts	Rocky Mountain Range
	
Snowies	**Upper Blackfoot**
	

Engelmann spruce presence

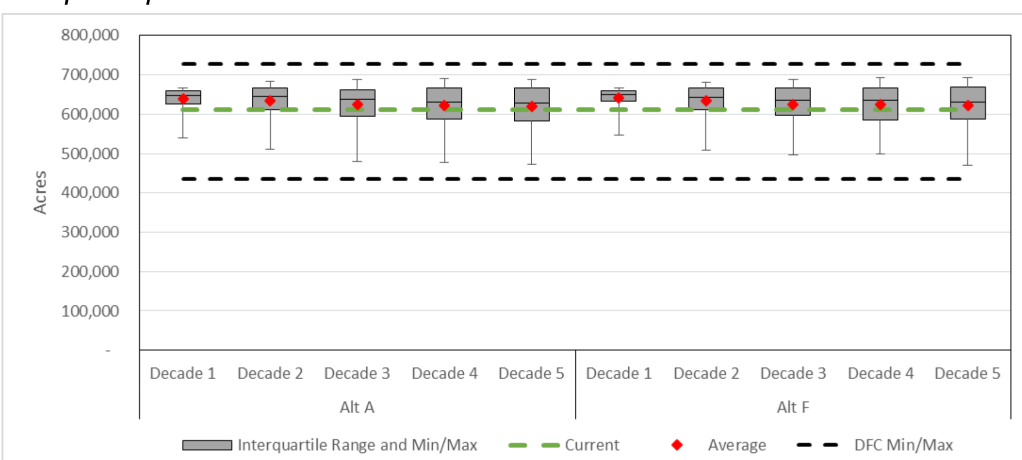


Figure 156. Engelmann spruce presence (total acres) over 5 decades, alternatives A and F

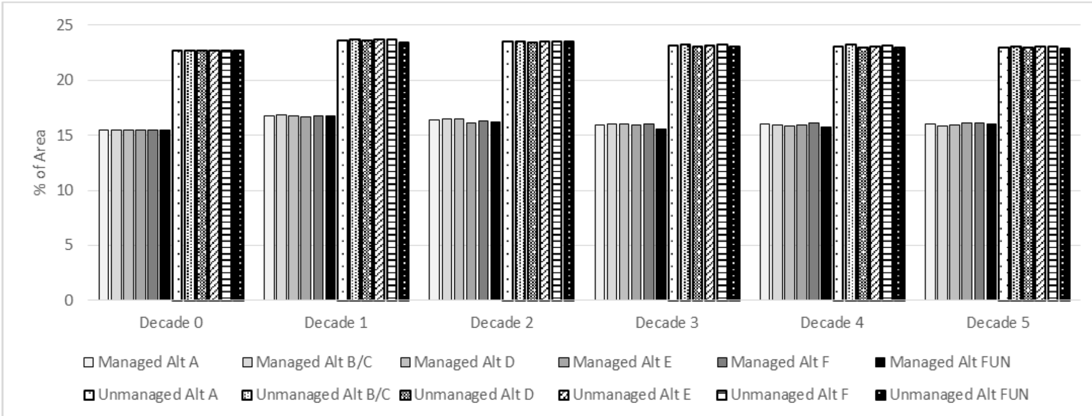


Figure 157. Engelmann spruce presence in managed versus unmanaged landscapes, forestwide

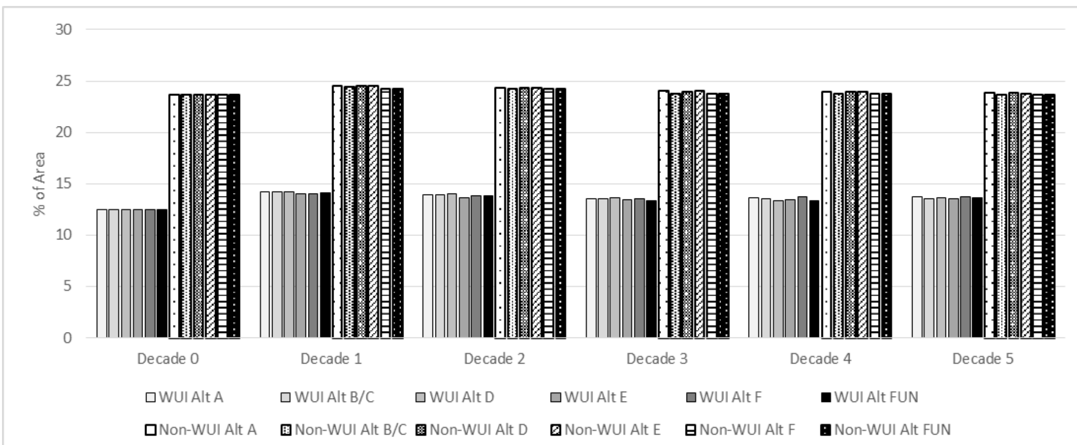


Figure 158. Engelmann spruce presence in WUI versus non-WUI areas, forestwide

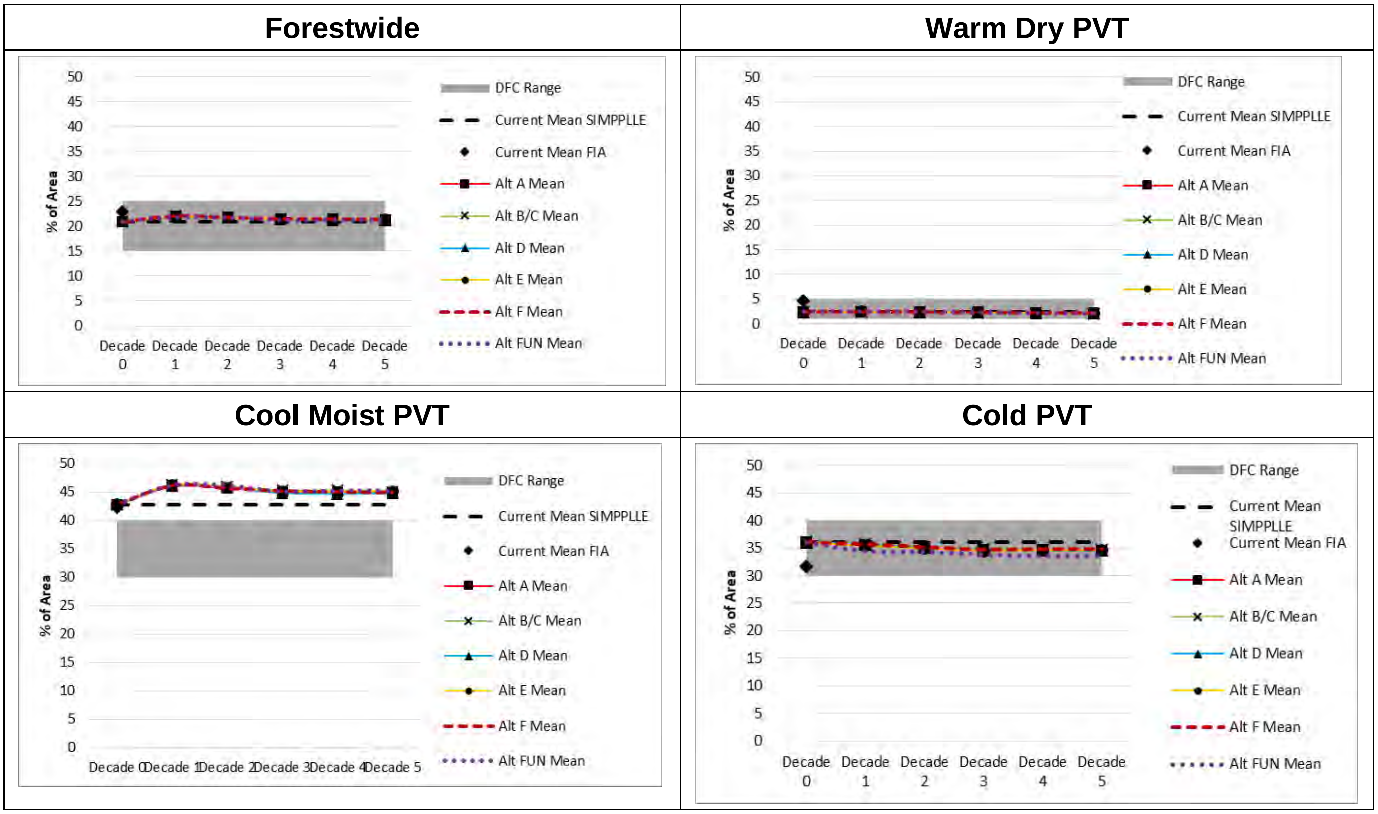
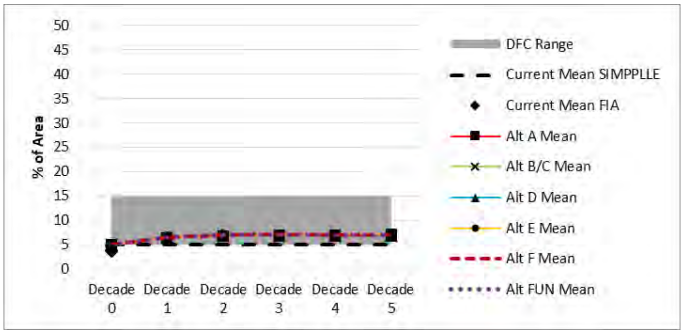


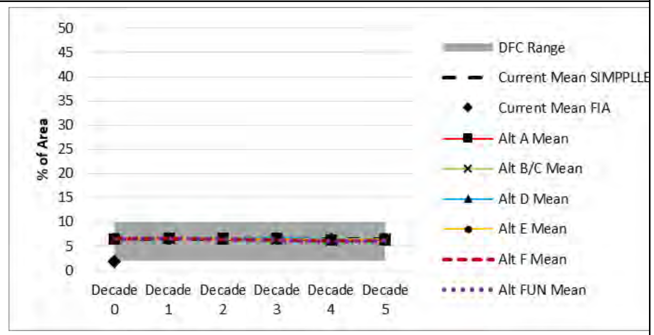
Figure 159. Engelmann spruce presence (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 160. Engelmann spruce presence (% of total area) over 5 decades by alternative, by GA

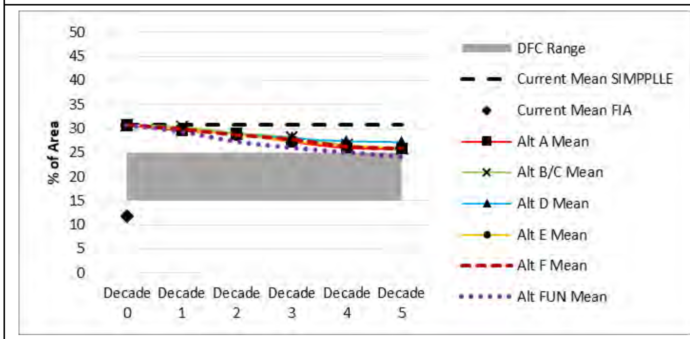
Big Belts



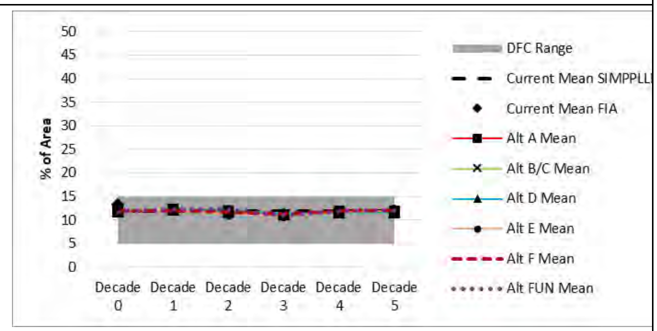
Castles



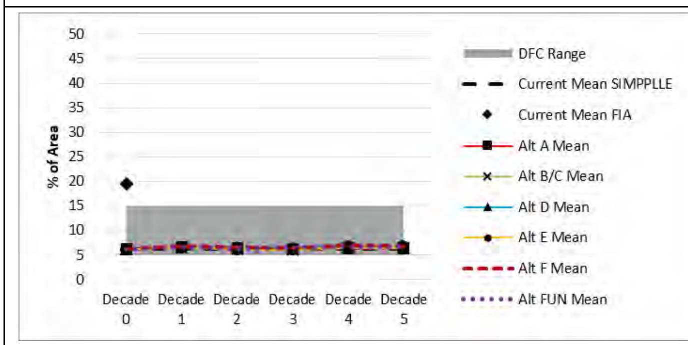
Crazies



Divide



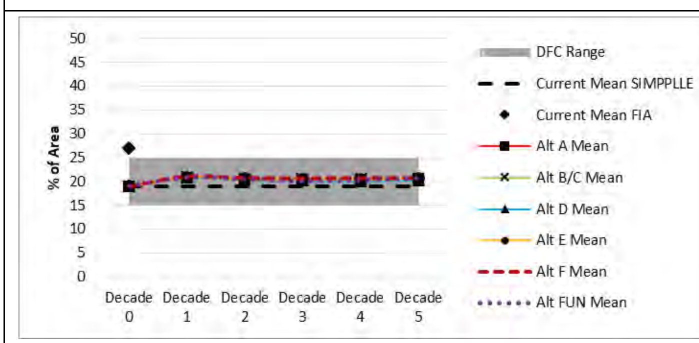
Elkhorns



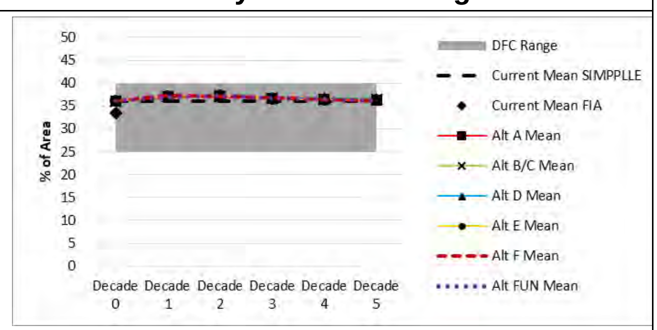
Highwoods

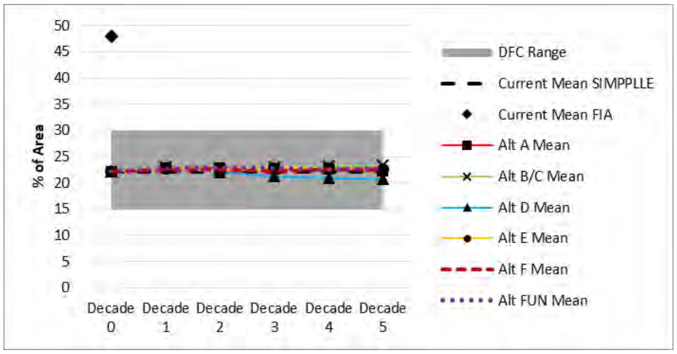
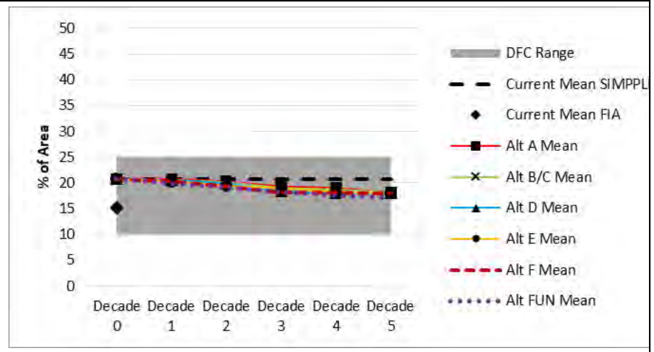
N/A

Little Belts



Rocky Mountain Range



Snowies	Upper Blackfoot
	

Subalpine fir presence

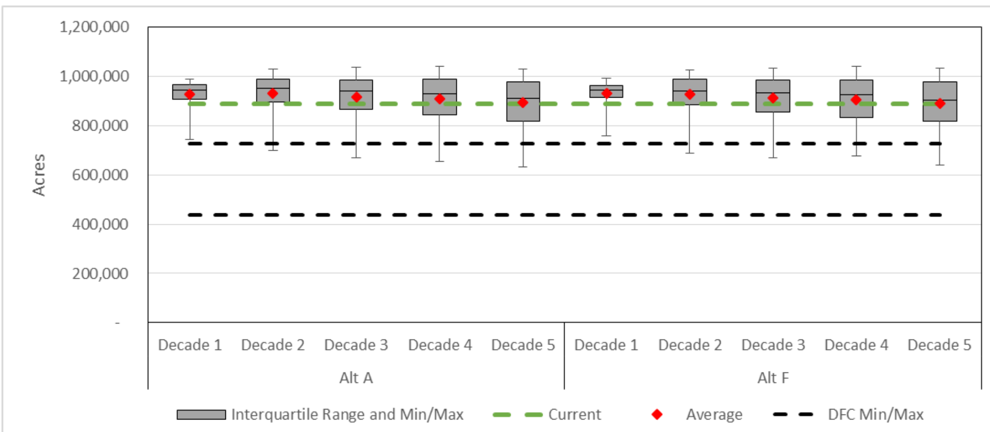


Figure 161. Subalpine fir presence (total acres) over 5 decades, alternatives A and F

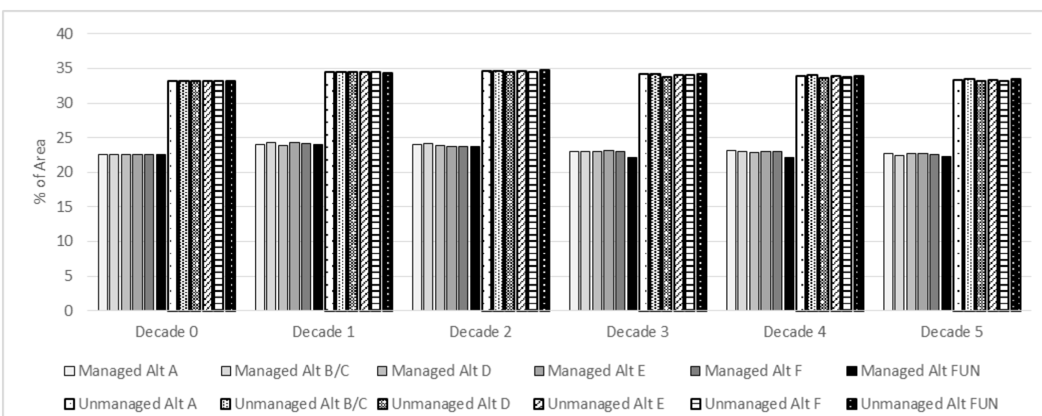


Figure 162. Subalpine fir presence in managed versus unmanaged landscapes, forestwide

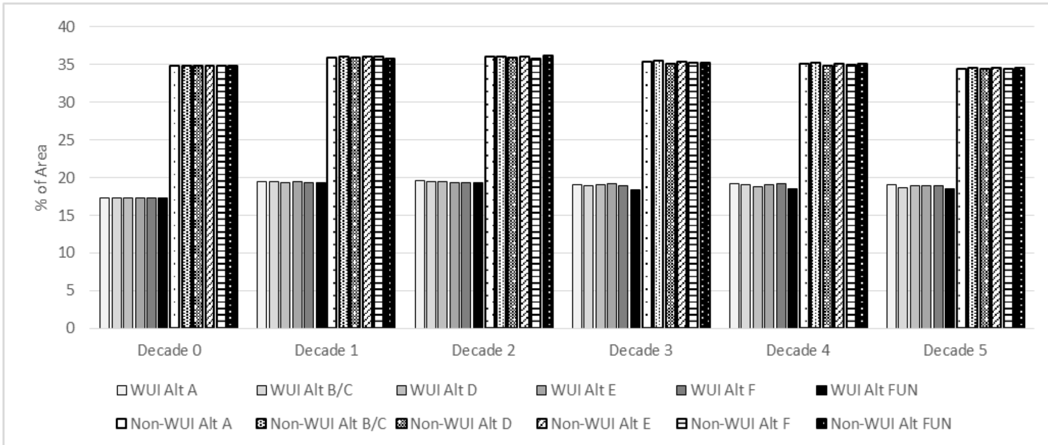


Figure 163. Subalpine fir presence in WUI versus non-WUI areas, forestwide

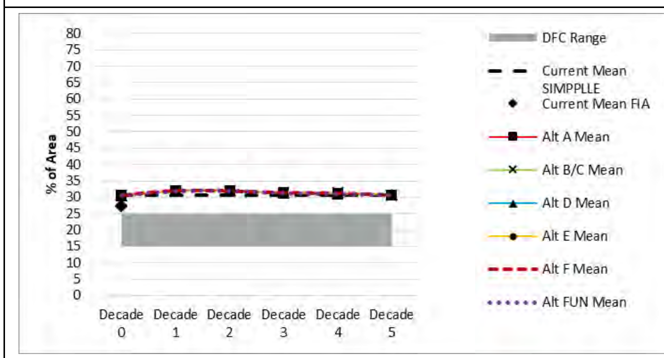
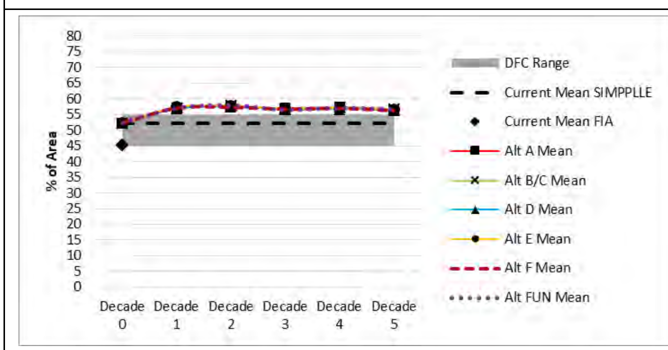
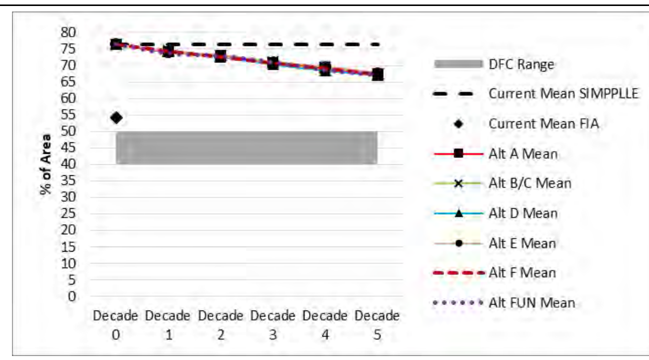
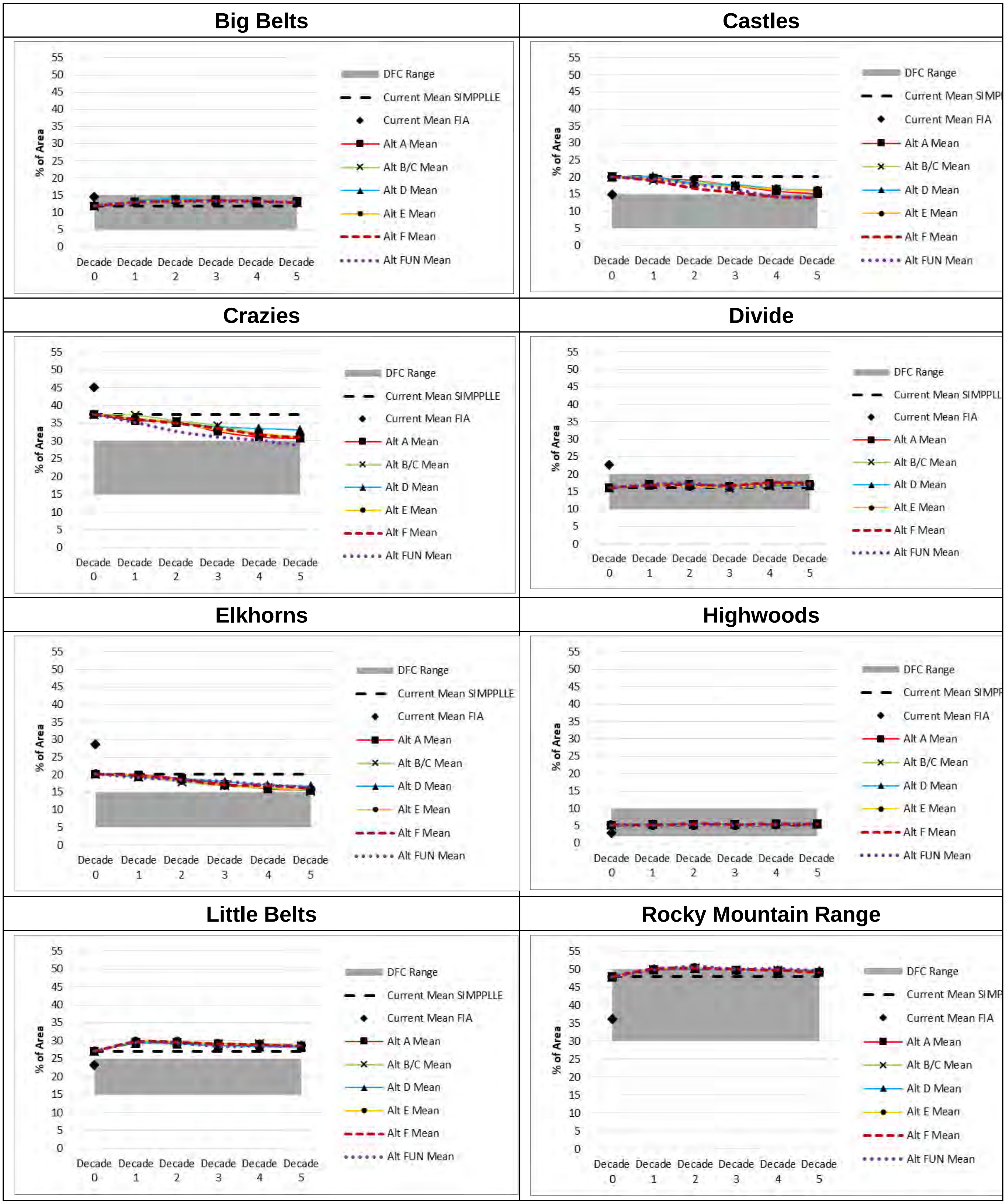
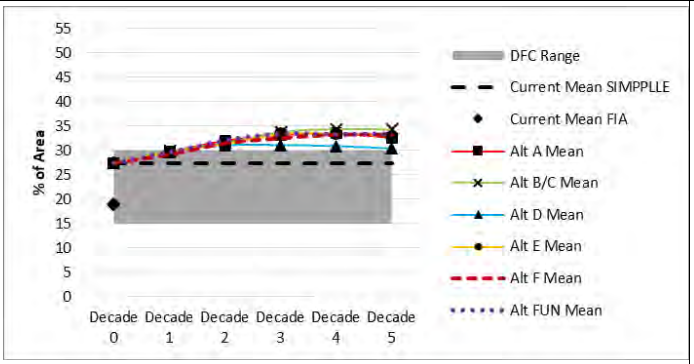
Forestwide	Warm Dry PVT
	N/A
Cool Moist PVT	**Cold PVT**
	

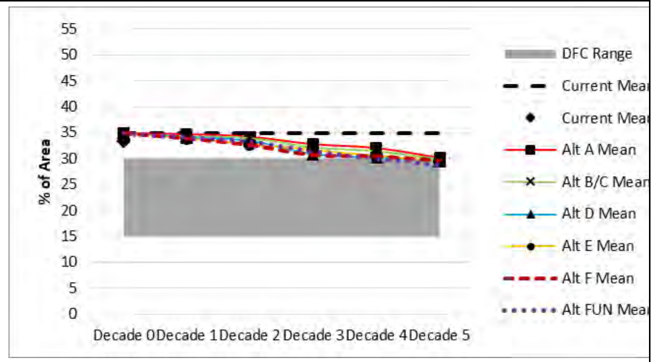
Figure 164. Subalpine fir presence (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 165. Subalpine fir presence (% of total area) over 5 decades by alternative, by GA



Snowies	Upper Blackfoot





Whitebark pine cover type and presence of whitebark pine

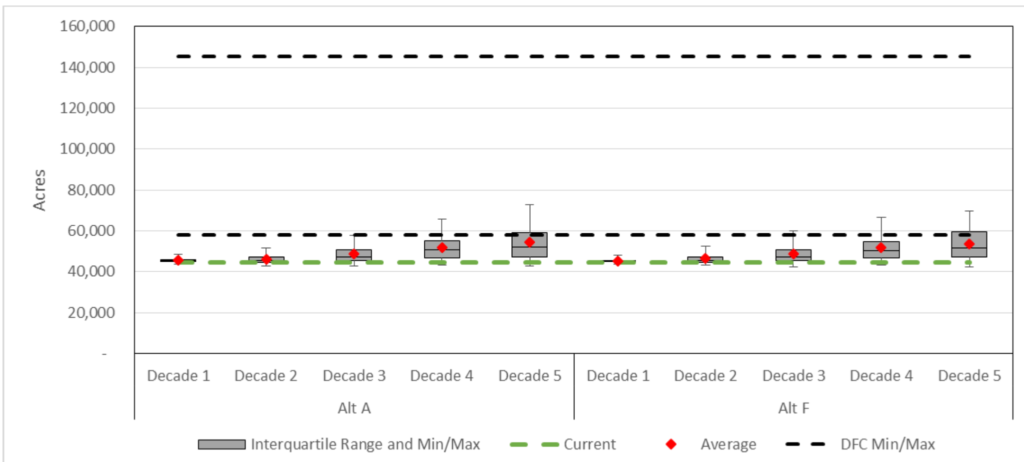


Figure 166. Whitebark pine cover type (total acres) over 5 decades, alternatives A and F

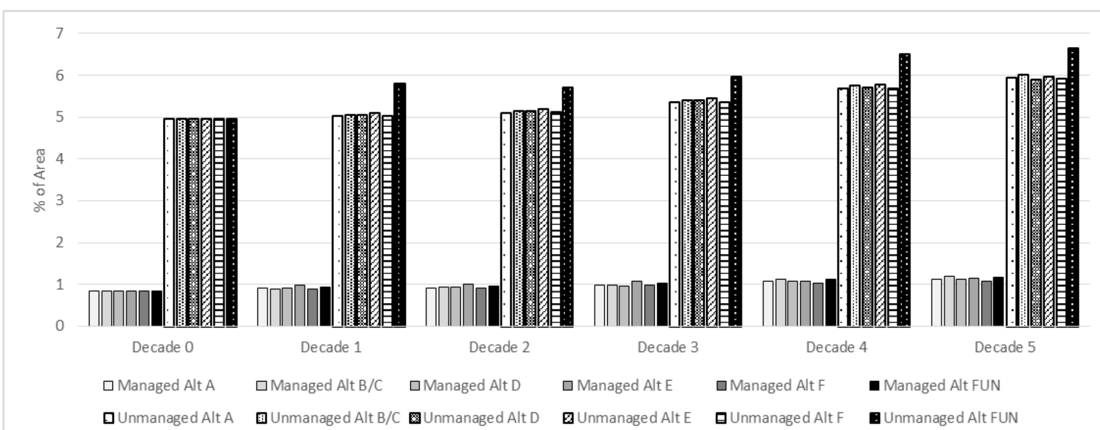


Figure 167. Whitebark pine cover type in managed versus unmanaged landscapes, forestwide

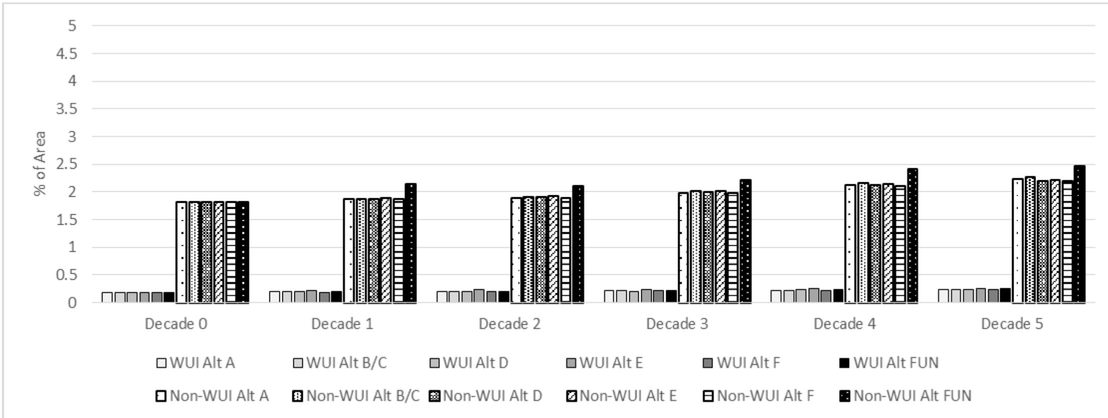


Figure 168. Whitebark pine cover type in WUI versus non-WUI areas, forestwide

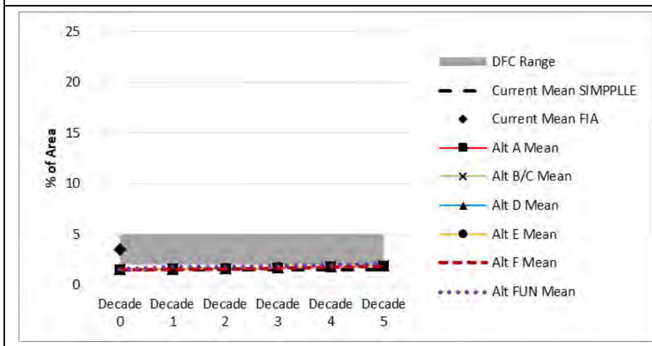
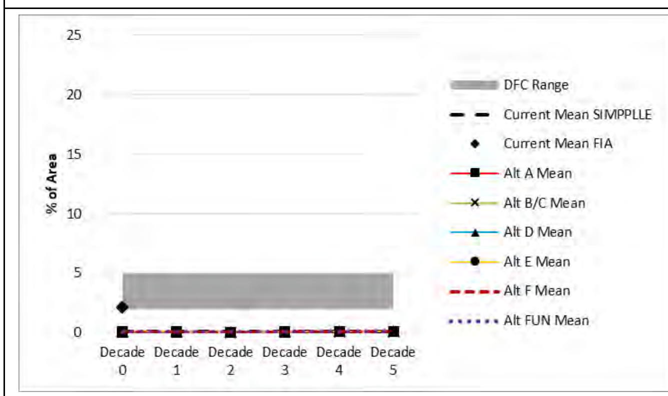
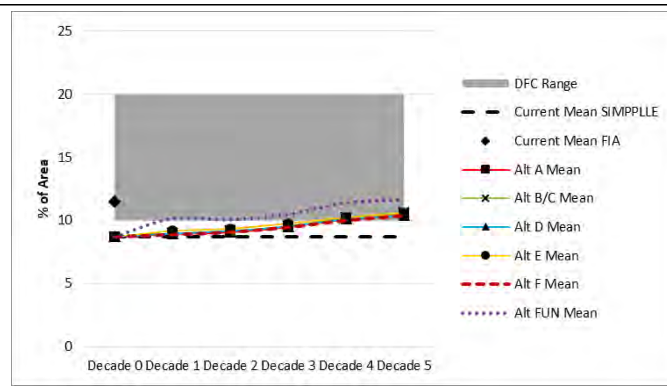
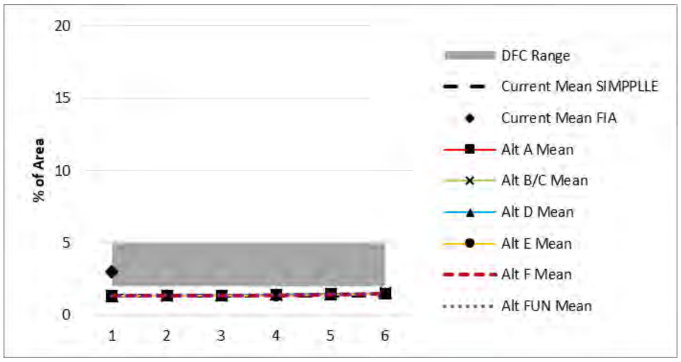
Forestwide	Warm Dry PVT
	N/A
Cool Moist PVT	**Cold PVT**
	

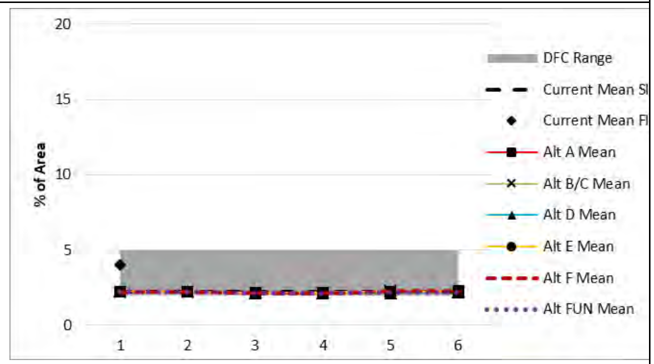
Figure 169. Whitebark pine cover type (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 170. Whitebark pine cover type (% of total area) over 5 decades by alternative, by GA

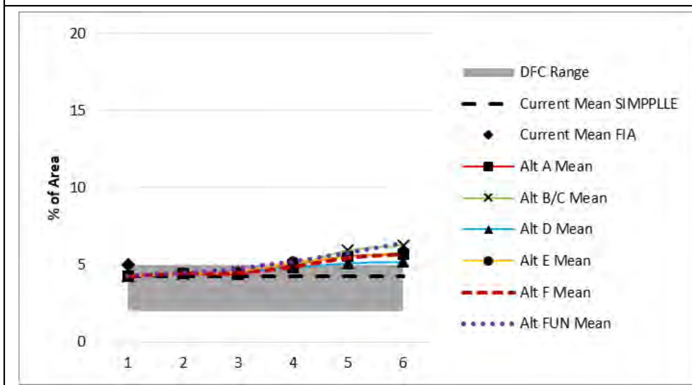
Big Belts



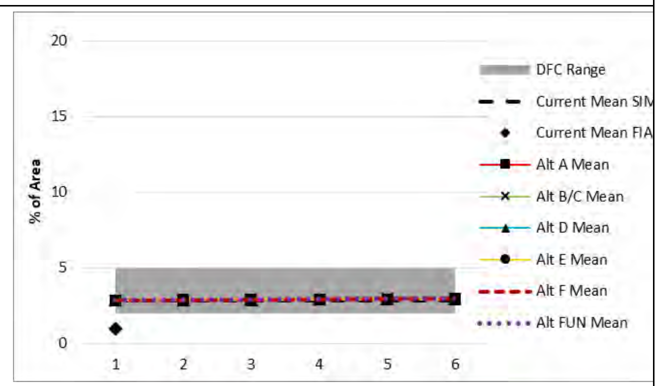
Castles



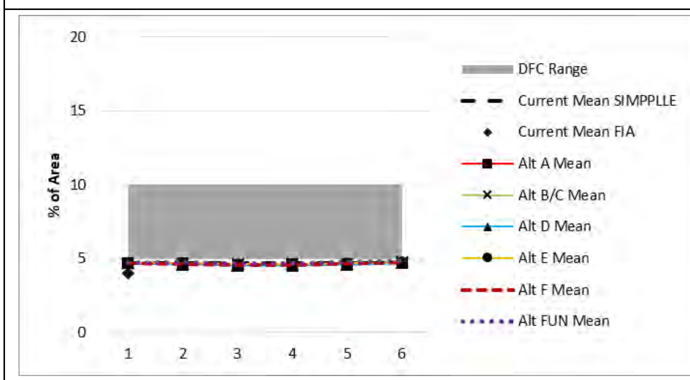
Crazies



Divide



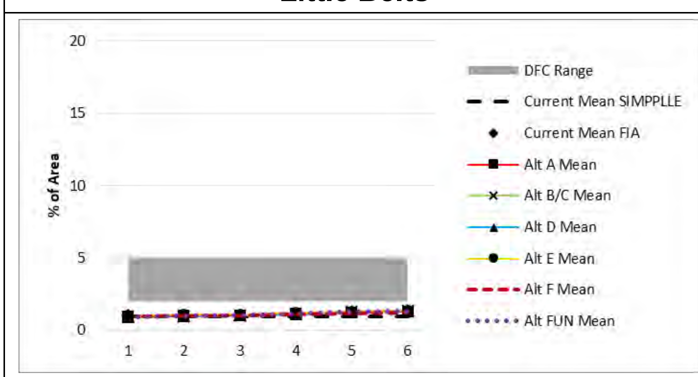
Elkhorns



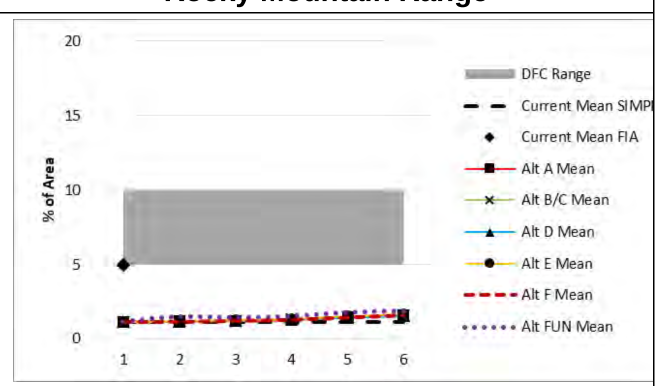
Highwoods

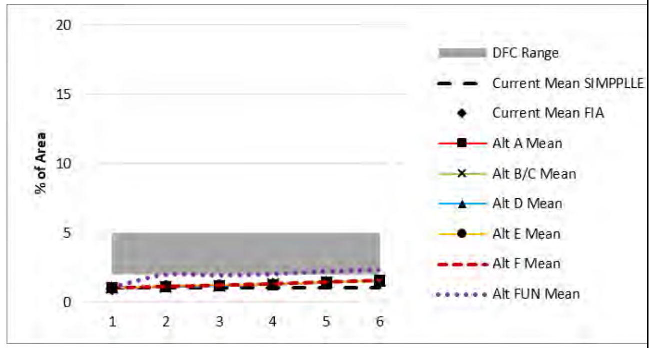
N/A

Little Belts



Rocky Mountain Range



Snowies	Upper Blackfoot
N/A	

Whitebark pine presence

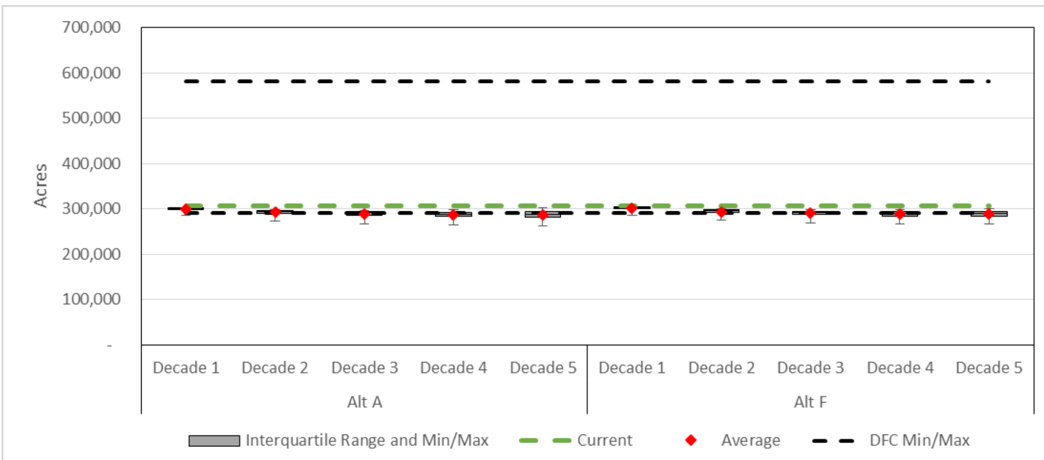


Figure 171. Whitebark pine presence (total acres) over 5 decades, alternatives A and F

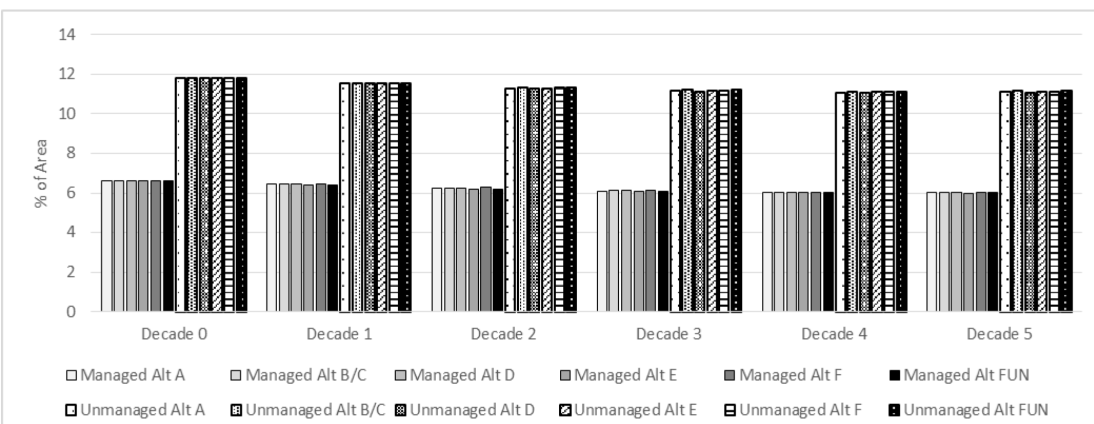


Figure 172. Whitebark pine presence in managed versus unmanaged landscapes, forestwide

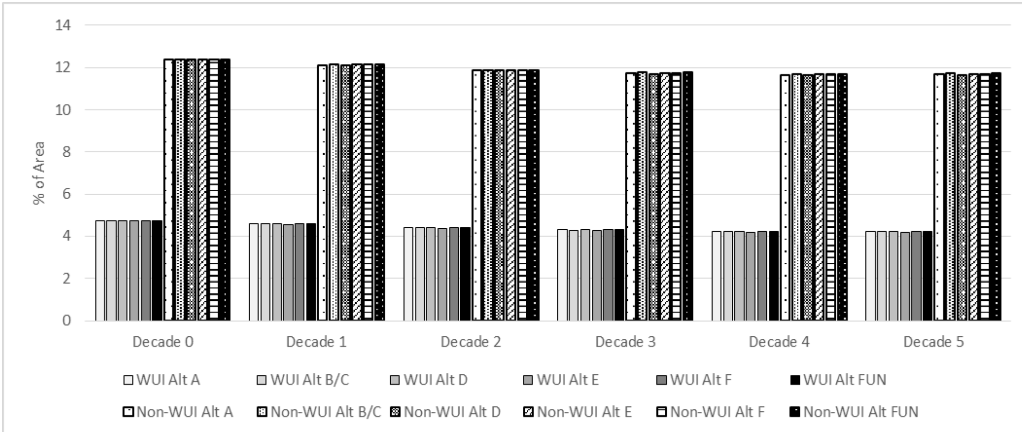


Figure 173. Whitebark pine presence in WUI versus non-WUI areas, forestwide

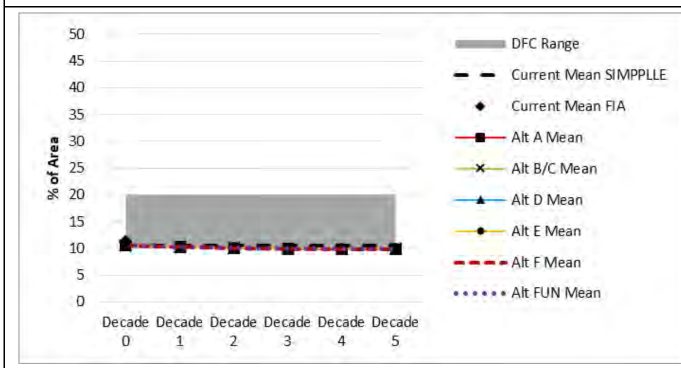
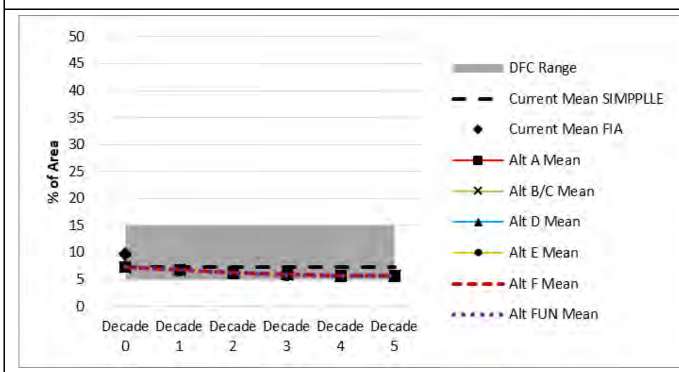
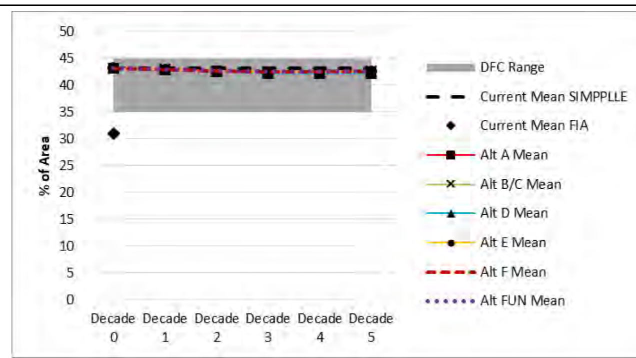
<table>
<tr><th>Forestwide</th><th>Warm Dry PVT</th></tr>
<tr><td>
</td><td>N/A</td></tr>
<tr><th>Cool Moist PVT</th><th>Cold PVT</th></tr>
<tr><td>
</td><td>
</td></tr>
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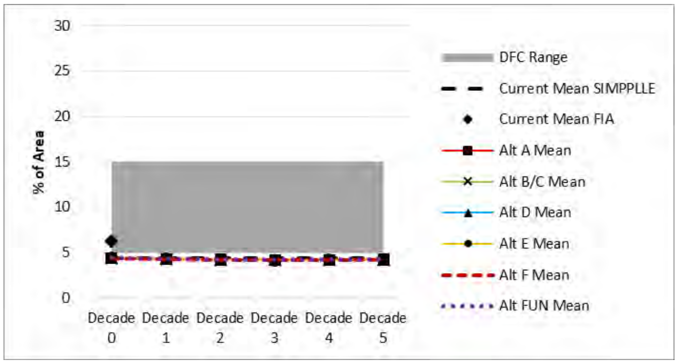
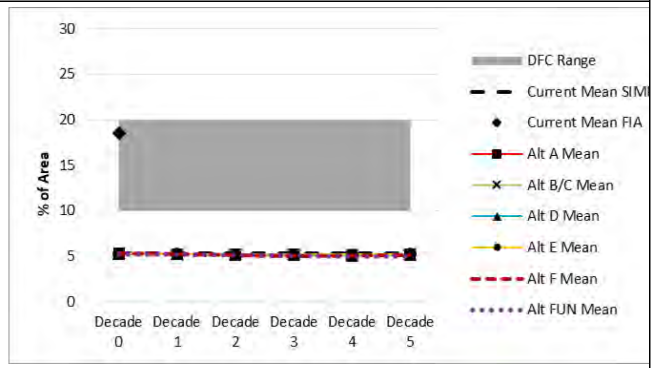
Figure 174. Whitebark pine presence (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 175. Whitebark pine presence (% of total area) over 5 decades by alternative, by GA

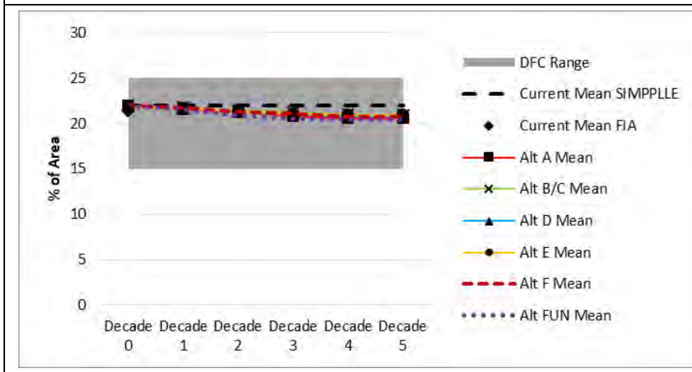
Big Belts



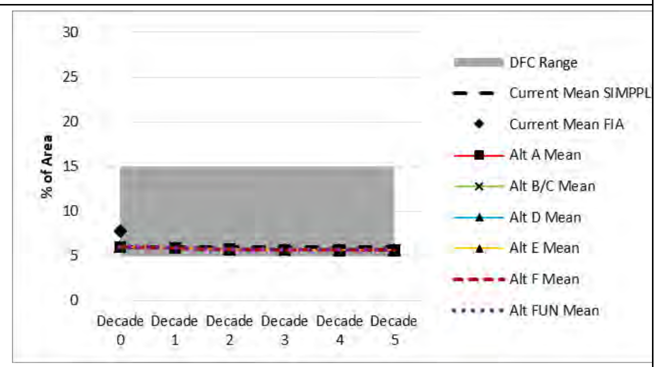
Castles



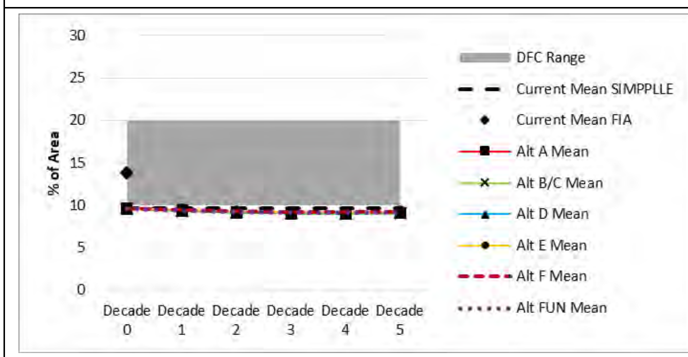
Crazies



Divide



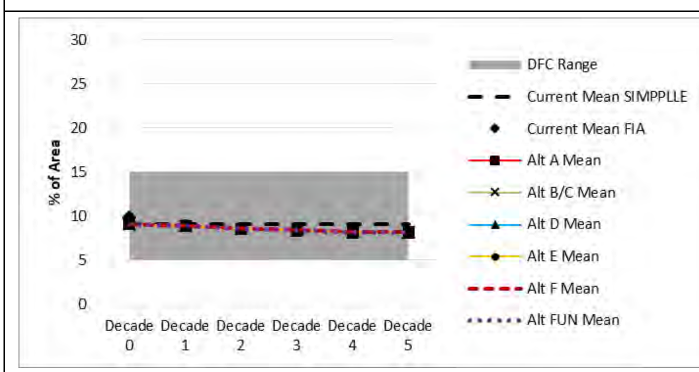
Elkhorns



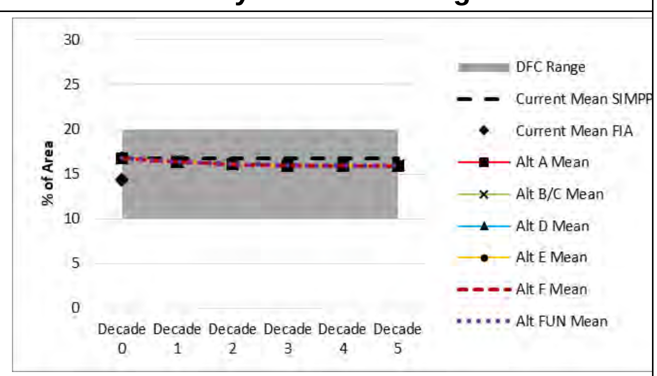
Highwoods

N/A

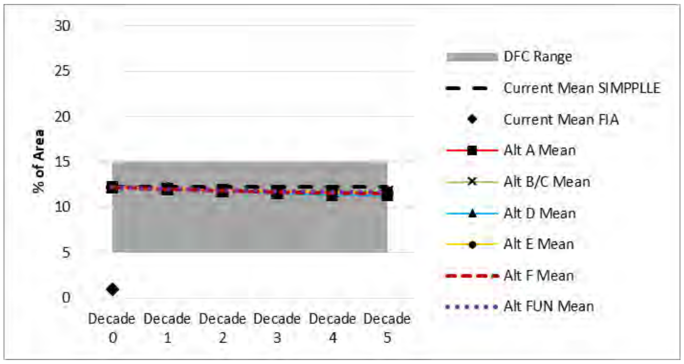
Little Belts



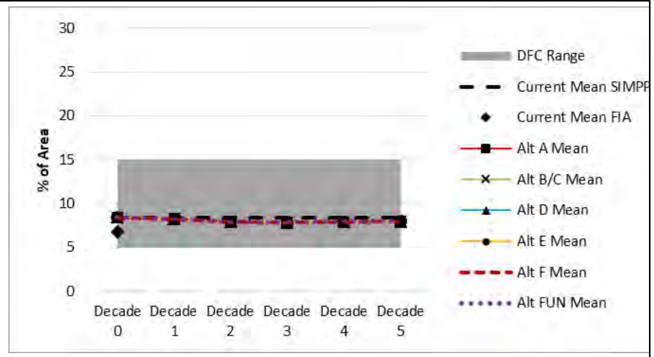
Rocky Mountain Range



Snowies



Upper Blackfoot



Forest structure

Forest size class

Seedling/sapling

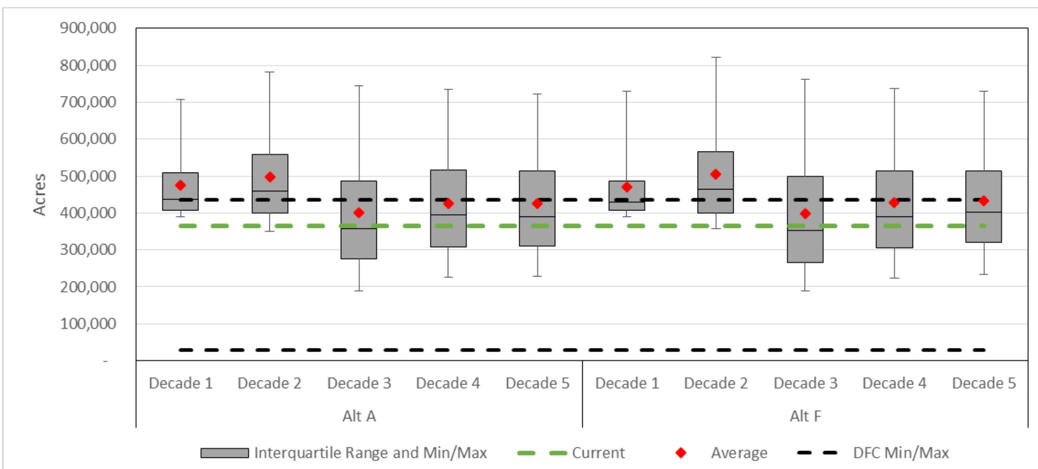


Figure 176. Seedling/sapling size class (total acres) over 5 decades, alternatives A and F

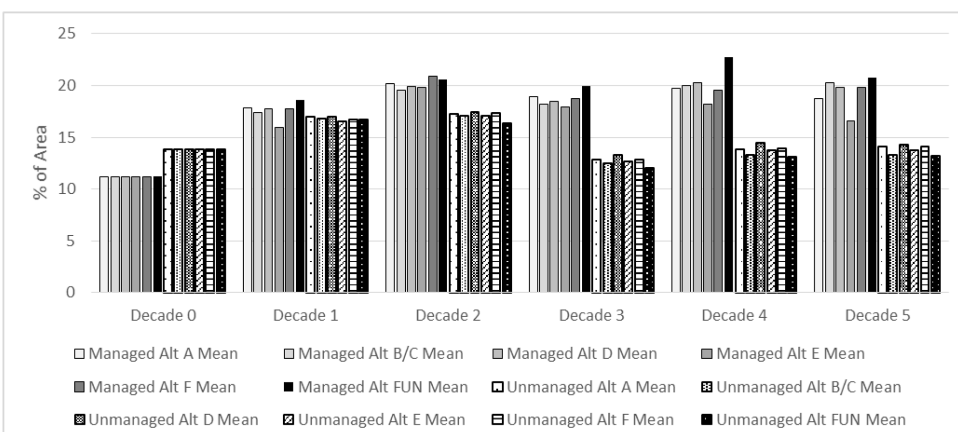


Figure 177. Seedling/sapling size class in managed versus unmanaged landscapes, forestwide

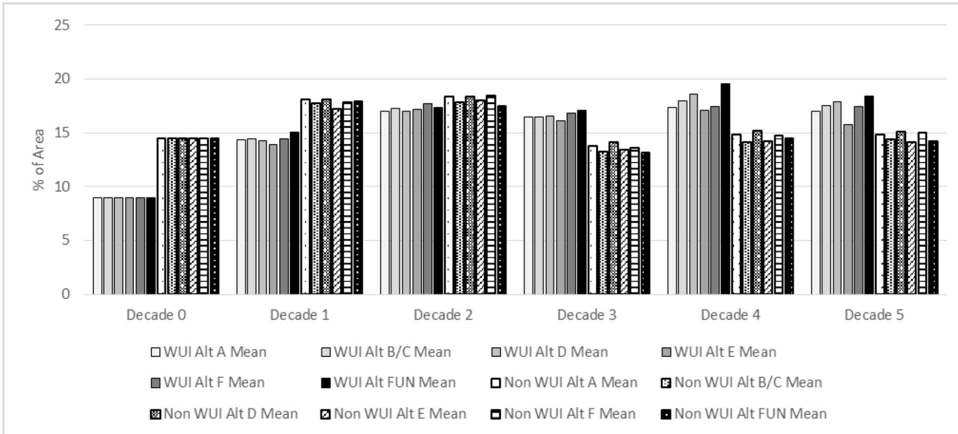


Figure 178. Seedling/sapling size class in WUI versus non-WUI areas, forestwide

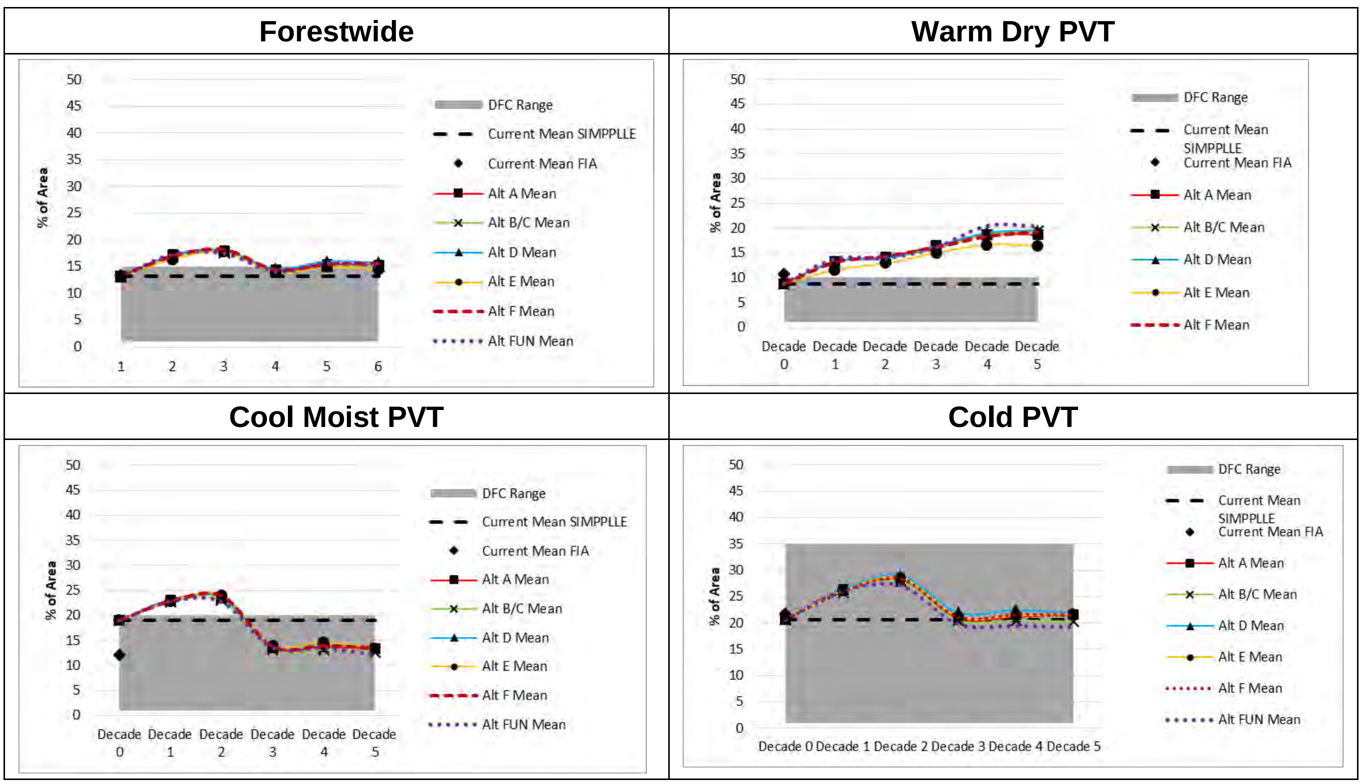
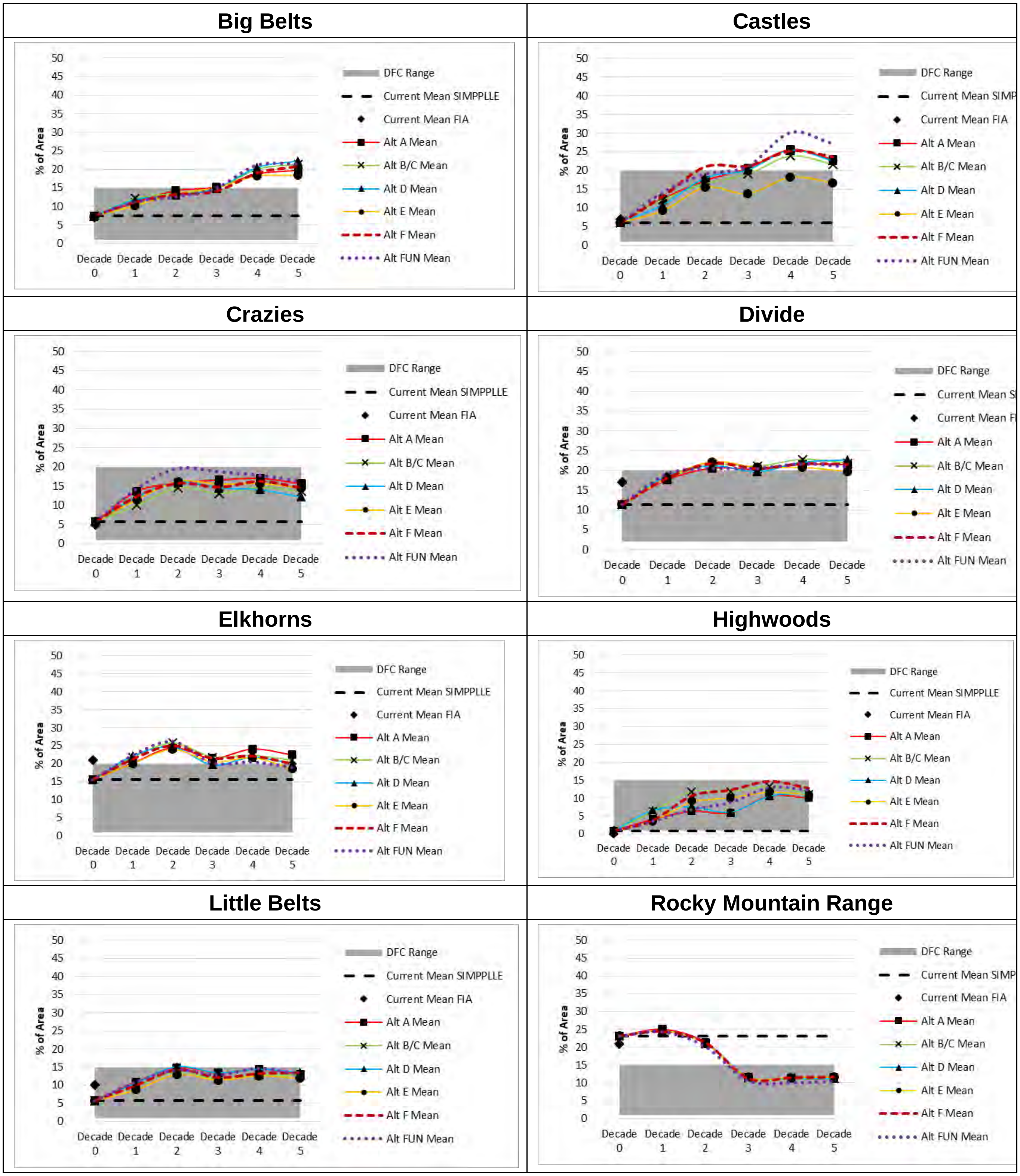
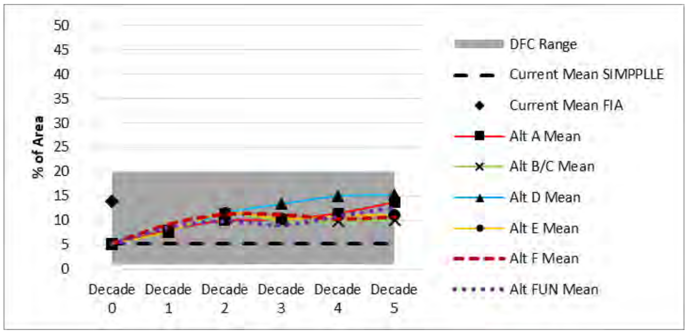
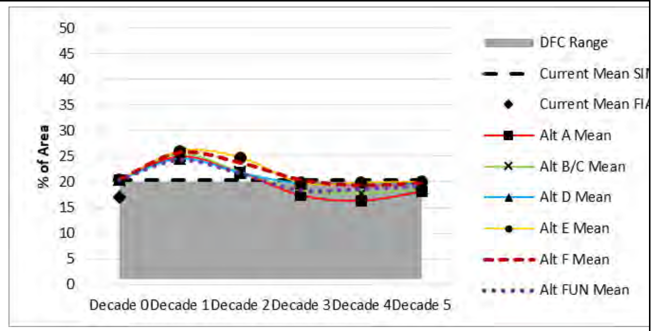


Figure 179. Seedling/sapling size class (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 180. Seedling/sapling size class (% of total area) over 5 decades by alternative, by GA



Snowies	Upper Blackfoot
	

Small tree

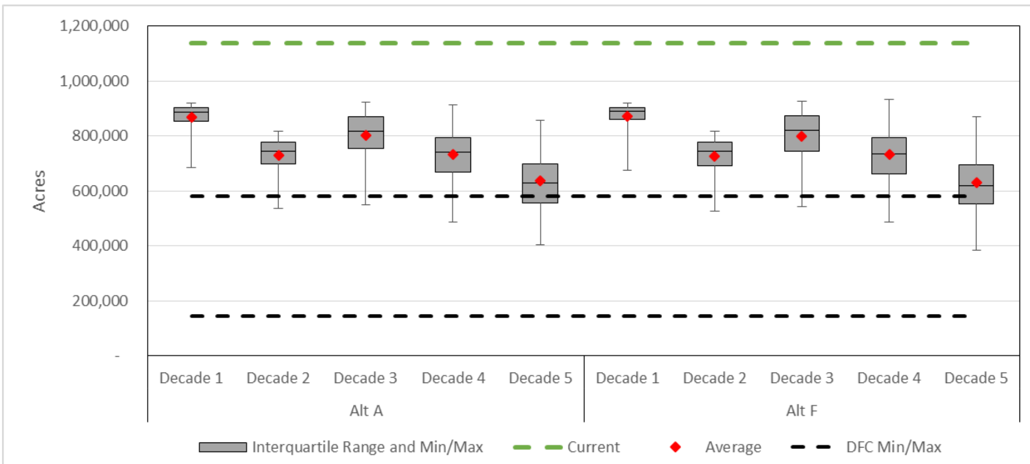


Figure 181. Small size class (total acres) over 5 decades, alternatives A and F

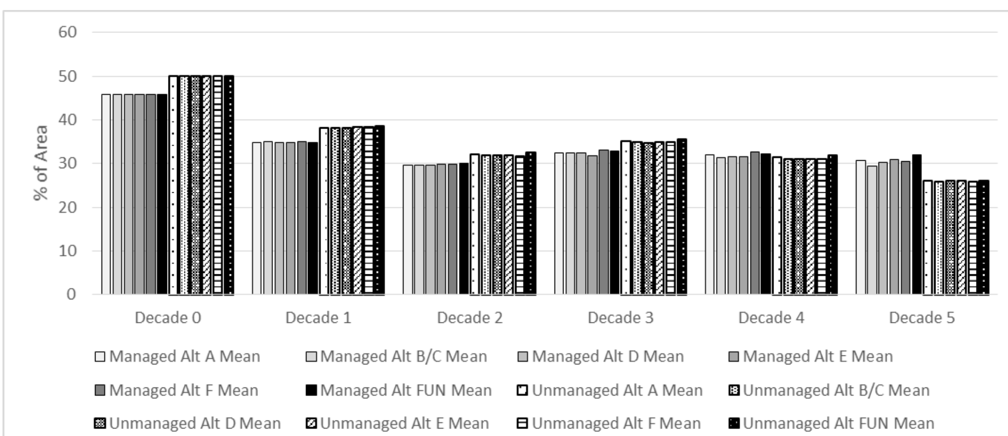


Figure 182. Small size class in managed versus unmanaged landscapes, forestwide

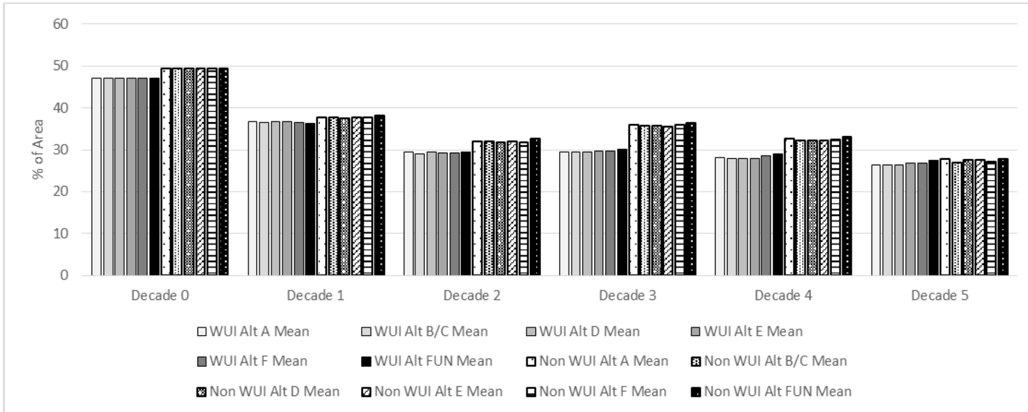


Figure 183. Small size class in WUI versus non-WUI areas, forestwide

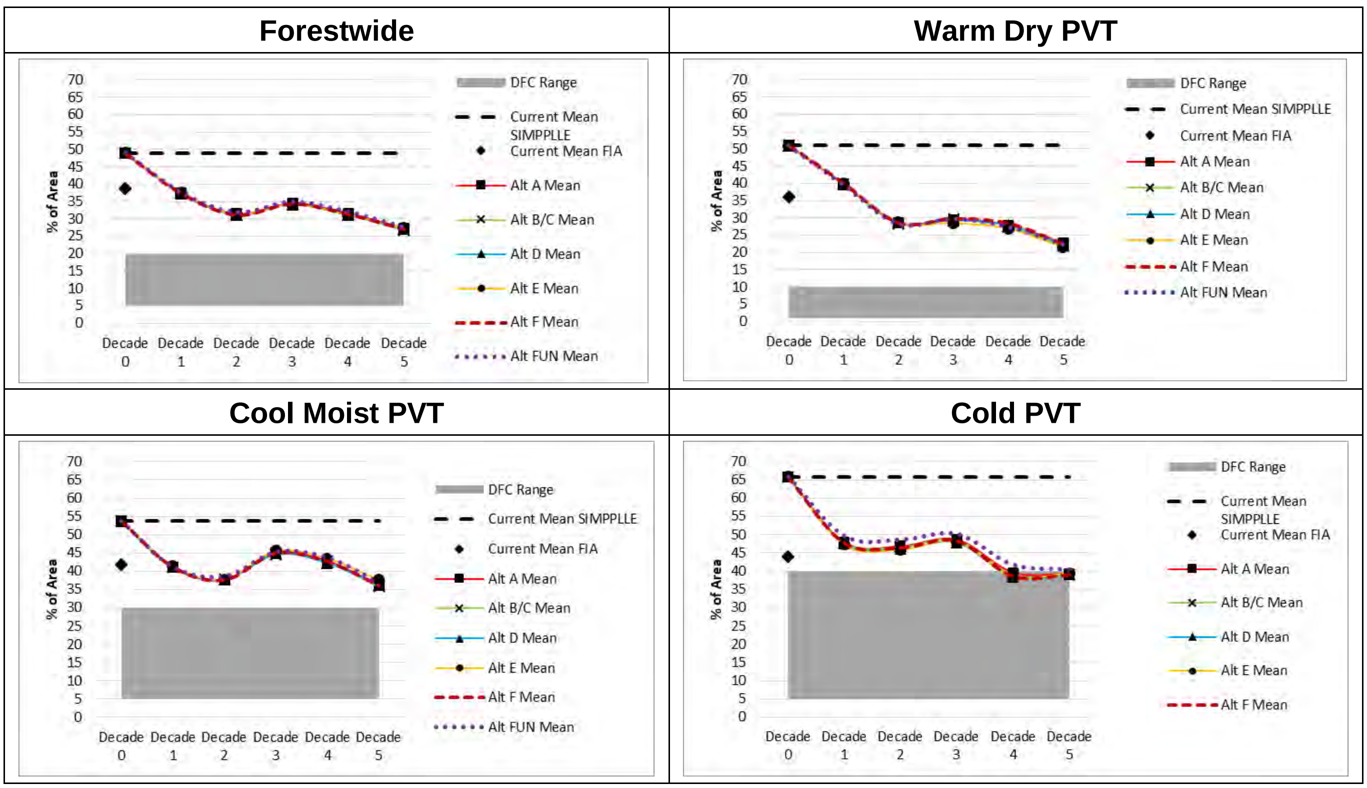
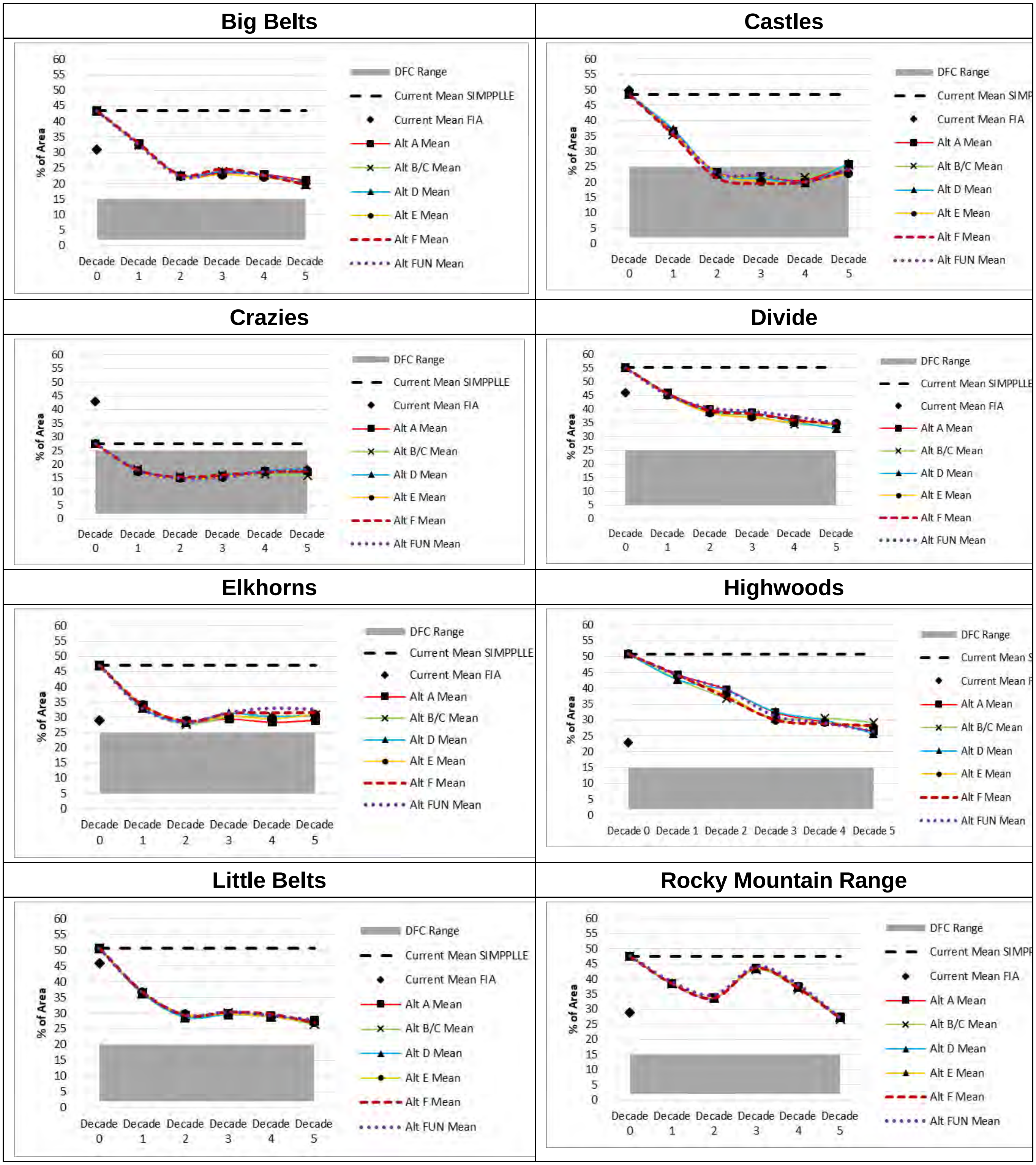
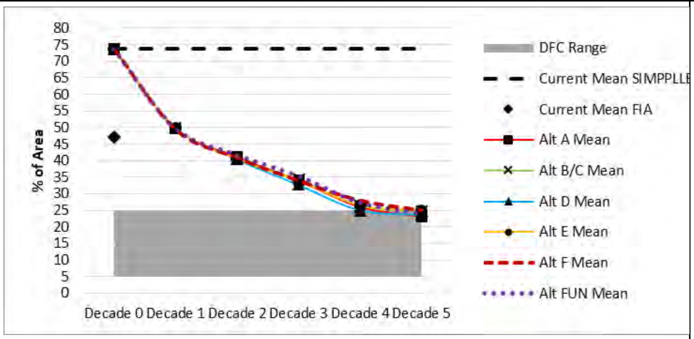
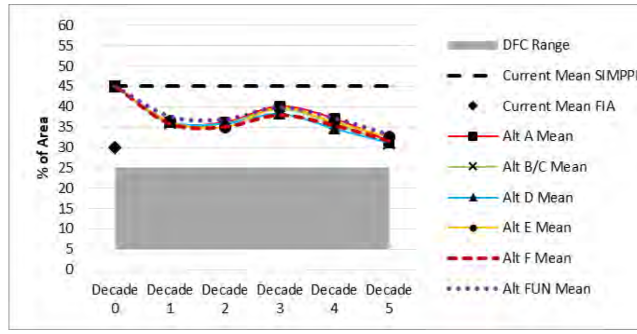


Figure 184. Small size class (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 185. Small size class (% of total area) over 5 decades by alternative, by GA



Snowies	Upper Blackfoot
	

Medium tree

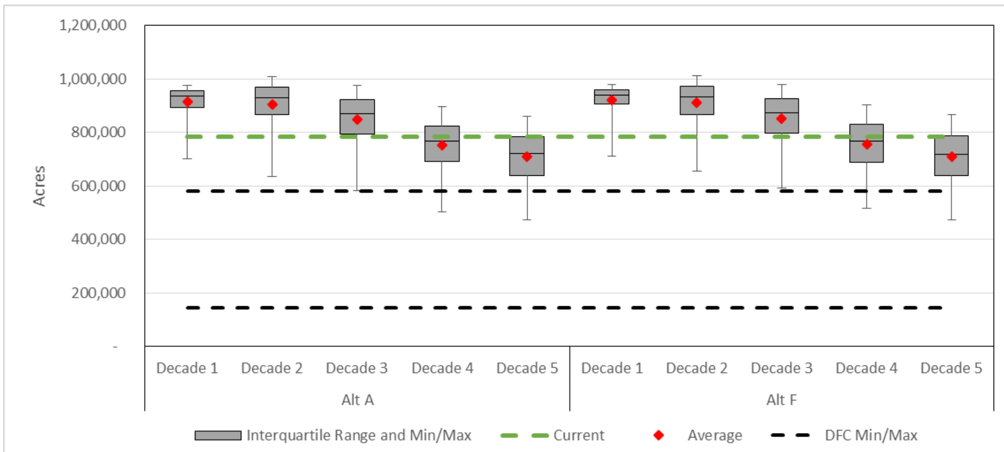


Figure 186. Medium size class (total acres) over 5 decades, alternatives A and F

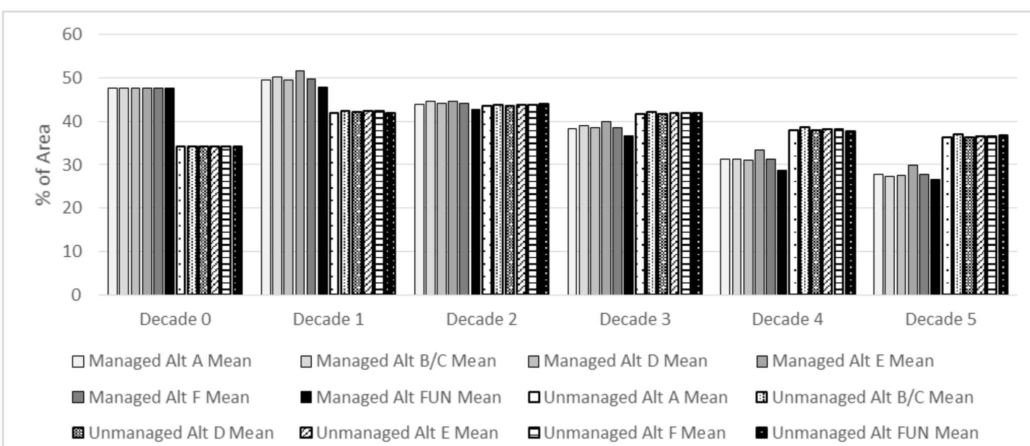


Figure 187. Medium size class in managed versus unmanaged landscapes, forestwide

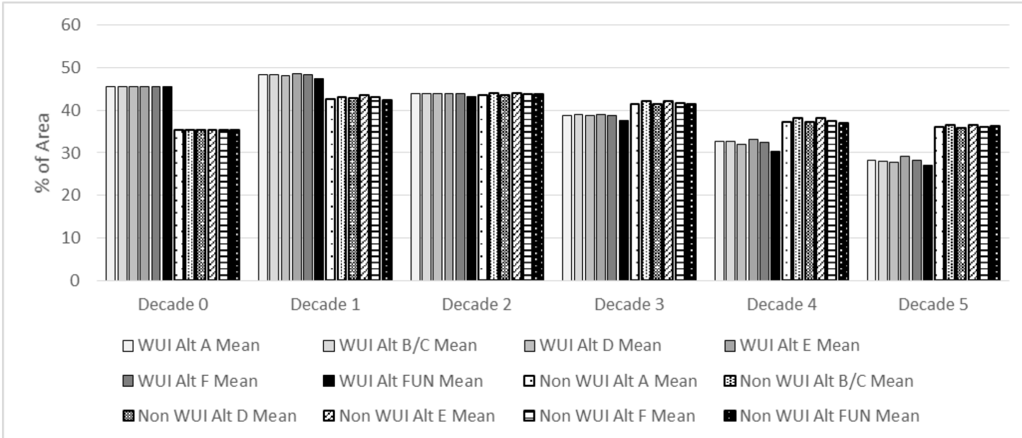


Figure 188. Medium size class in WUI versus non-WUI areas, forestwide

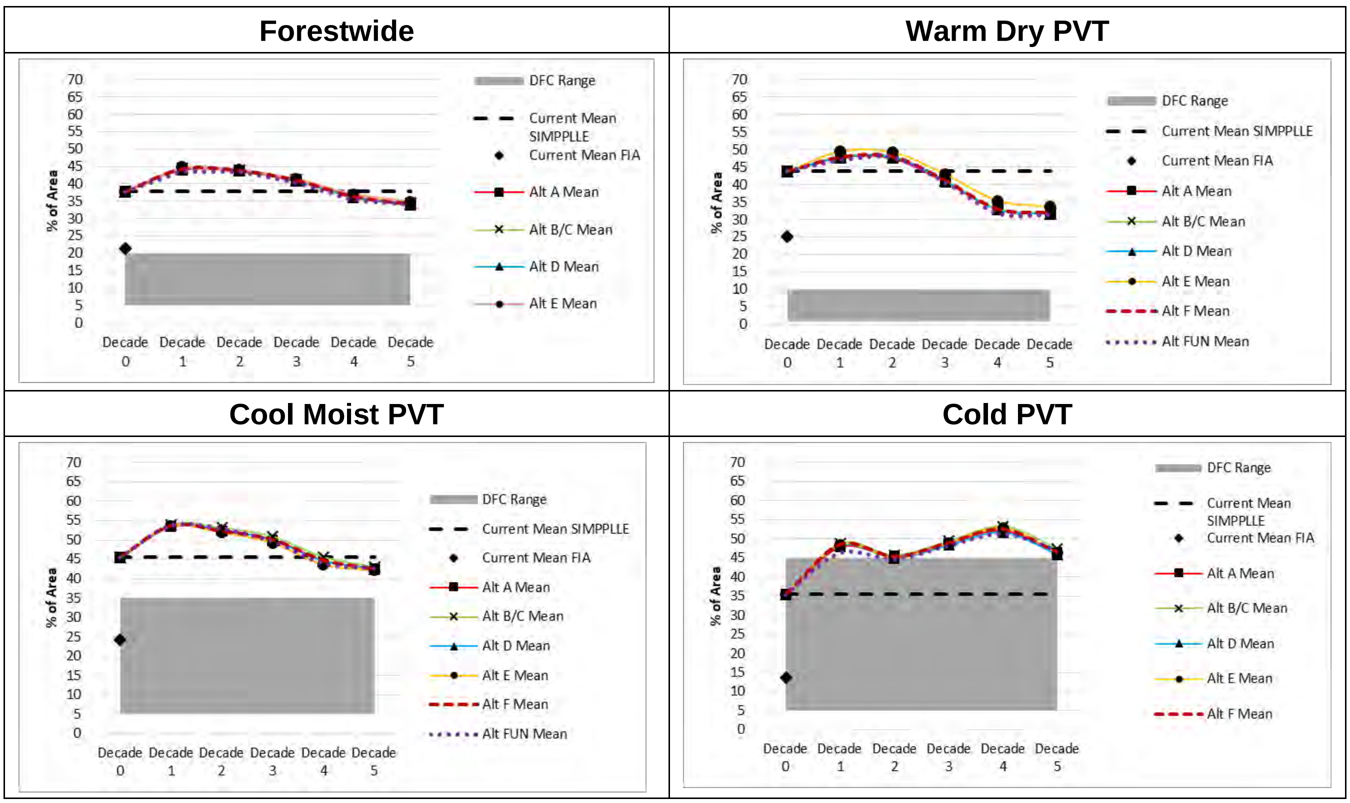
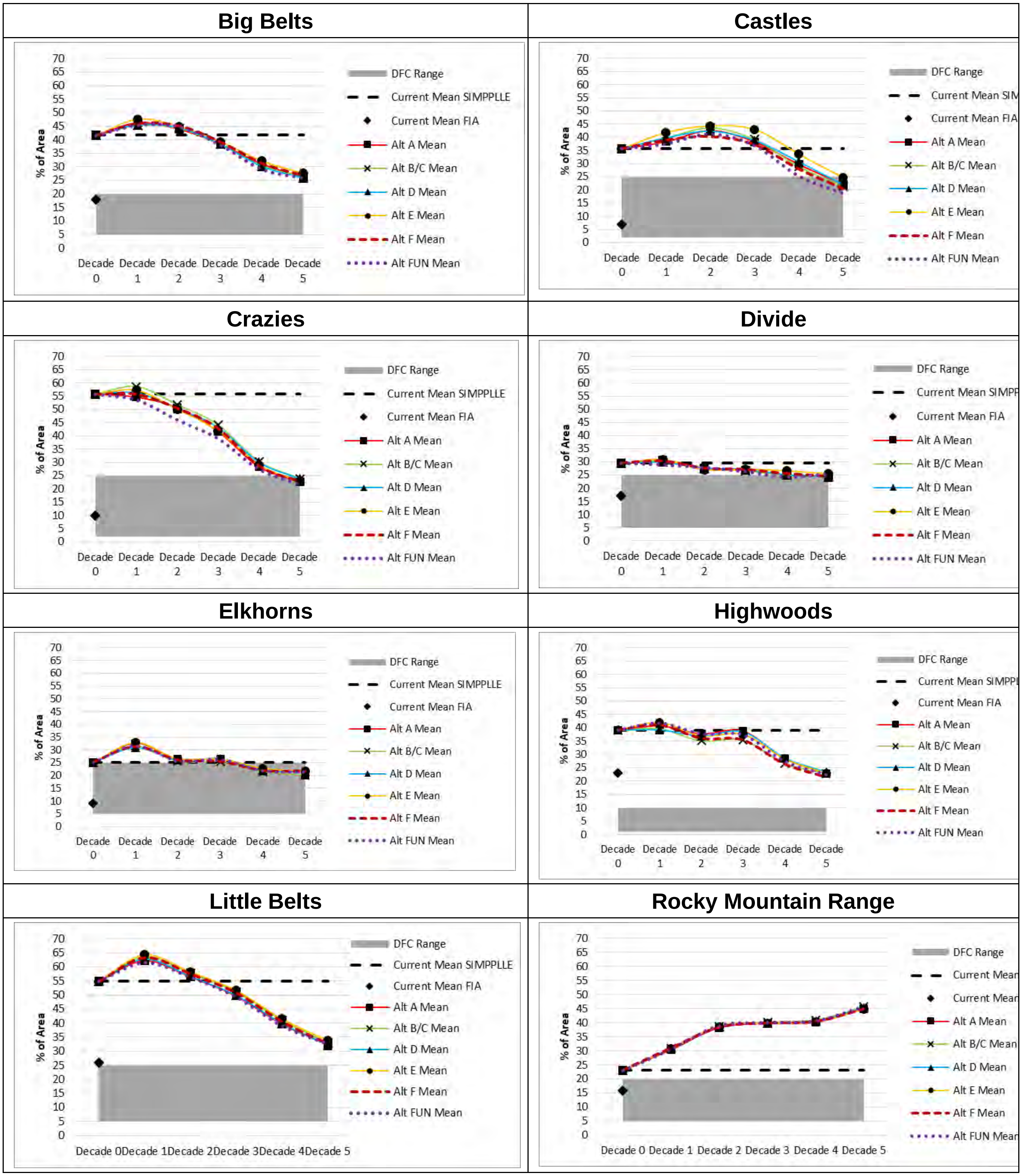
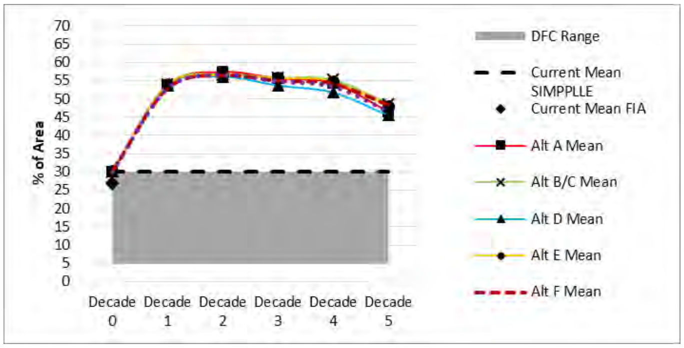
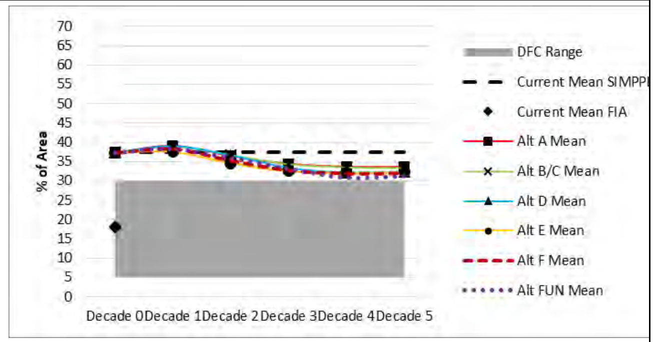


Figure 189. Medium size class (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 190. Medium size class (% of total area) over 5 decades by alternative, by GA



Snowies	Upper Blackfoot
	

Large tree

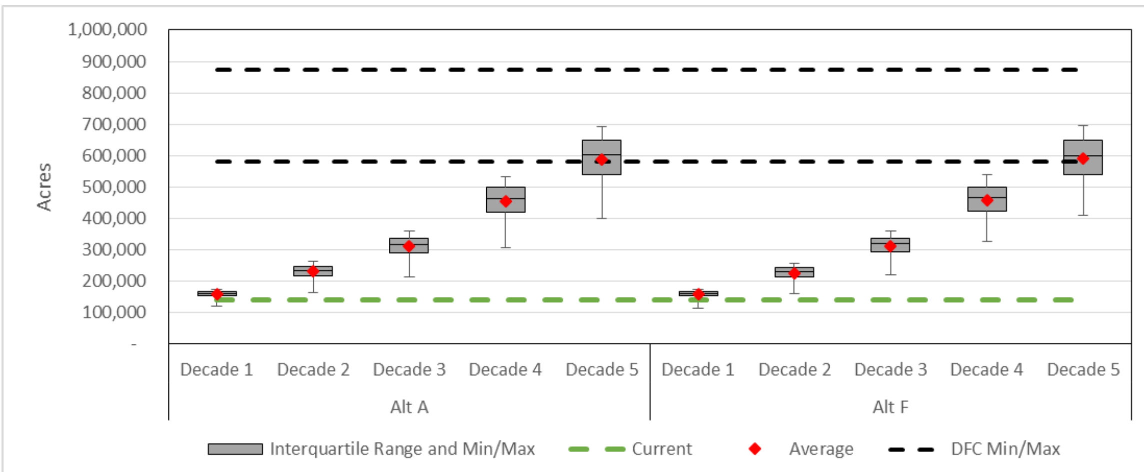


Figure 191. Large size class (total acres) over 5 decades, alternatives A and F

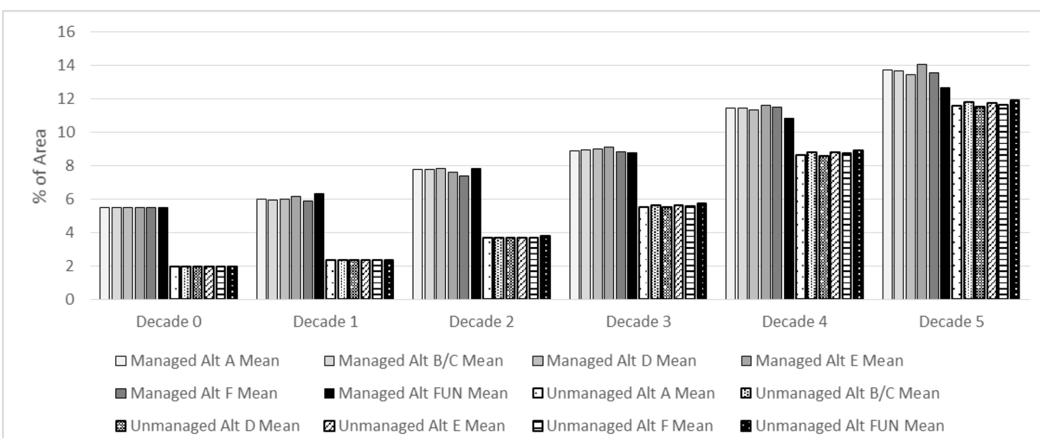


Figure 192. Large size class in managed versus unmanaged landscapes, forestwide

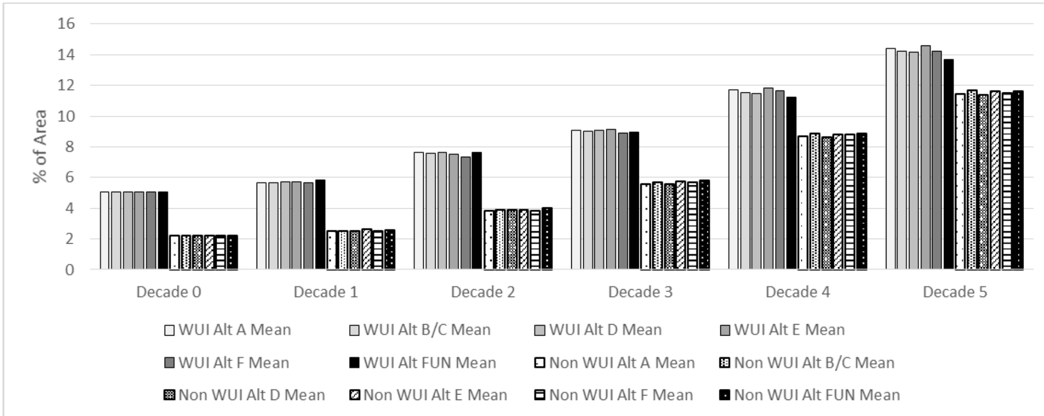


Figure 193. Large size class in WUI versus non-WUI areas, forestwide

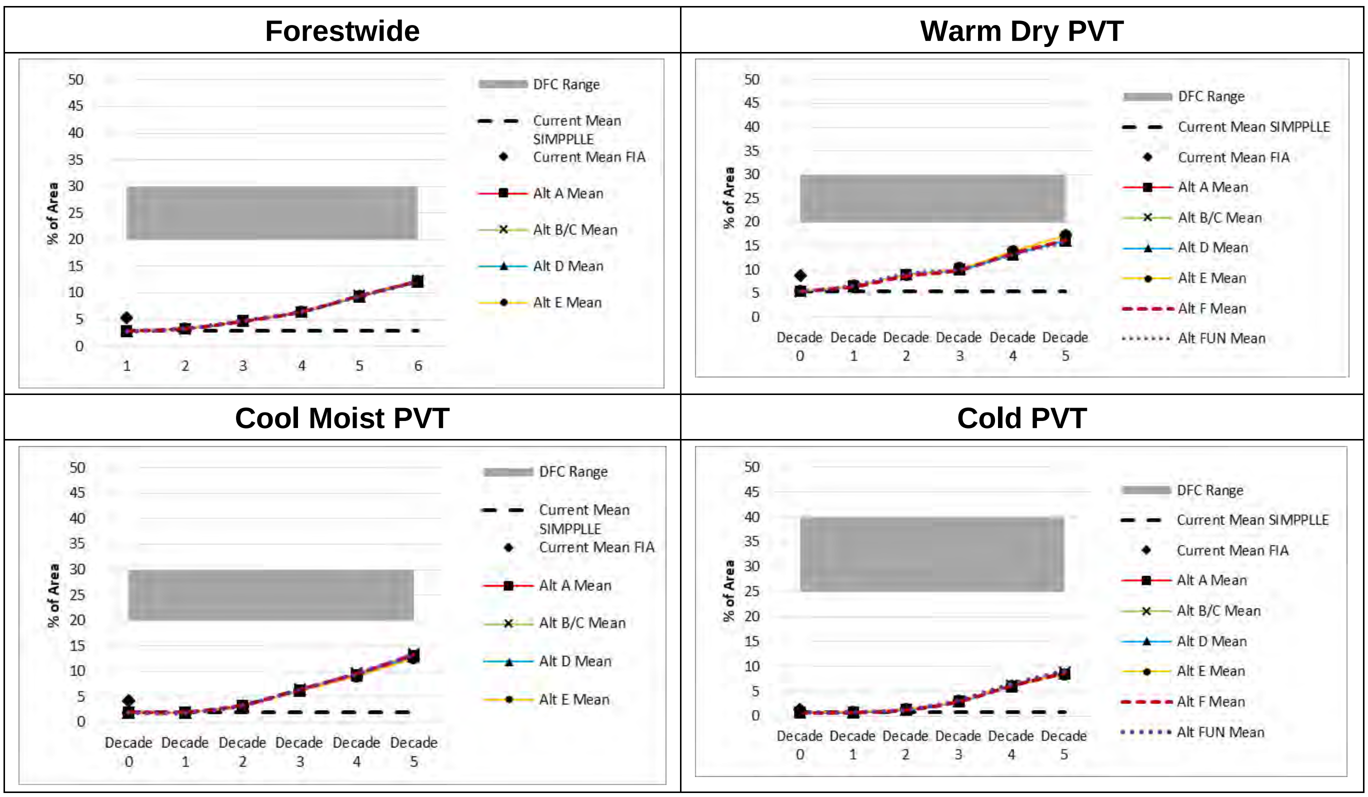
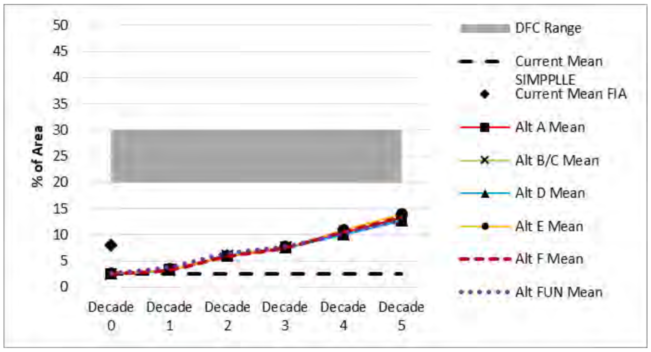


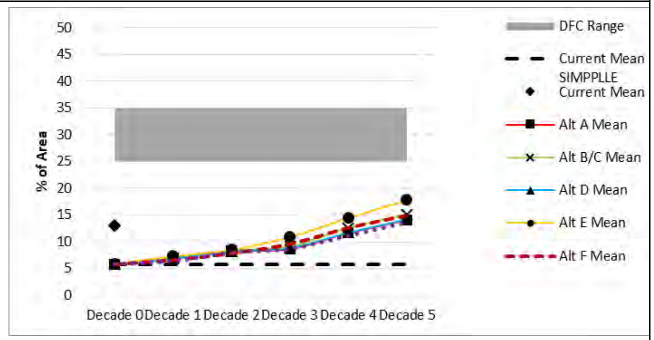
Figure 194. Large size class (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 195. Large size class (% of total area) over 5 decades by alternative, by GA

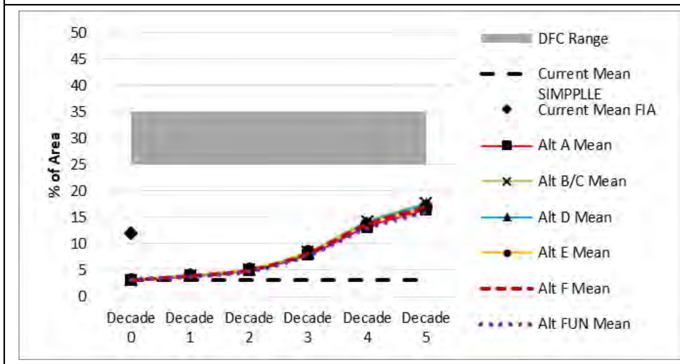
Big Belts



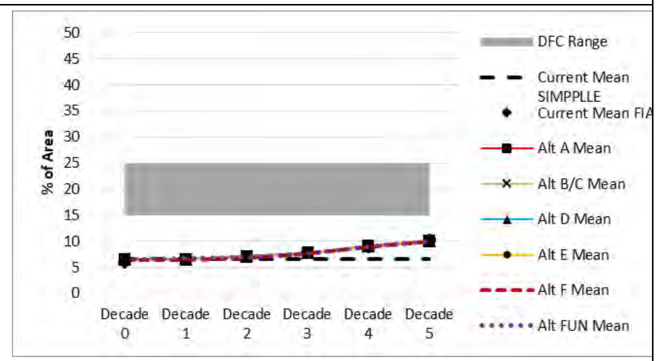
Castles



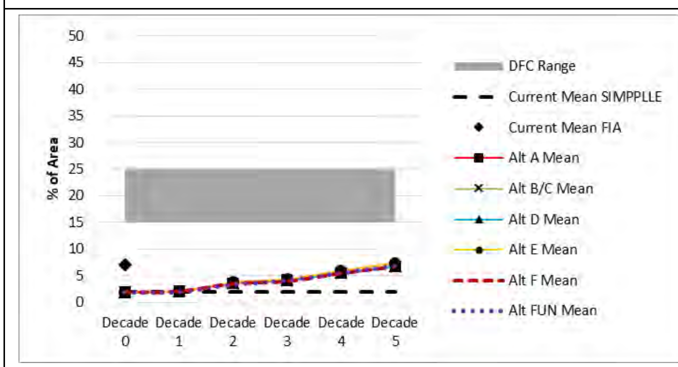
Crazies



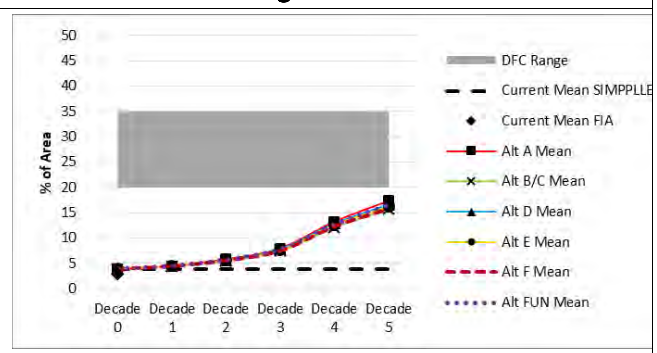
Divide



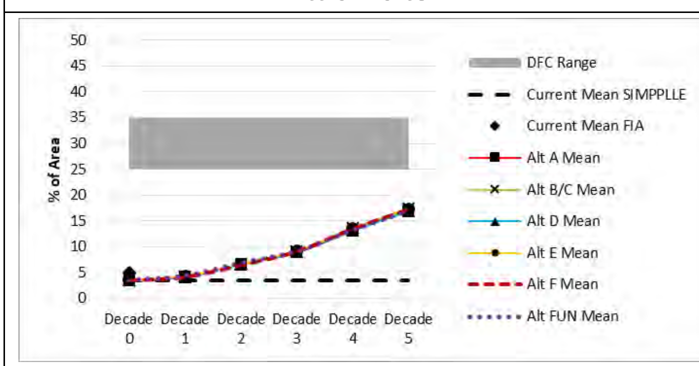
Elkhorns



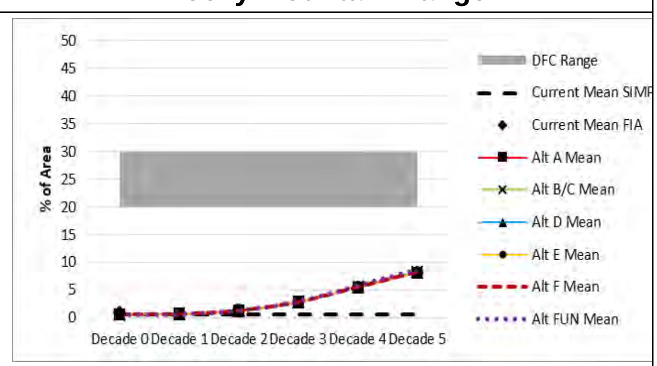
Highwoods

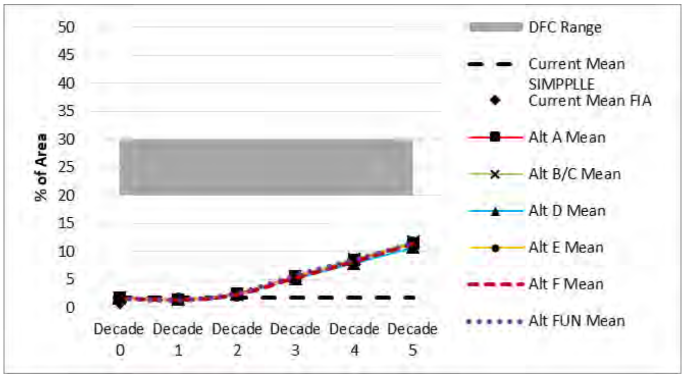
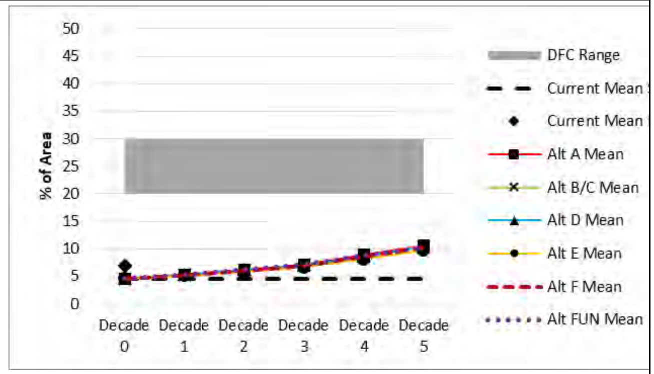


Little Belts



Rocky Mountain Range



Snowies	Upper Blackfoot
	

Very large tree

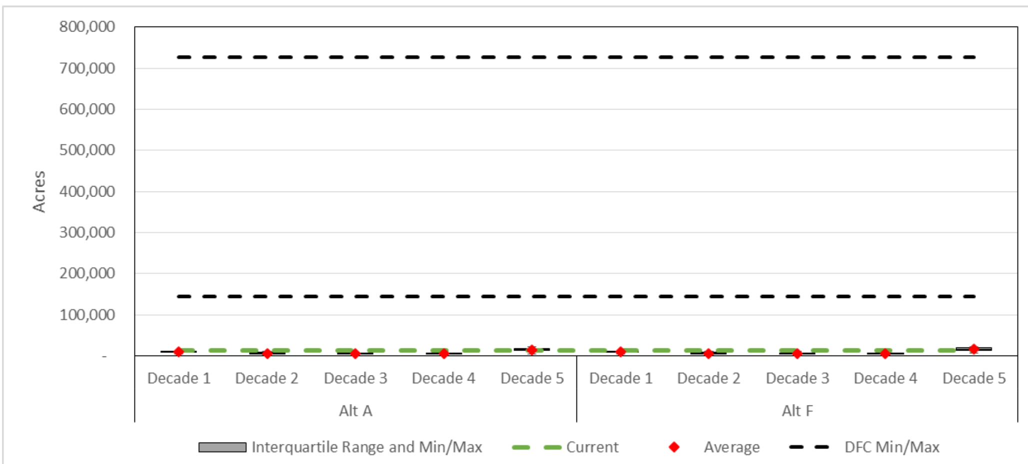


Figure 196. Very large size class (total acres) over 5 decades, alternatives A and F

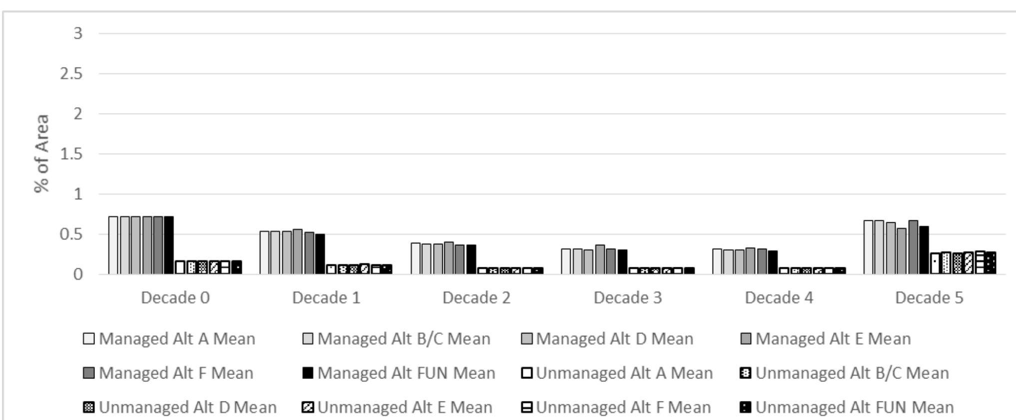


Figure 197. Very large size class in managed versus unmanaged landscapes, forestwide

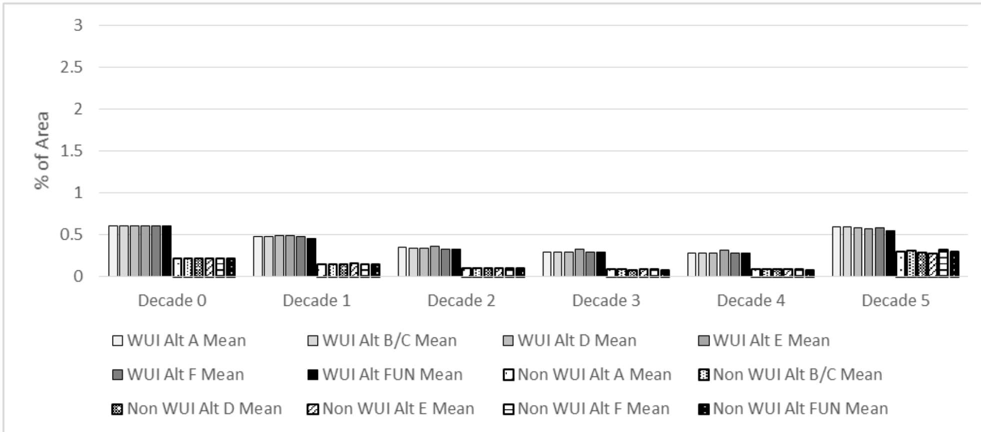


Figure 198. Very large size class in WUI versus non-WUI areas, forestwide

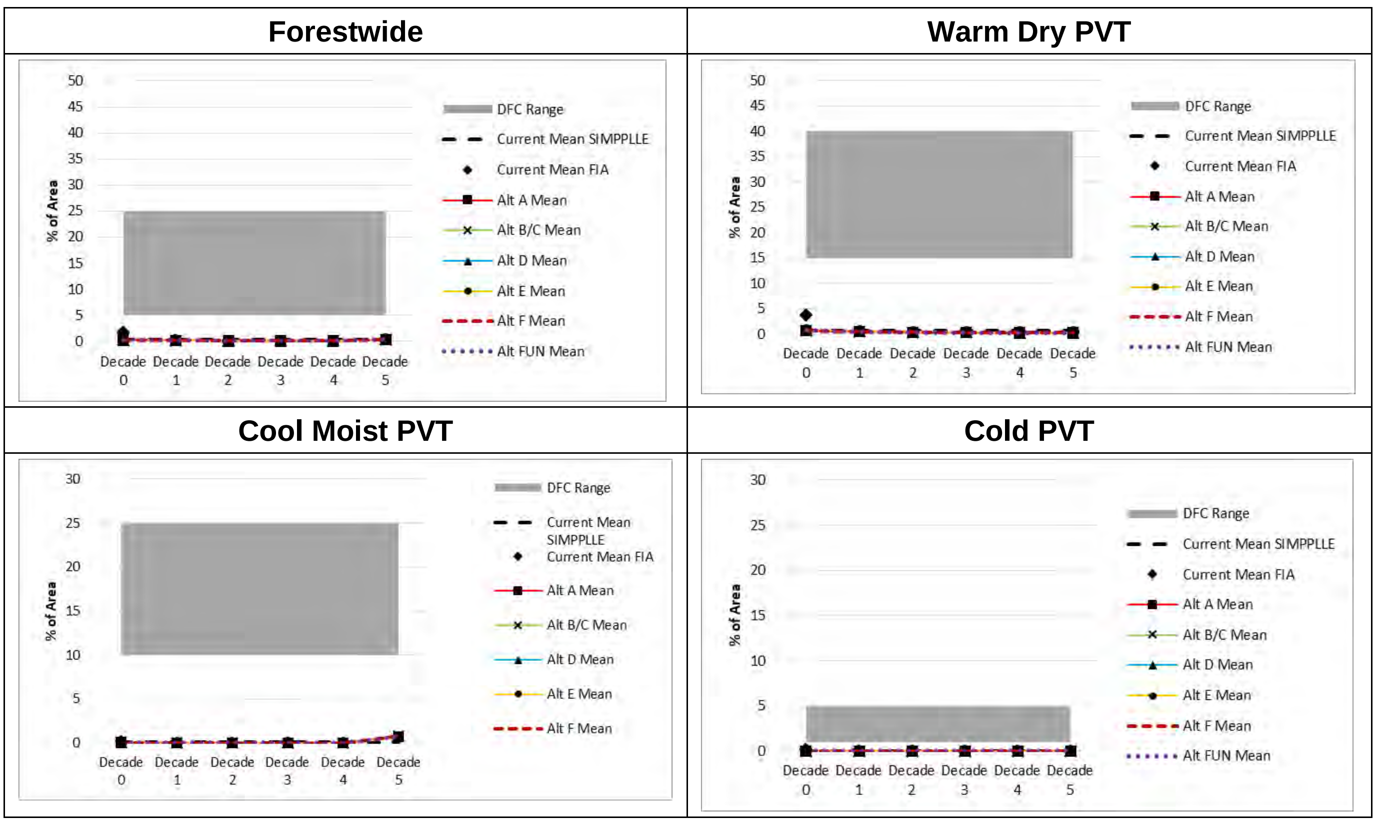
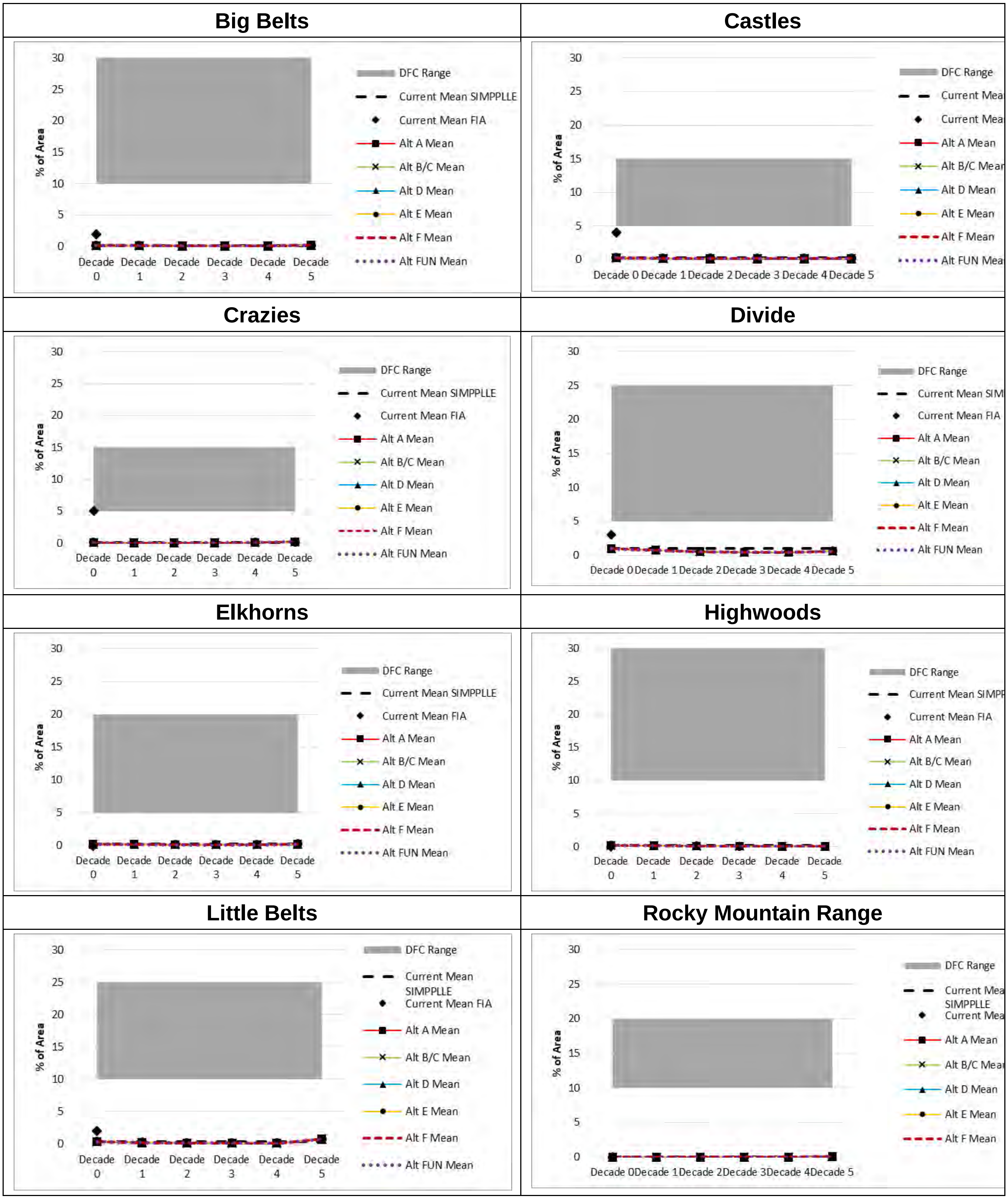
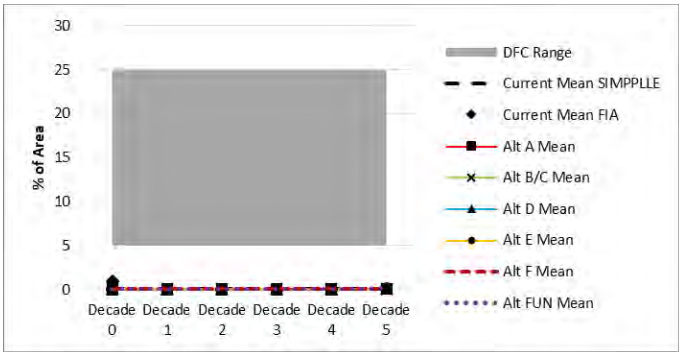
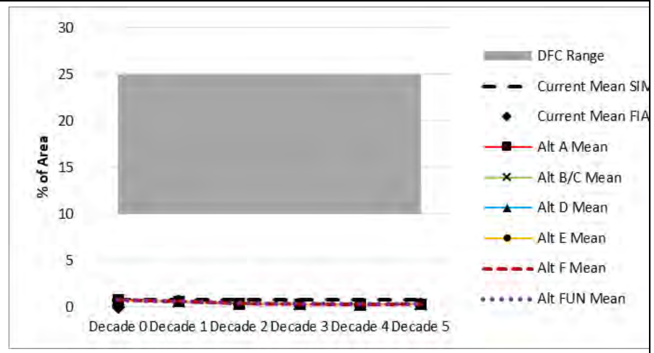


Figure 199. Very large size class (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 200. Very large size class (% of total area) over 5 decades by alternative, by GA



Snowies	Upper Blackfoot
	

Large-tree structure

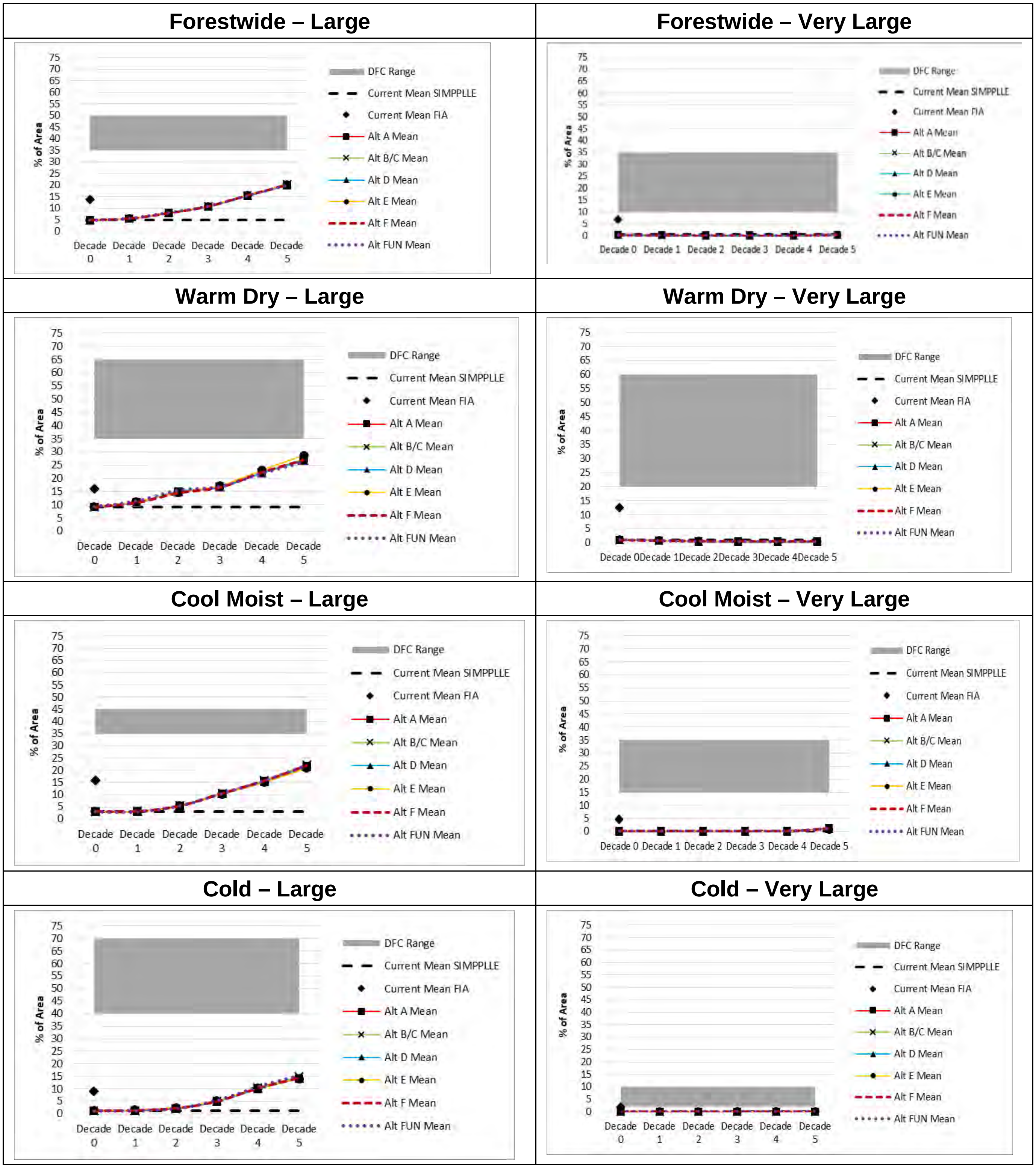


Figure 201. Large-tree structure (% of total area) over 5 decades by alternative, forestwide and by PVT

Forest density and vertical structure

Nonforested/Low/Medium Density

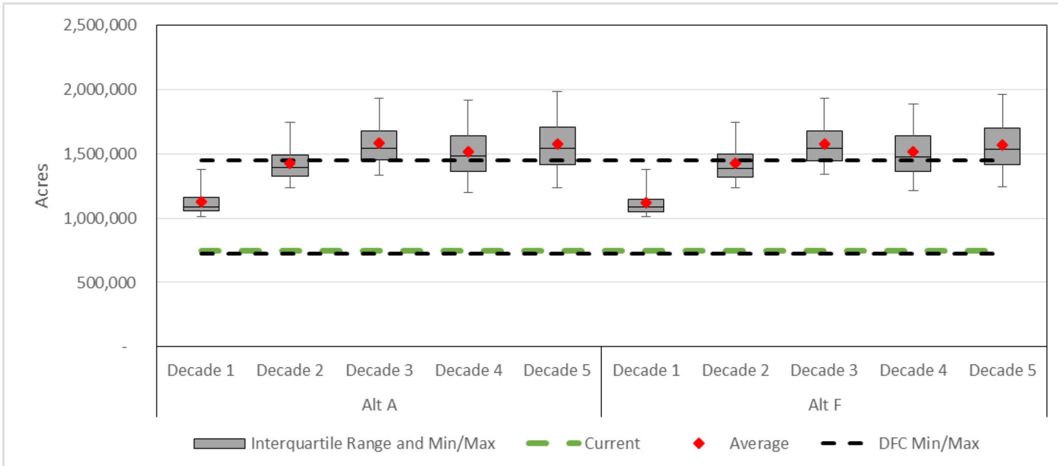


Figure 202. Nonforested/low/medium density class (total acres) over 5 decades, alternatives A and F

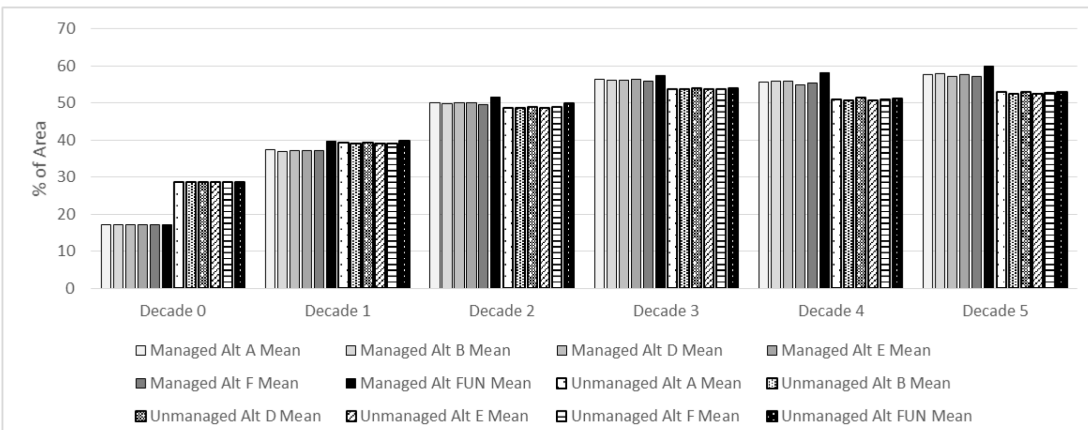


Figure 203. Nonforested/low/medium density class in managed versus unmanaged landscapes, forestwide

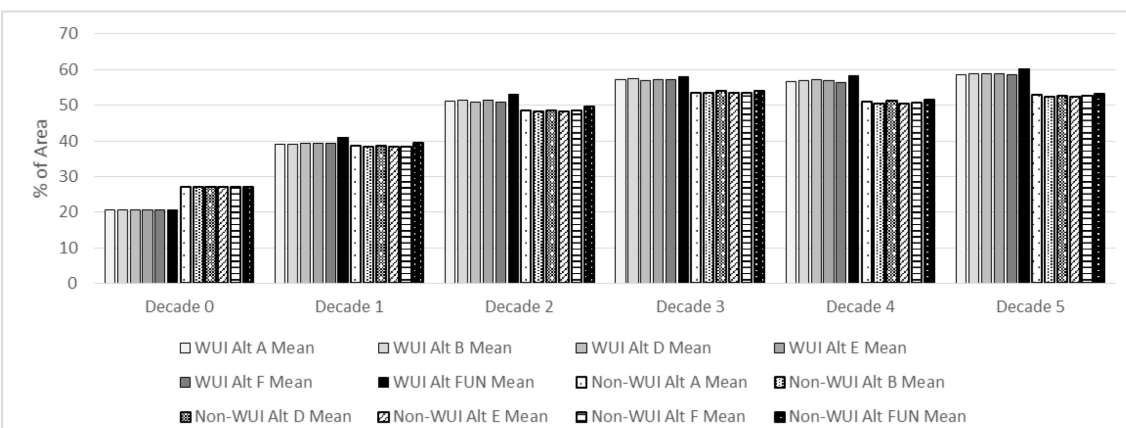


Figure 204. Nonforested/low/medium density class in WUI versus non-WUI areas, forestwide

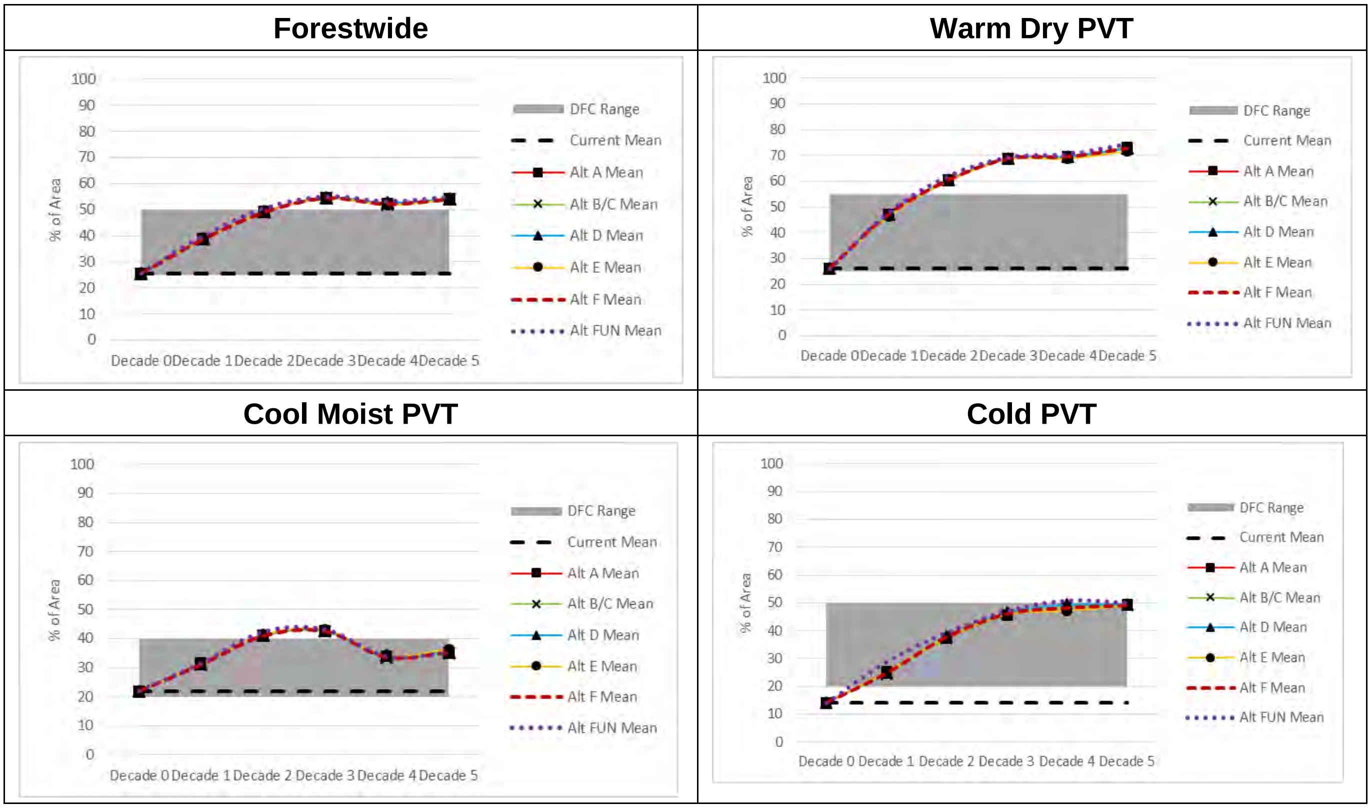
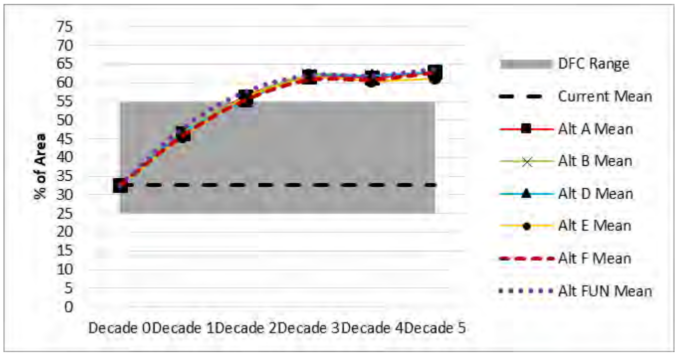


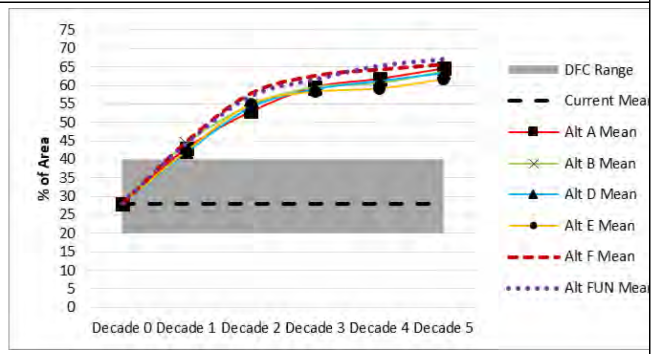
Figure 205. Nonforested/low/medium density class (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 206. Nonforested/low/medium density class (% of total area) over 5 decades by alternative, by GA

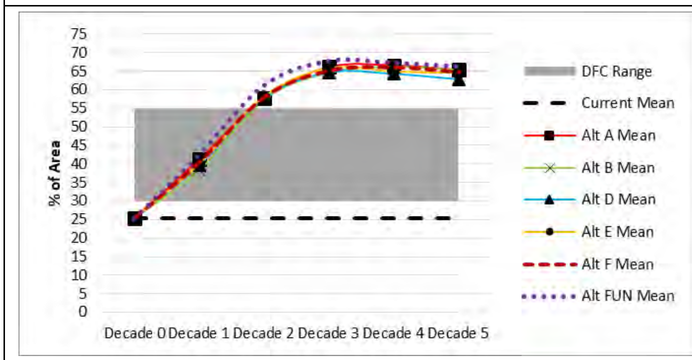
Big Belts



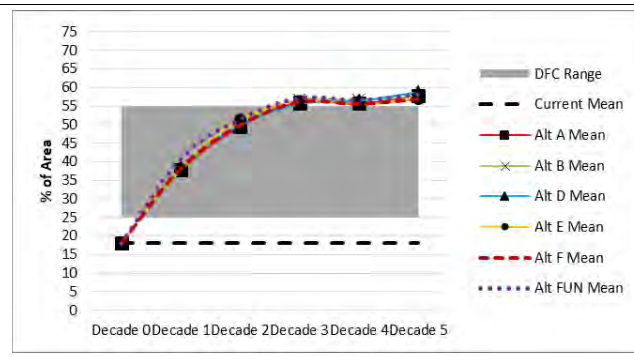
Castles



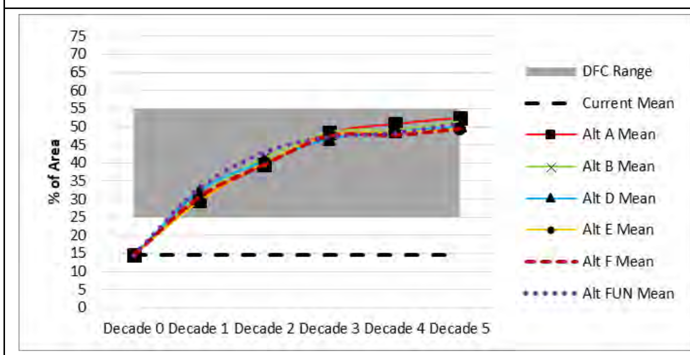
Crazies



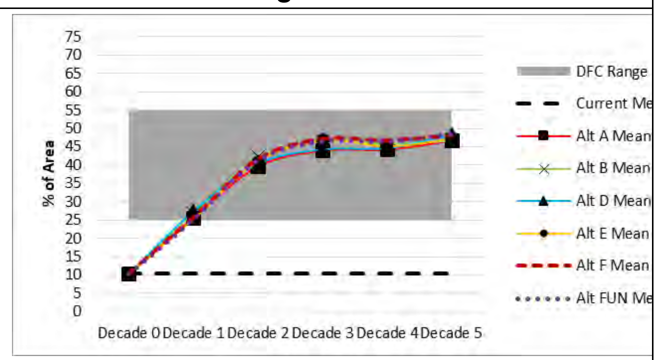
Divide



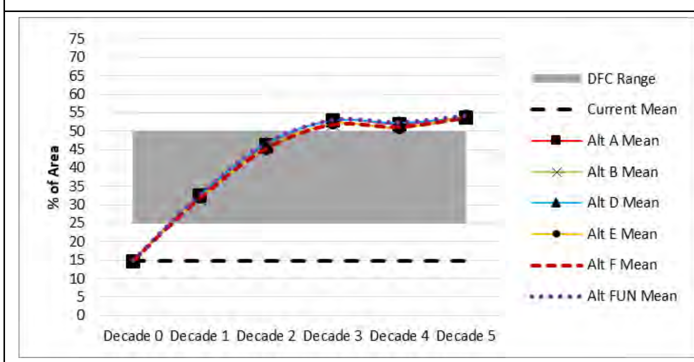
Elkhorns



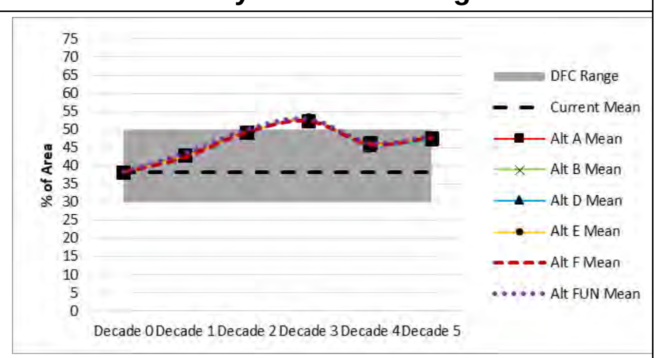
Highwoods



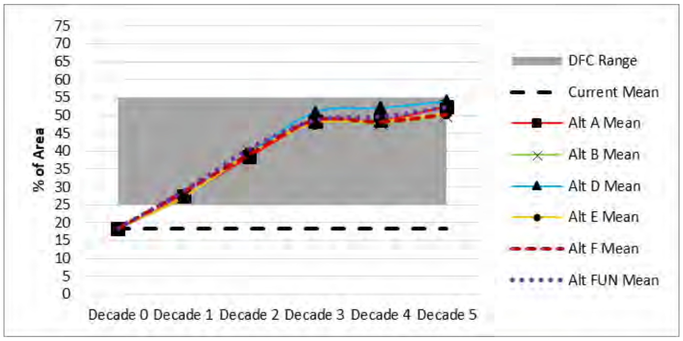
Little Belts

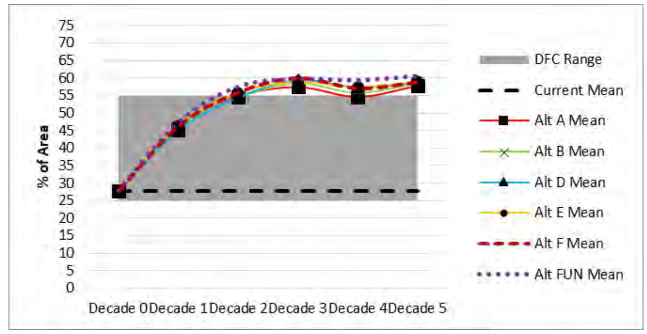


Rocky Mountain Range



Snowies	Upper Blackfoot





Medium/high density

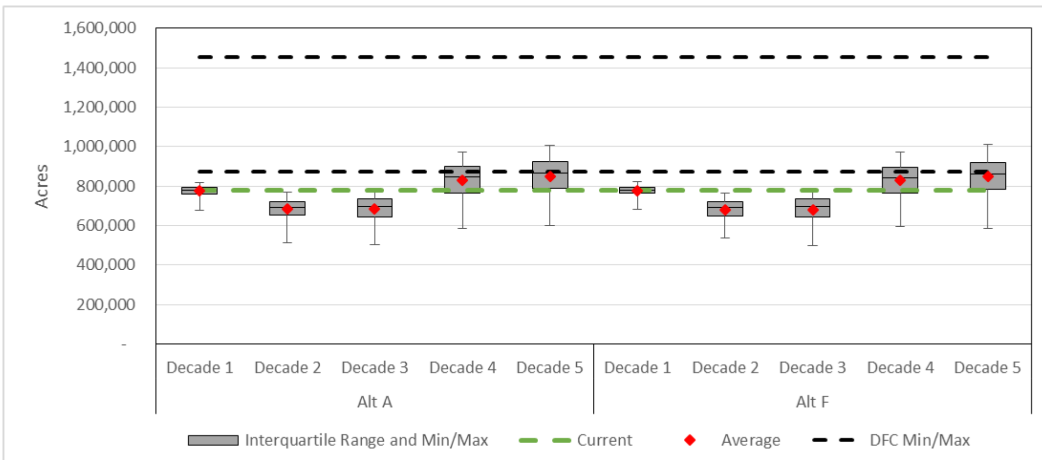


Figure 207. Medium/high density class (total acres) over 5 decades, alternatives A and F

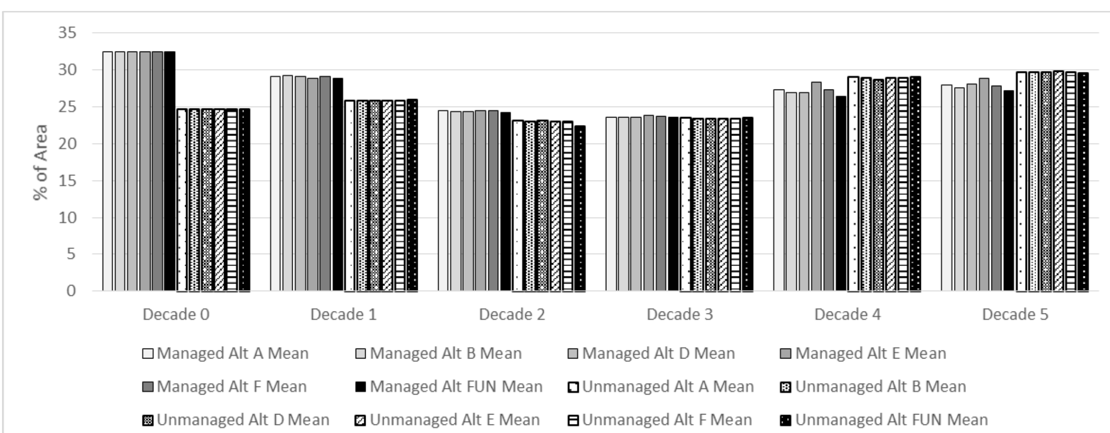


Figure 208. Medium/high density class in managed versus unmanaged landscapes, forestwide

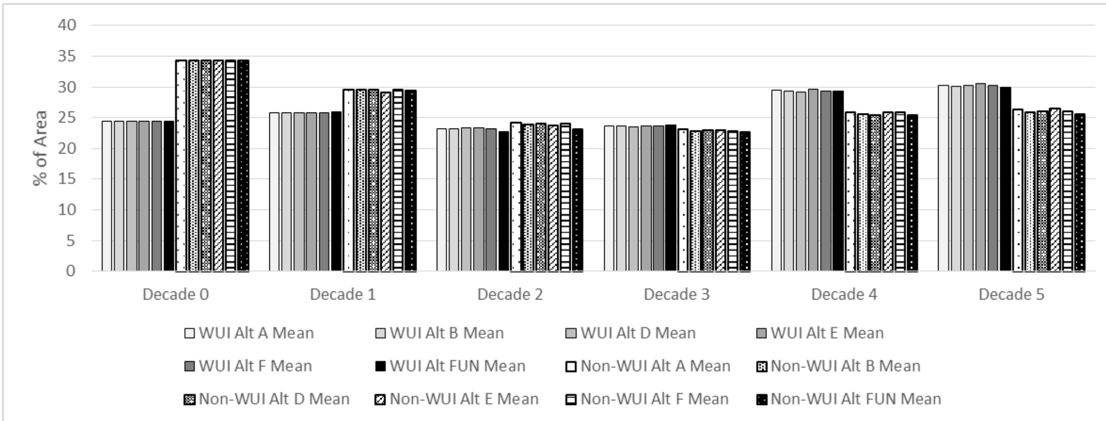


Figure 209. Medium/high density class in WUI versus non-WUI areas, forestwide

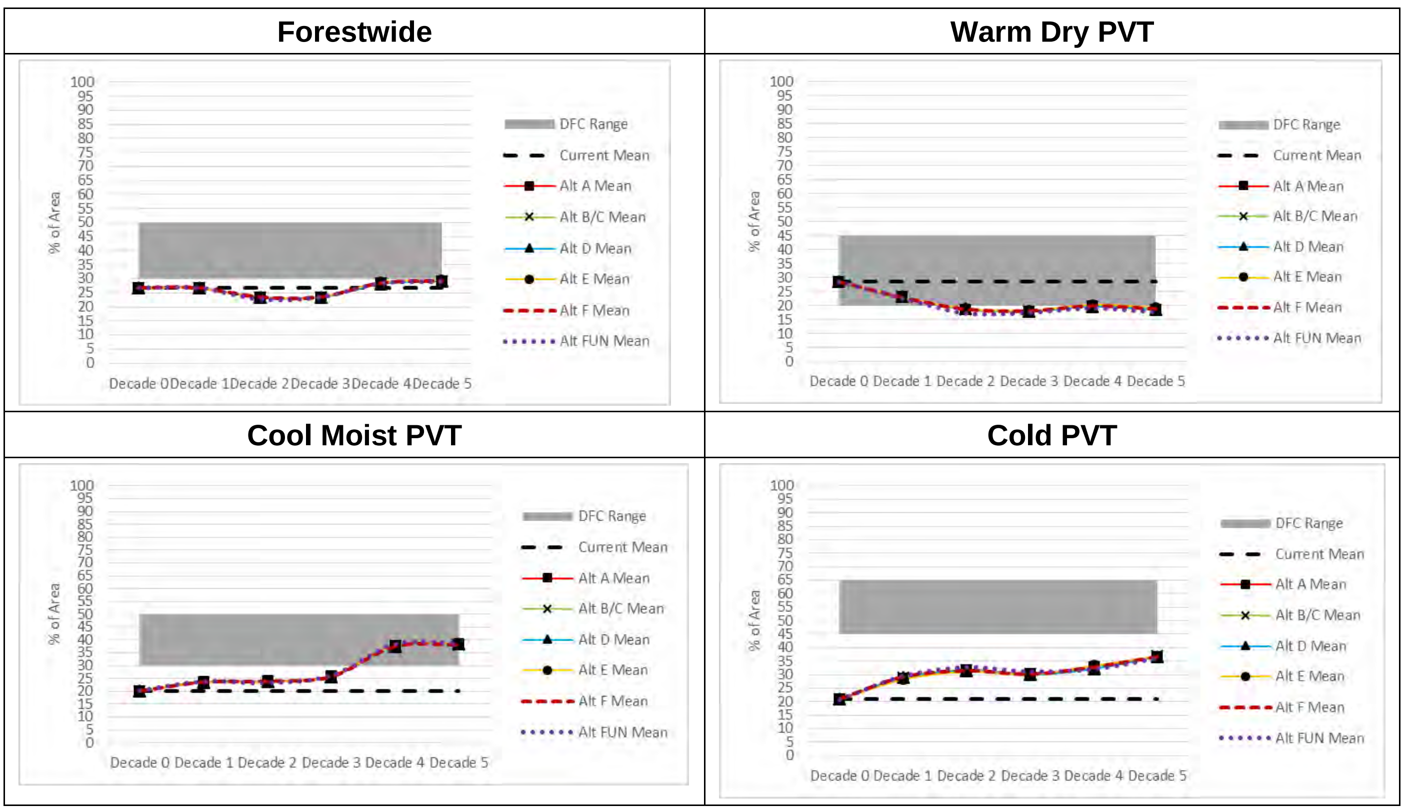
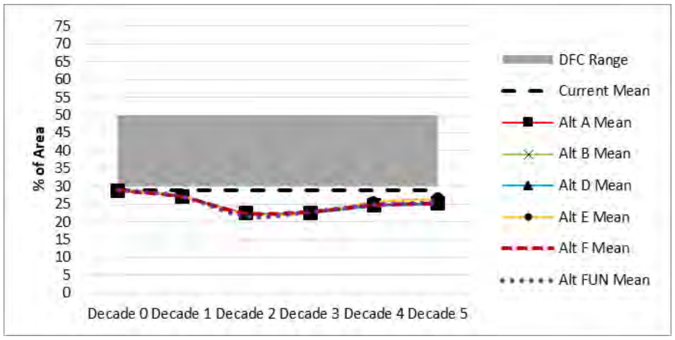


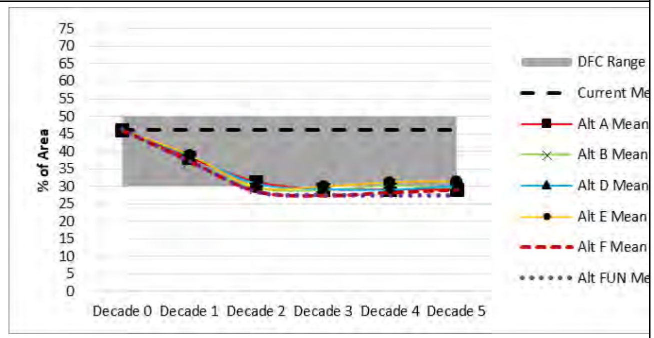
Figure 210. Medium/high density class (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 211. Medium/high density class (% of total area) over 5 decades by alternative, by GA

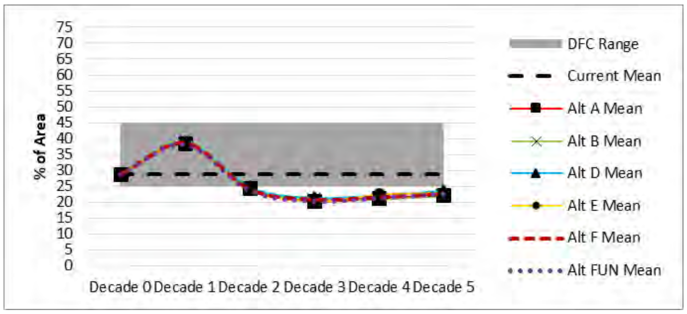
Big Belts



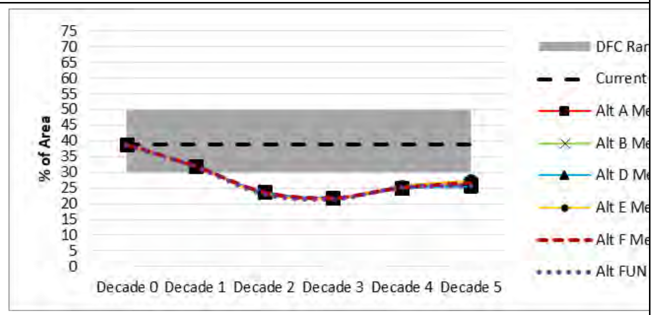
Castles



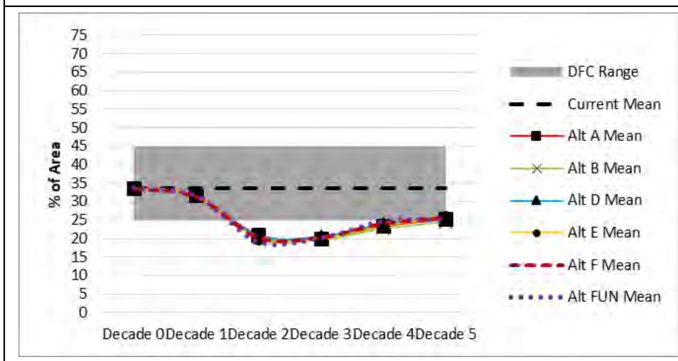
Crazies



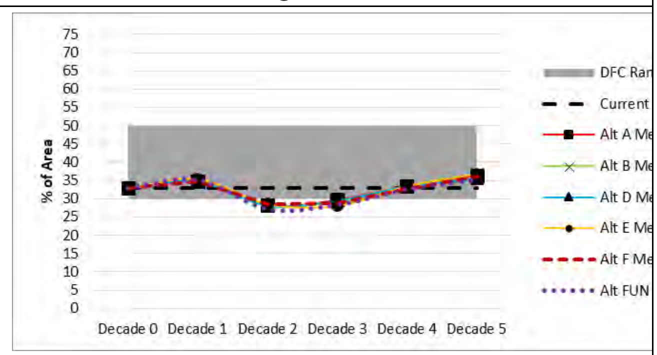
Divide



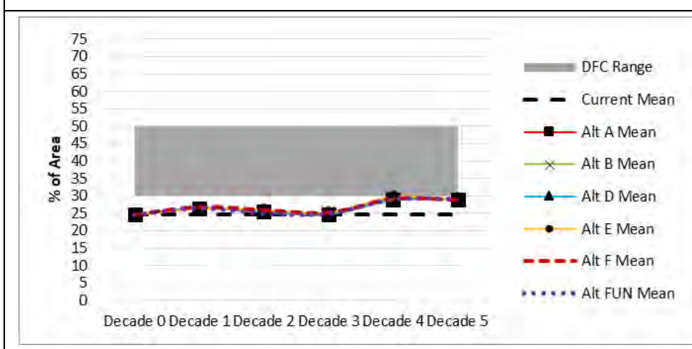
Elkhorns



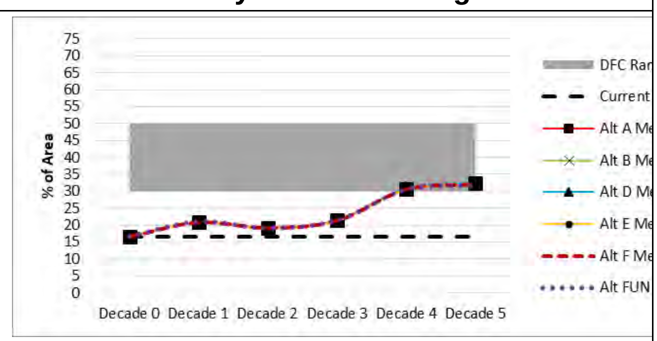
Highwoods

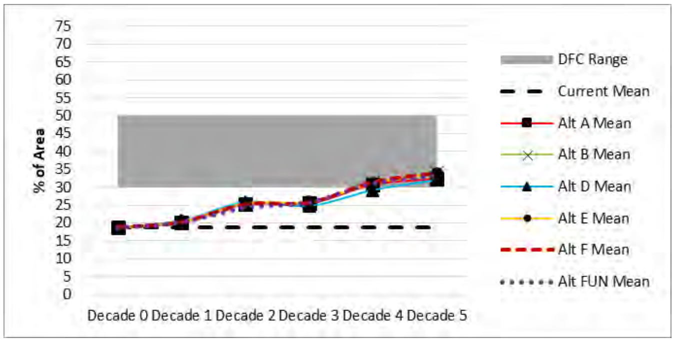
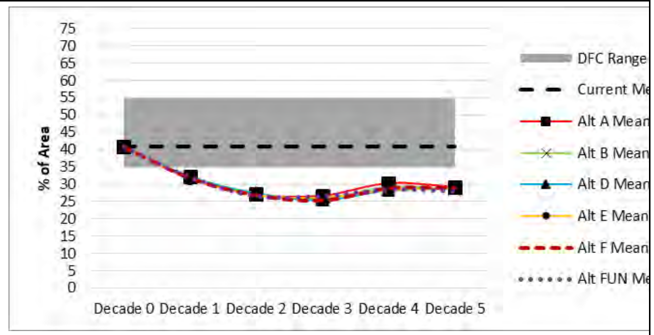


Little Belts



Rocky Mountain Range



Snowies	Upper Blackfoot
	

High density

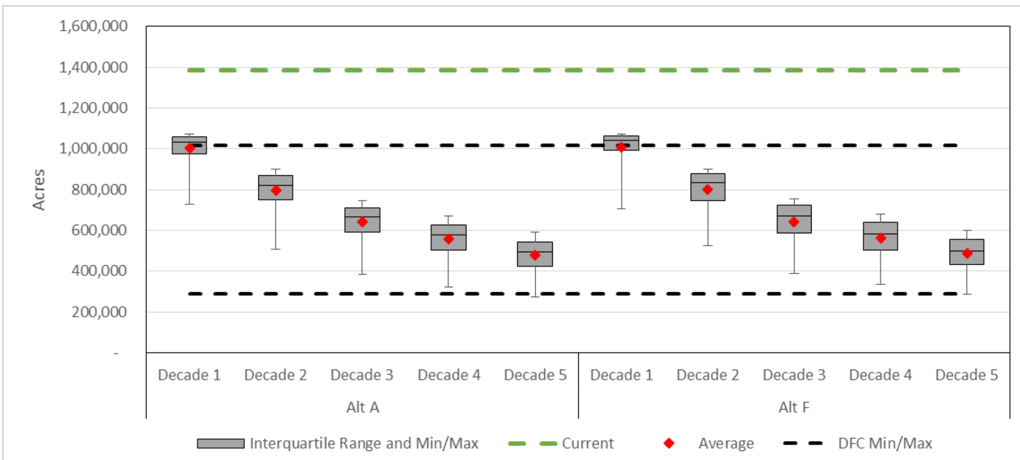


Figure 212. High density class (total acres) over 5 decades, alternatives A and F

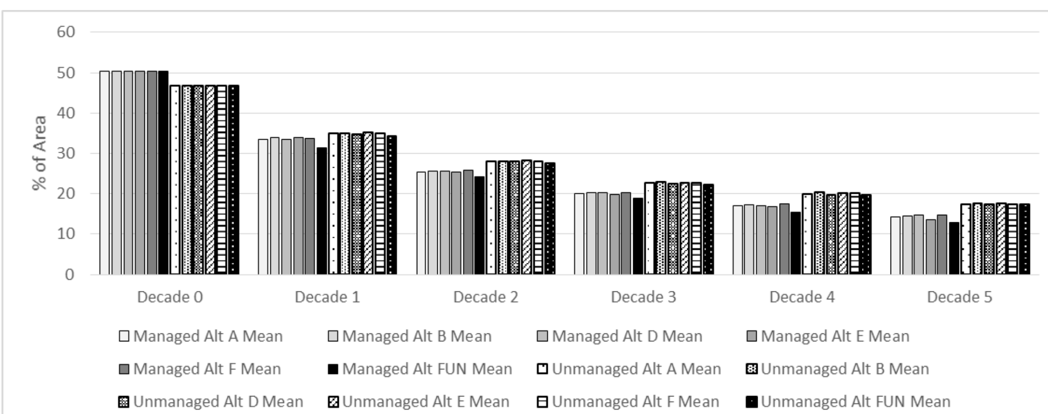


Figure 213. High density class in managed versus unmanaged landscapes, forestwide

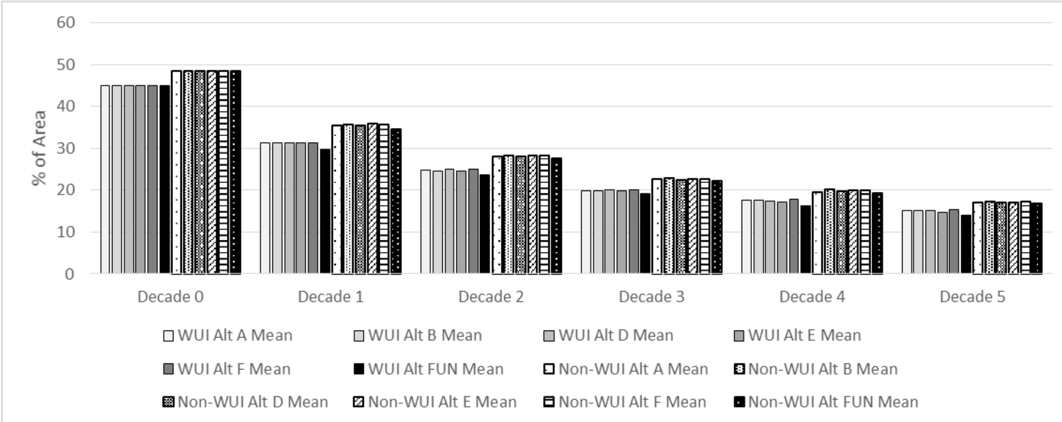
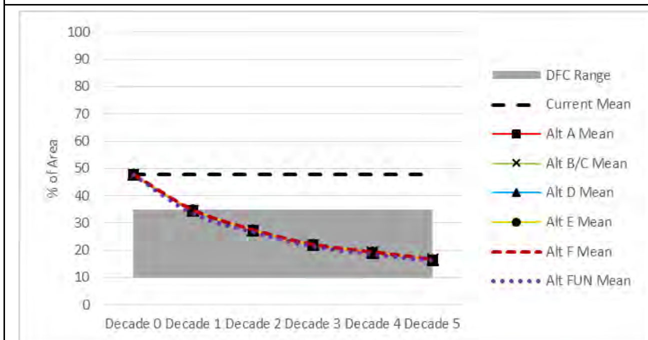
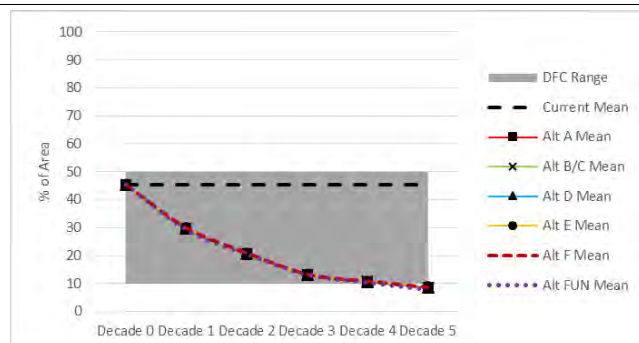


Figure 214. High density class in WUI versus non-WUI areas, forestwide

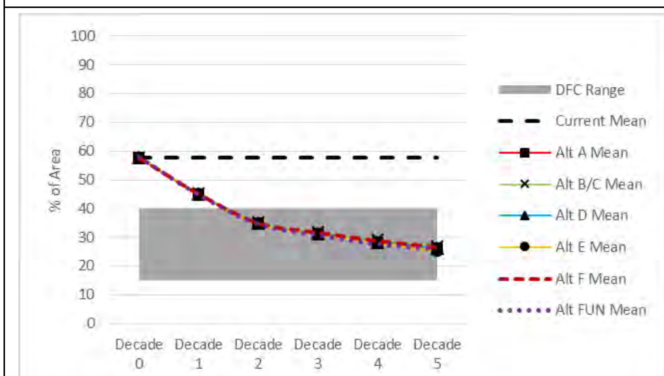
Forestwide



Warm Dry PVT



Cool Moist PVT



Cold PVT

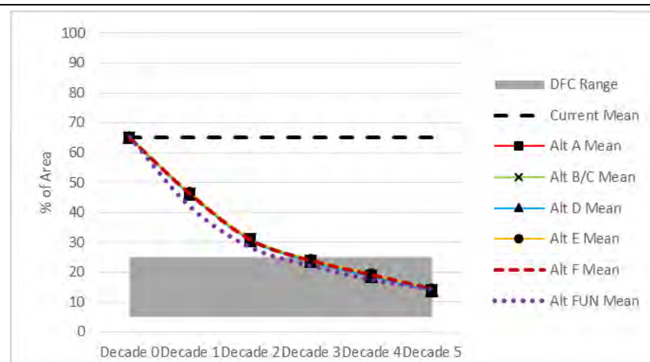
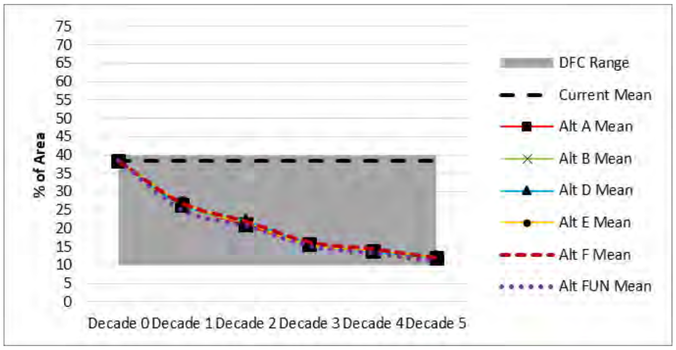


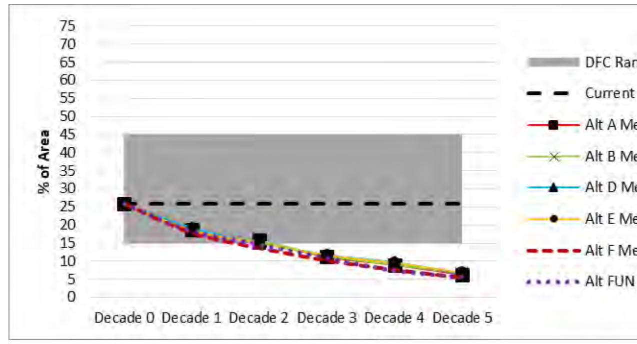
Figure 215. High density class (% of total area) over 5 decades by alternative, forestwide and by PVT

Figure 216. High density class (% of total area) over 5 decades by alternative, by GA

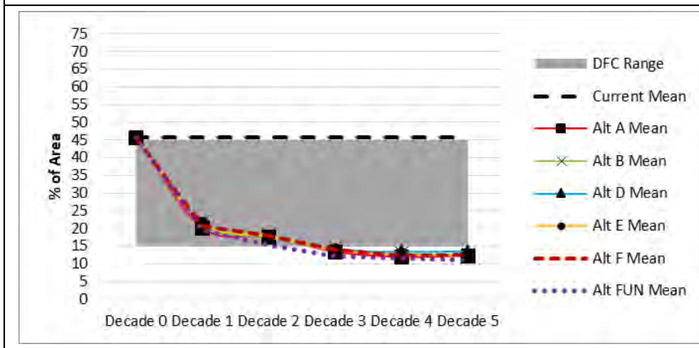
Big Belts



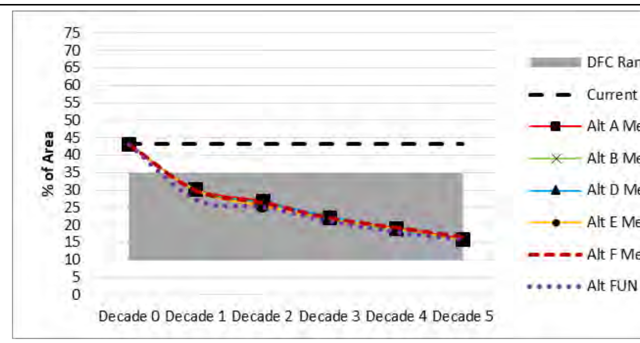
Castles



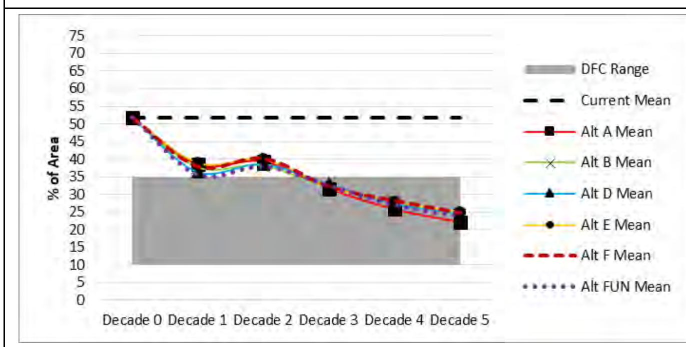
Crazies



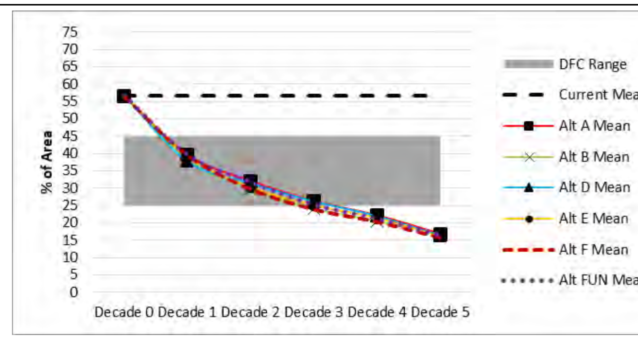
Divide



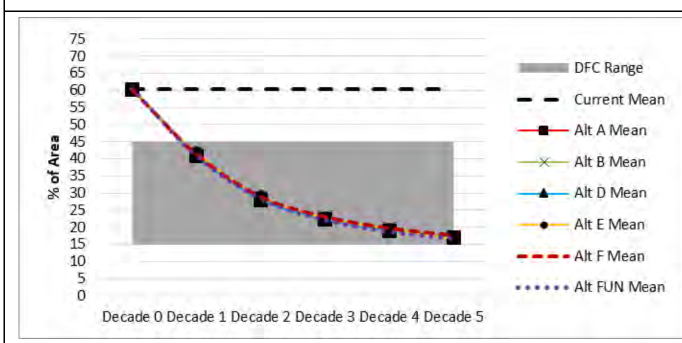
Elkhorns



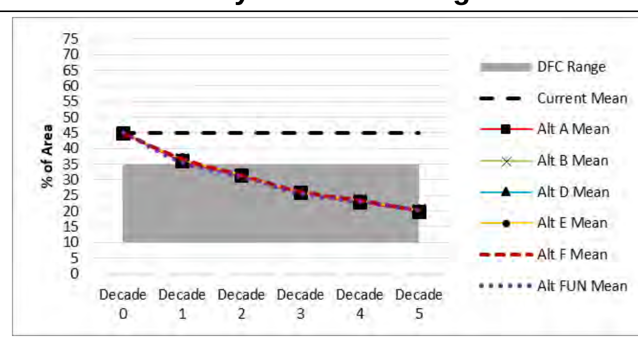
Highwoods

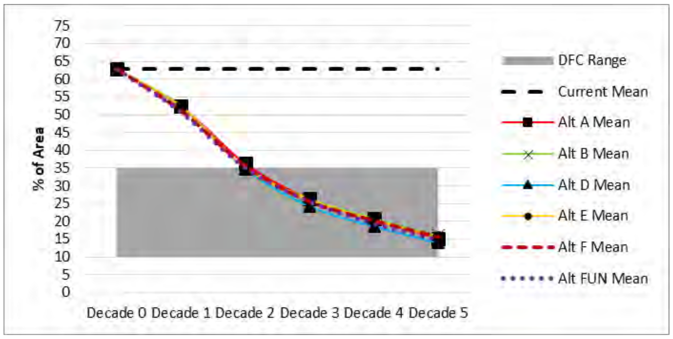
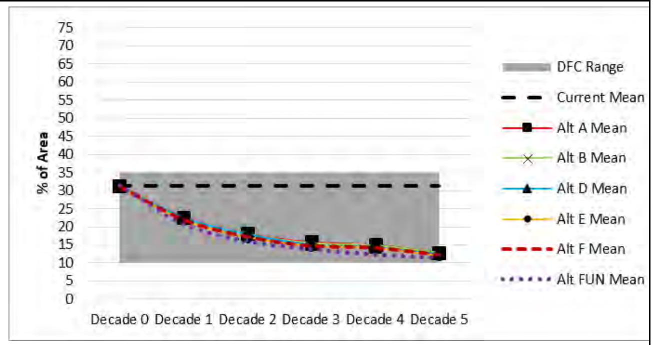


Little Belts



Rocky Mountain Range



Snowies	Upper Blackfoot
	

Vertical structure

Forestwide summaries are not shown because these structures vary strongly by PVT; and this attribute is not summarized by GA because there are no desired conditions. No Box/Whisker plots were produced.

Single-storied

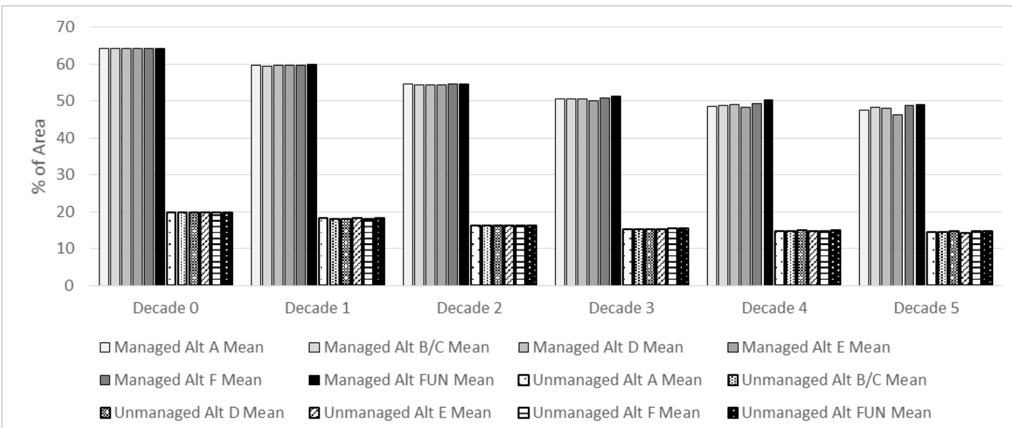


Figure 217. Single-storied vertical structure class in managed versus unmanaged landscapes, forestwide

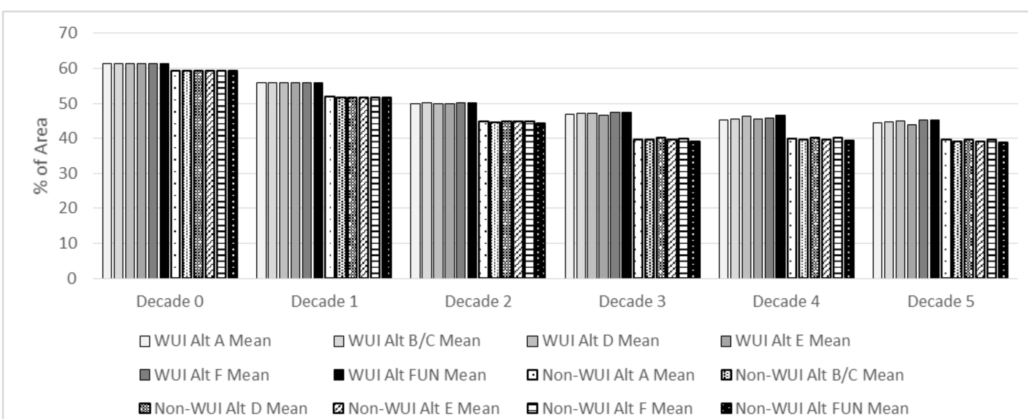


Figure 218. Single-storied vertical structure class in WUI versus non-WUI areas, forestwide

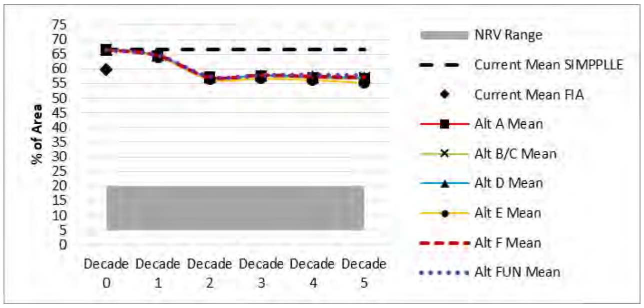
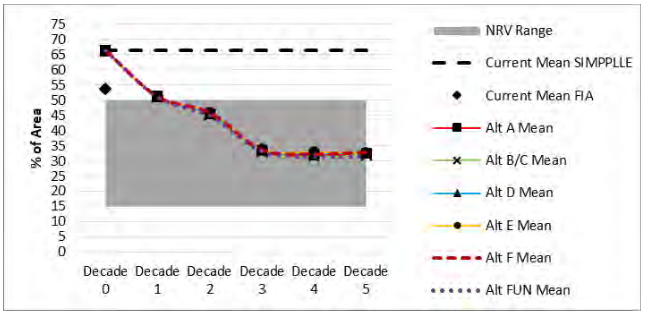
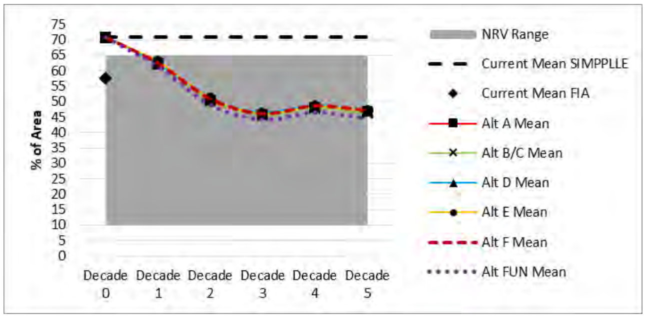
Forestwide	Warm Dry PVT
N/A	
Cool Moist PVT	**Cold PVT**
	

Figure 219. Single-storied vertical structure class (% of total area) over 5 decades by alternative, forestwide and by PVT

Two-storied

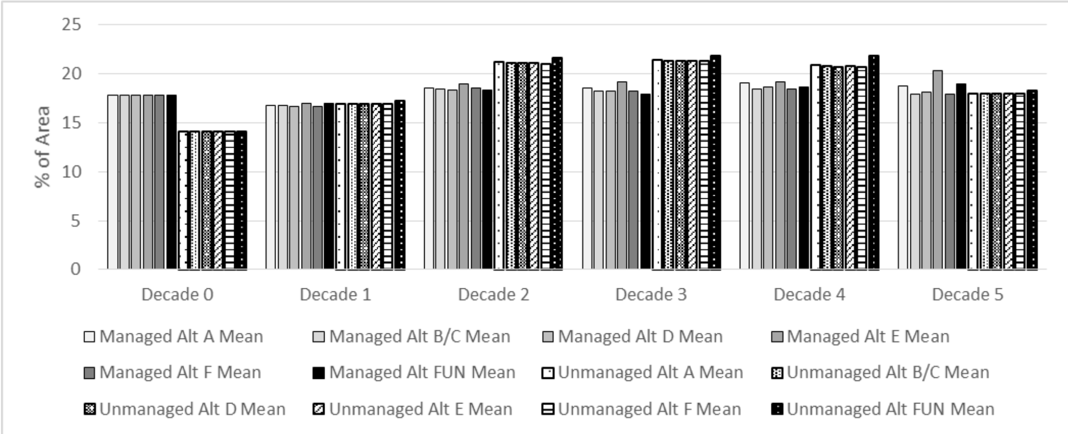


Figure 220. Two-storied vertical structure class in managed versus unmanaged landscapes, forestwide

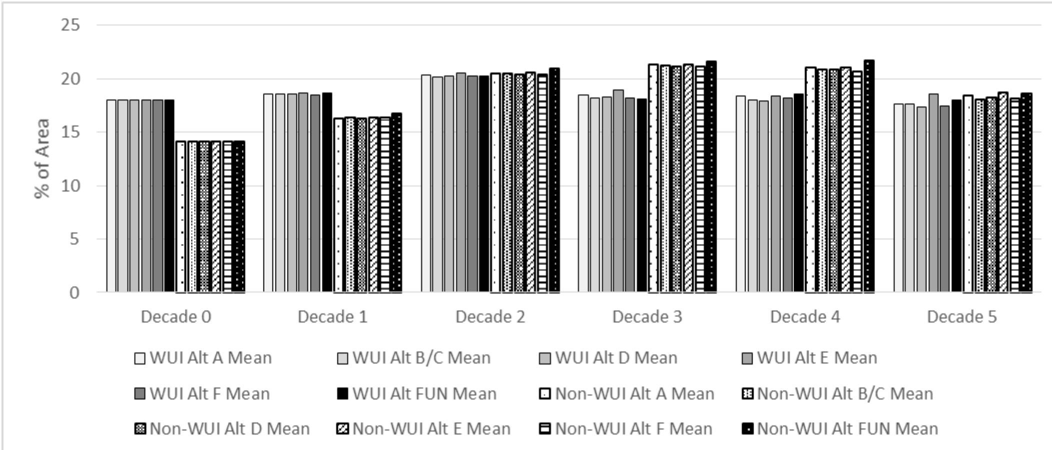


Figure 221. Two-storied vertical structure class in WUI versus non-WUI areas, forestwide

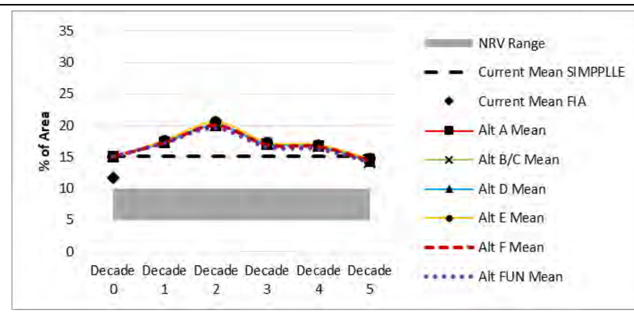
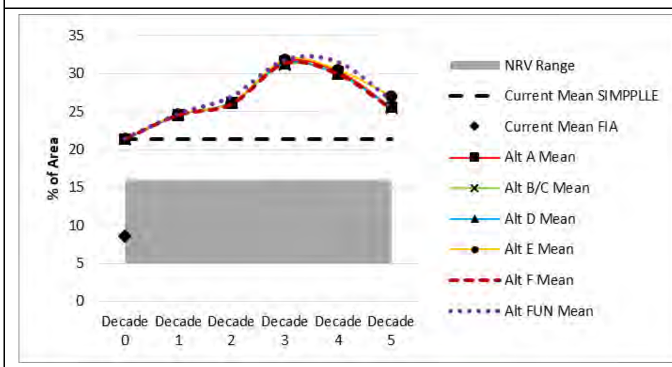
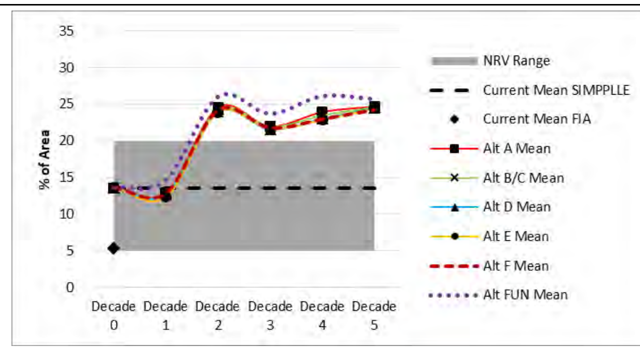
Forestwide	Warm Dry PVT
N/A	
Cool Moist PVT	**Cold PVT**
	

Figure 222. Two-storied vertical structure class (% of total area) over 5 decades by alternative, forestwide and by PVT

Multistoried

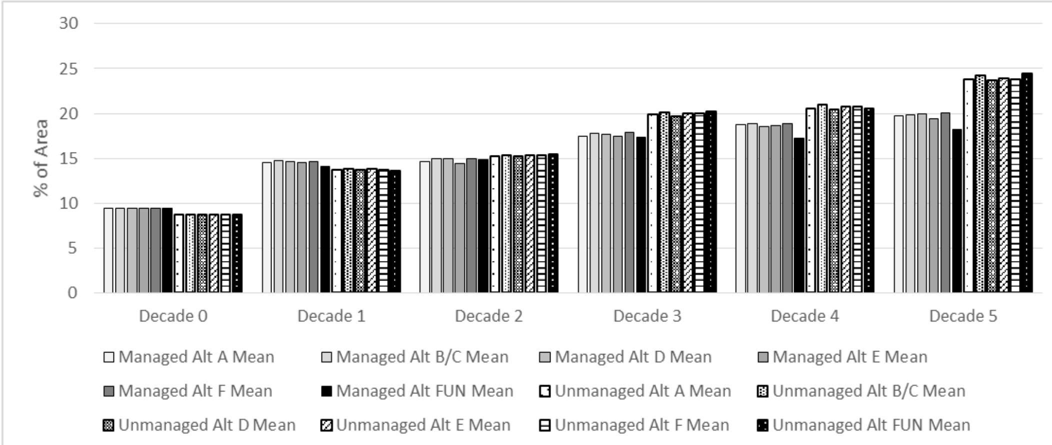


Figure 223. Multistoried vertical structure class in managed versus unmanaged landscapes, forestwide

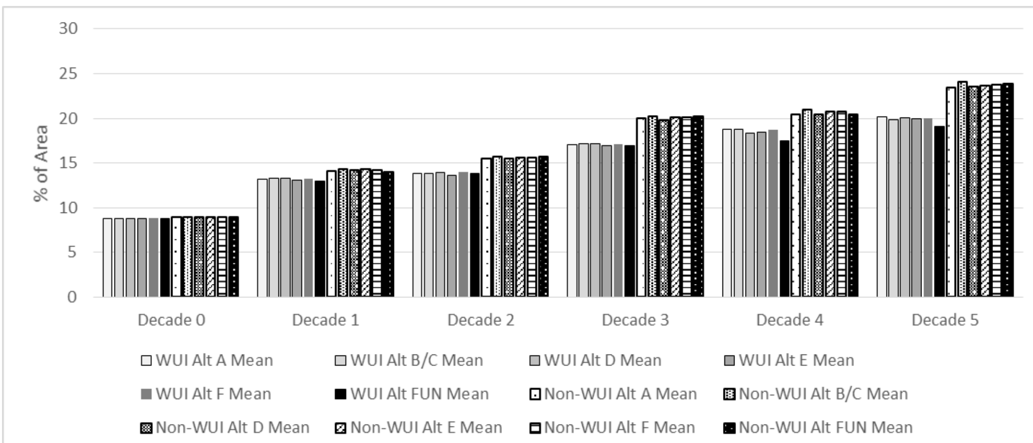


Figure 224. Multistoried vertical structure class in WUI versus non-WUI areas, forestwide

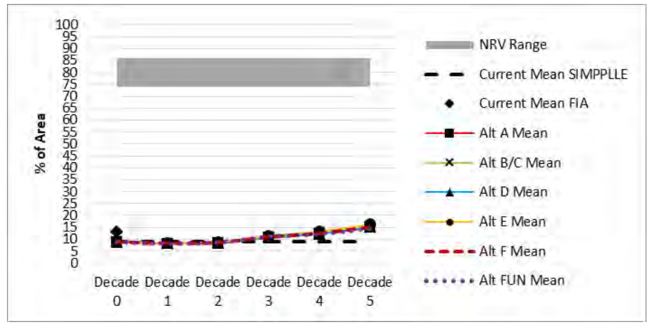
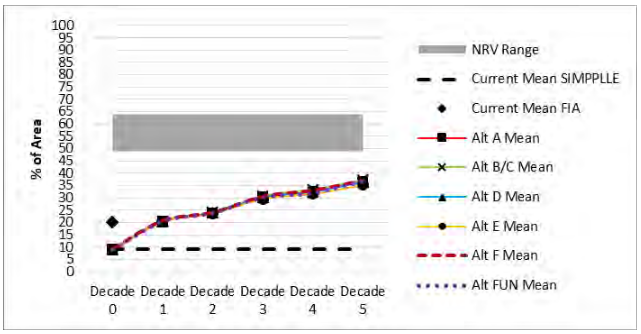
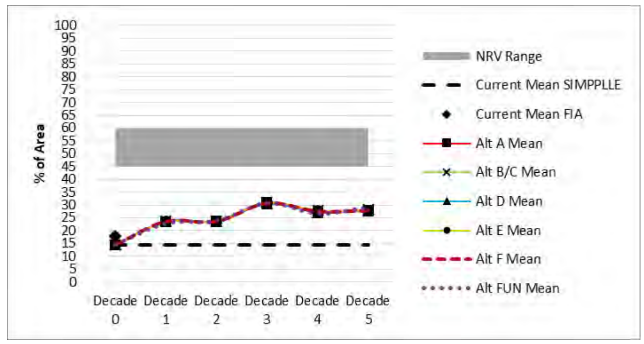
Forestwide	Warm Dry PVT
N/A	
Cool Moist PVT	**Cold PVT**
	

Figure 225. Multistoried vertical structure class (% of total area) over 5 decades by alternative, forestwide and by PVT

Landscape patch and pattern (early successional forest patches)

The average size (acres) of early successional forest patches is assessed. The first set of results below include seedling/sapling patches for as long as they remain in that size class.

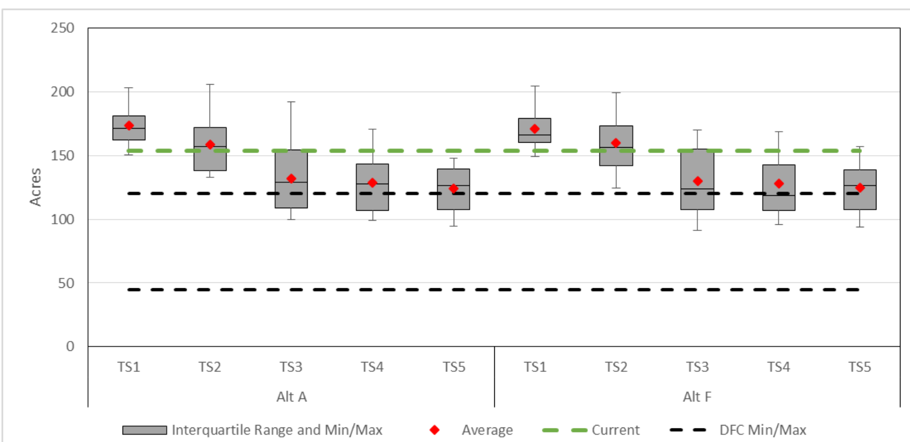


Figure 226. Early successional forest patches (average acres) over 5 decades, comparing alternatives A and F

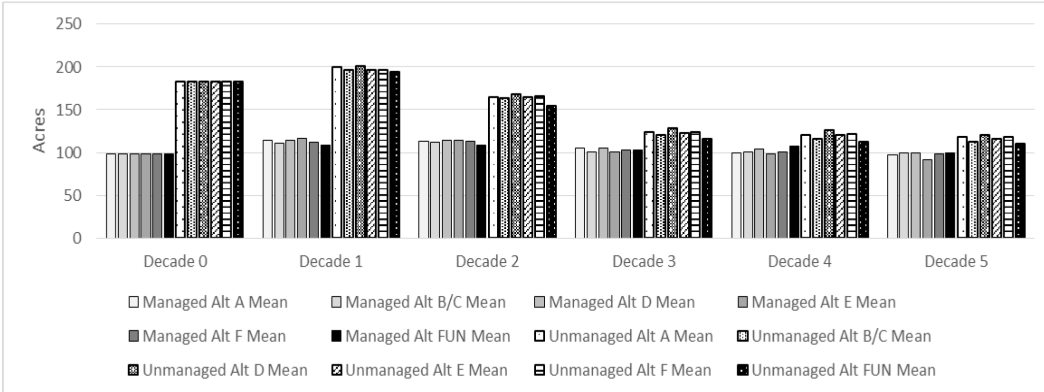


Figure 227. Early successional forest patches over 5 decades in managed versus unmanaged landscapes, forestwide

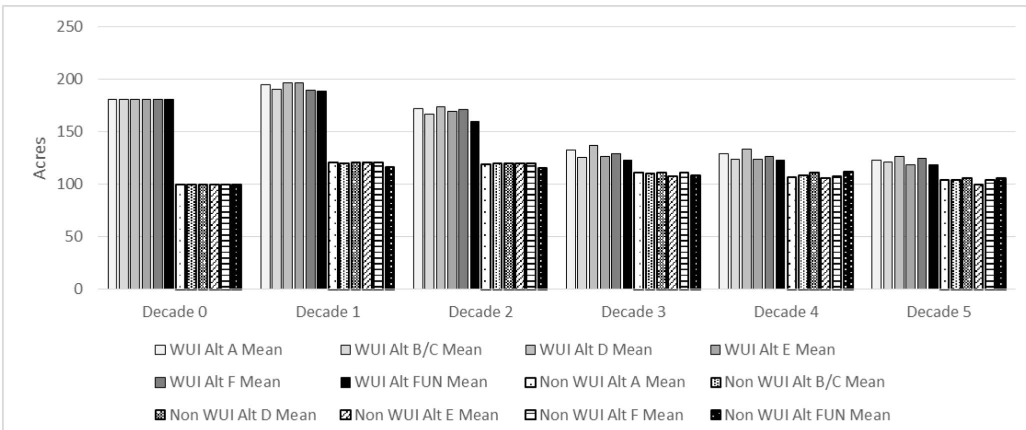


Figure 228. Early successional forest patches over 5 decades in WUI versus non-WUI landscapes, forestwide

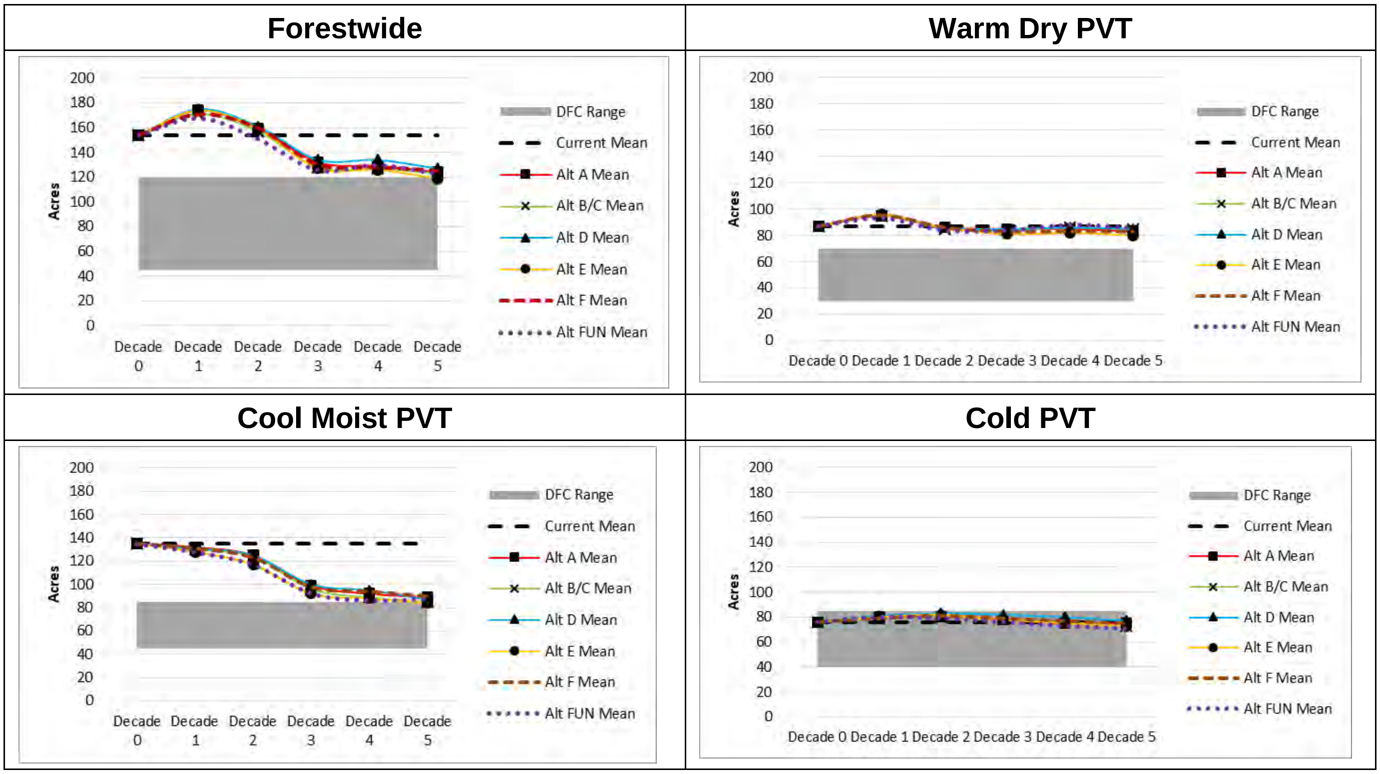


Figure 229. Early successional forest patches (average acres) over 5 decades by alternative, forestwide

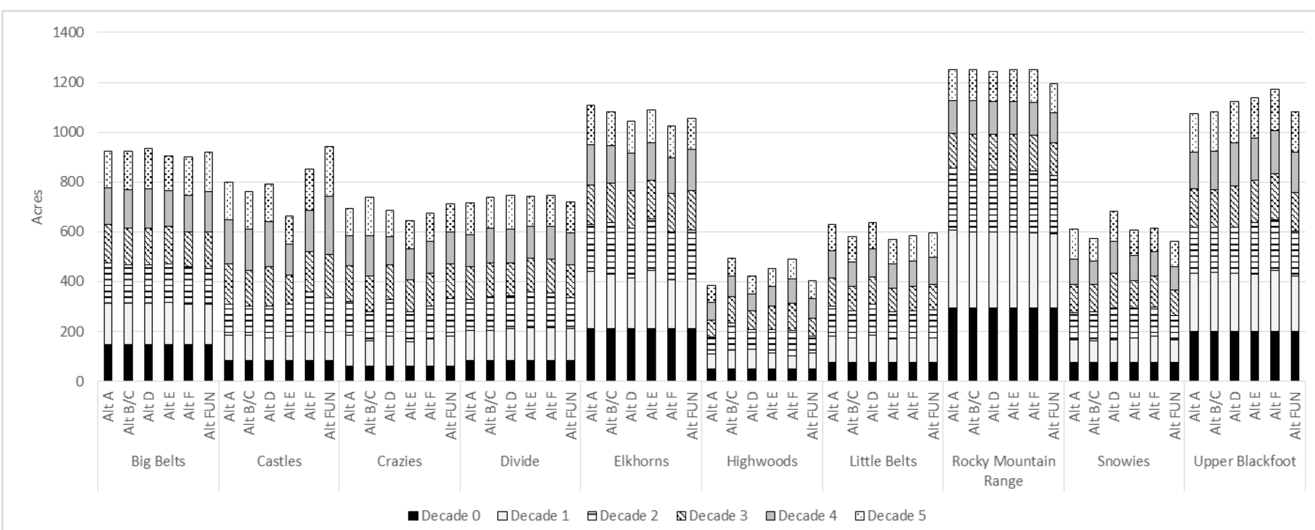
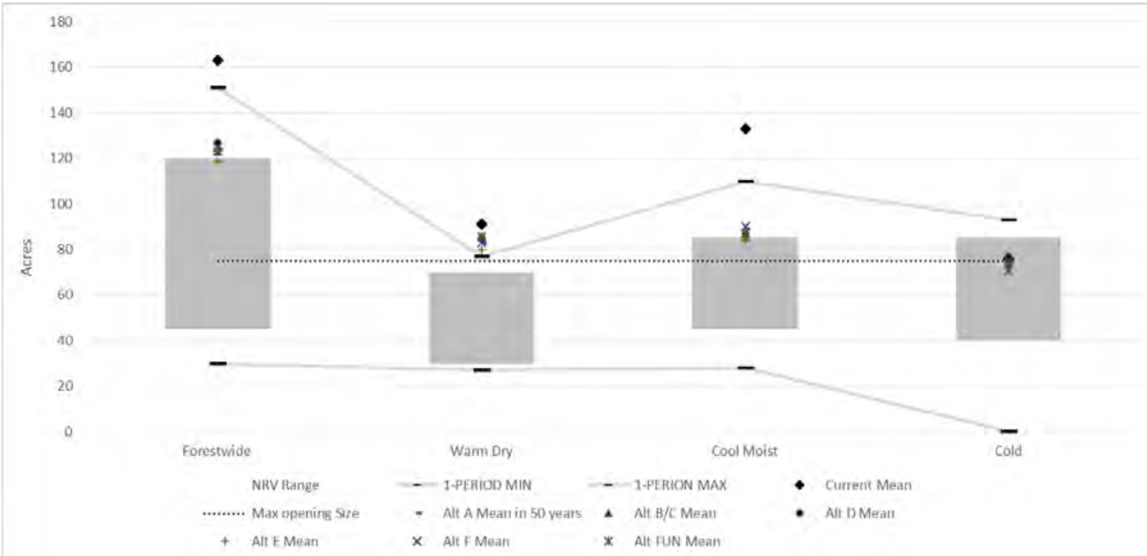


Figure 230. Early successional forest patches (average acres) over 5 decades by alternative and GA

The NRV analysis was also run with an assumption that forest openings would no longer be considered openings after 1 modeling period (10 years), once reforestation occurs, even though some of these patches would still be in the seedling/sapling size class. This analysis was used to inform FW-TIM-STD-08, the maximum opening size limit for even-aged regeneration harvest. The figure below displays the relationship between the two NRV ranges, along with the existing condition of early successional forest average patch sizes and predicted size in 50 years by alternative, and the maximum opening size limit.



This graphic displays the relationship between the NRV analysis for early successional forest patch sizes with the 75-acre limit (FW-TIM-STD-08), existing conditions, and projected conditions in 50 years by alternative. The gray columns indicate the NRV of patch sizes for as long as stands remain in a seedling/sapling condition. They gray lines with black bars indicate the NRV of patch sizes when openings are included for 1 decade (e.g., they are no longer considered openings after reforestation occurs); these ranges are slightly wider than the NRV of patches that are included until they progress out of the seedling/sapling stage. The black diamonds indicate the existing condition of patch sizes, and the other symbols depict the patch sizes in 50 years by alternative. The dashed line shows the opening size limit of 75 acres.

Figure 231. Early successional forest patches and maximum even-aged regeneration harvest openings

Special components: old growth, snags, and coarse woody debris

Old growth cannot be explicitly modeled. However, SIMPPLLE was used to estimate the abundance of large and very large forest size classes. As described in the methodology section, the proportions of large-tree structure show correlation to areas that are most likely to be old growth. The figures in the large-tree structure section show the anticipated trend of this condition as a proxy indicator for the potential expected trend of old growth. Snags and coarse woody debris cannot be modeled into the future with SIMPPLLE. The future effects to these attributes are addressed qualitatively in the EIS.

Wildlife habitat

Elk

The following series of figures display the SIMPPLLE modeling results for elk hiding cover for each alternative, over a 50-year analysis period, to supplement the information and conclusions presented in the body of the EIS. The figures include forestwide averages, and GA averages. Results and charts for each Elk Analysis Unit are available in the project record.

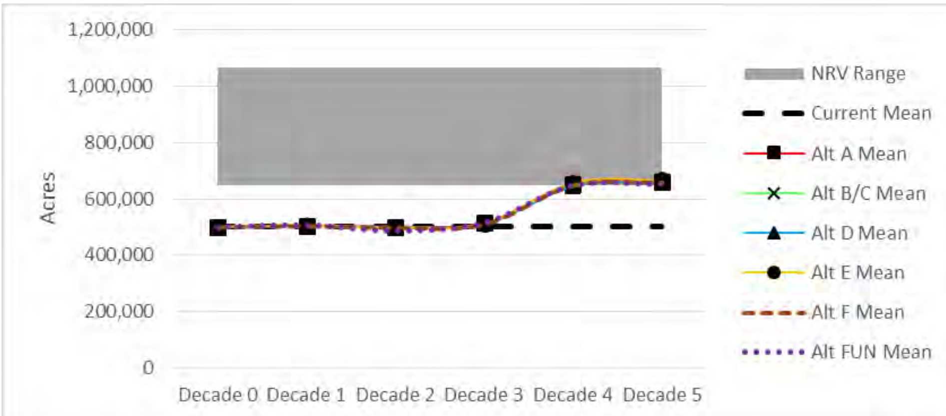
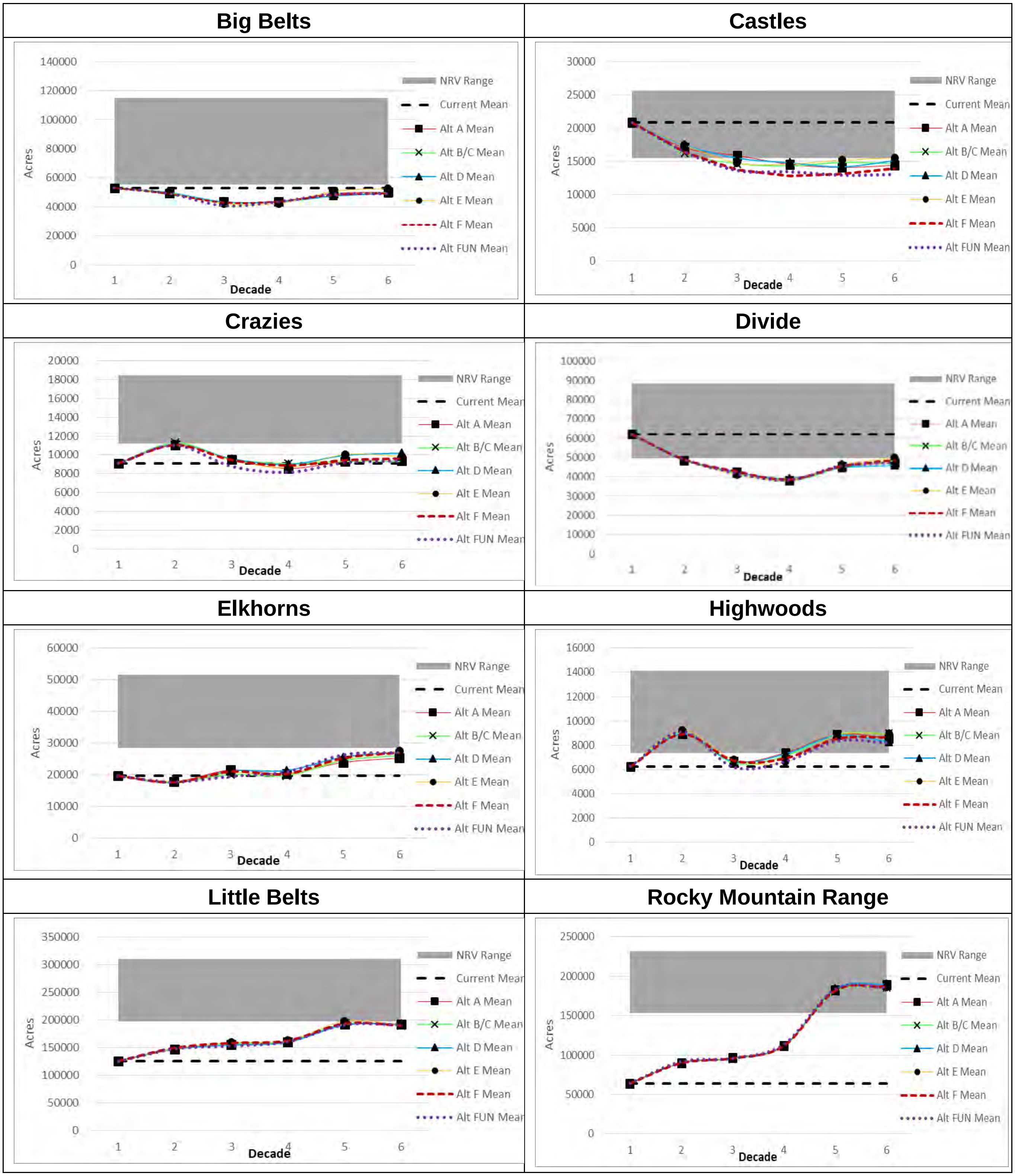
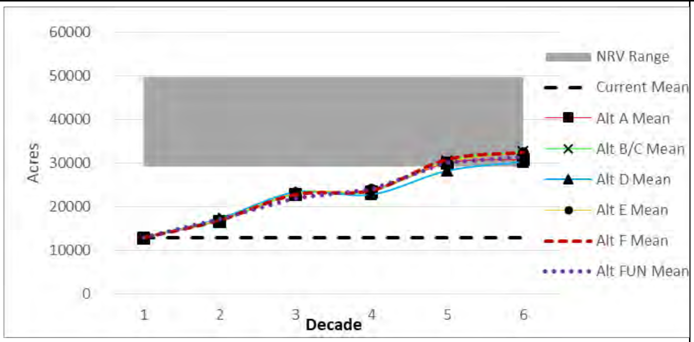
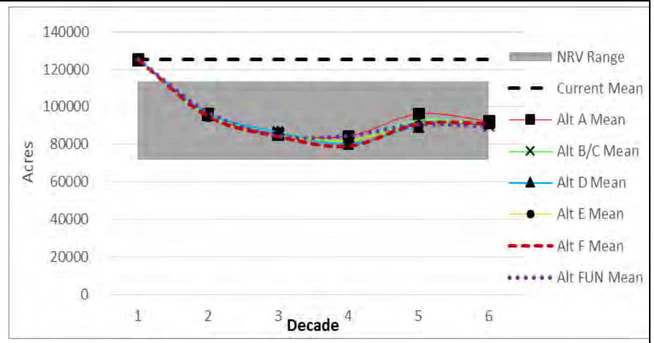


Figure 232. Elk spring/summer/fall hiding cover forestwide over time by alternative

Figure 233. Elk spring/summer/fall hiding cover over time by alternative, by GA



Snowies	Upper Blackfoot
	

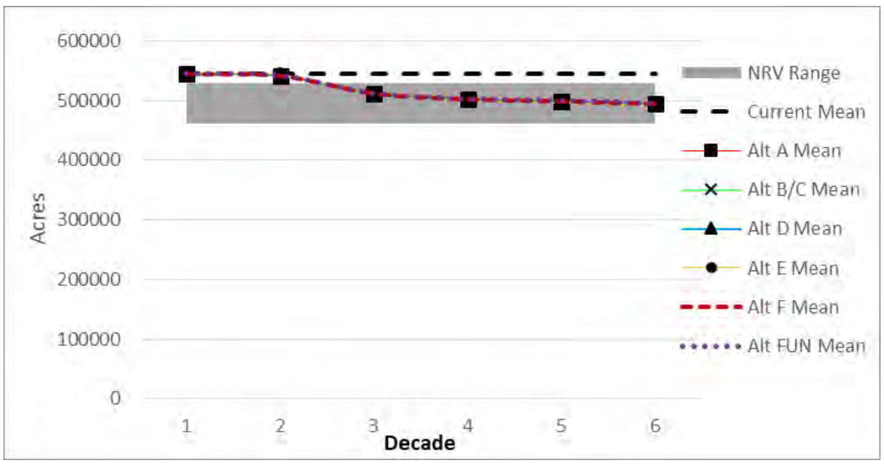
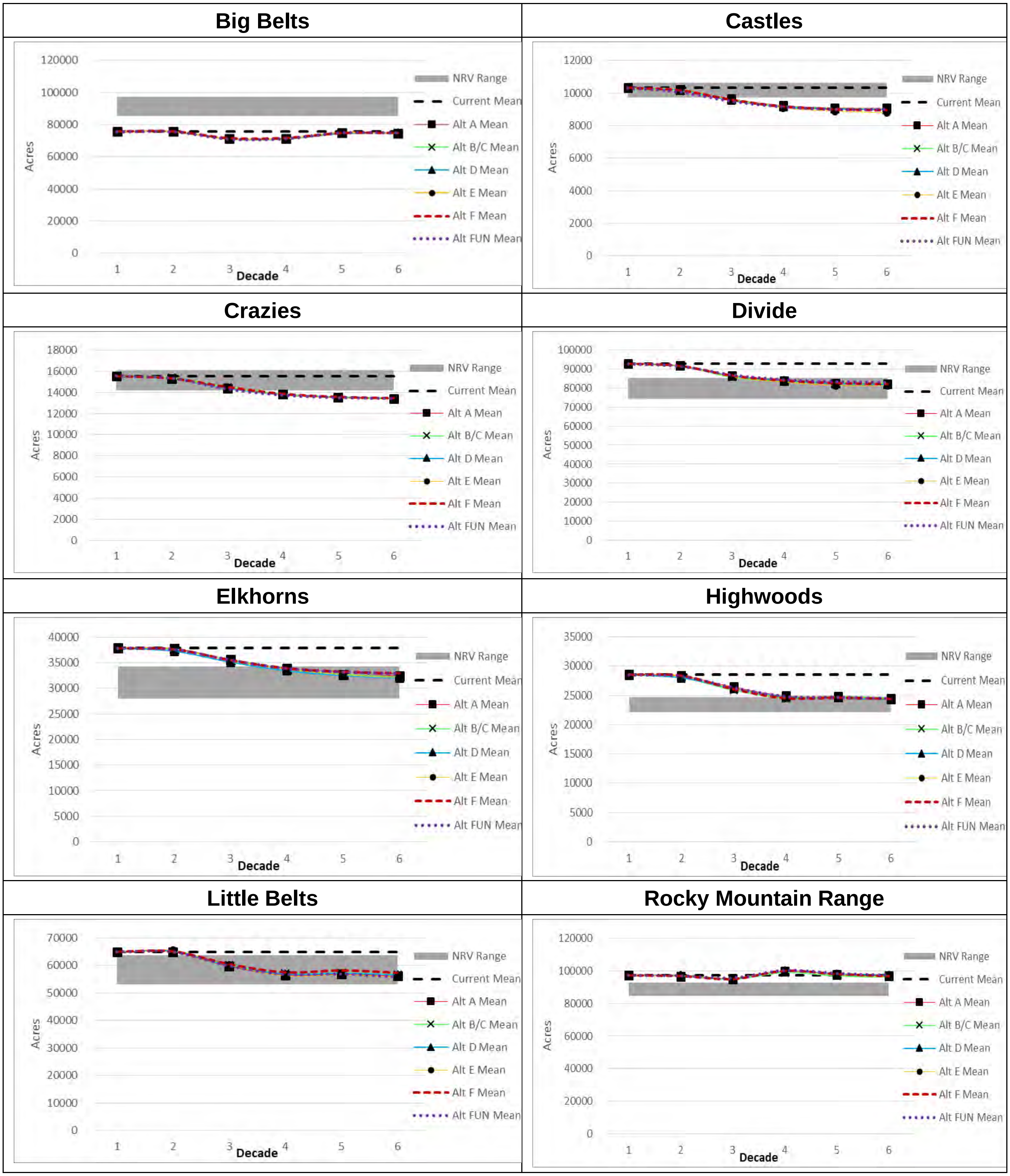
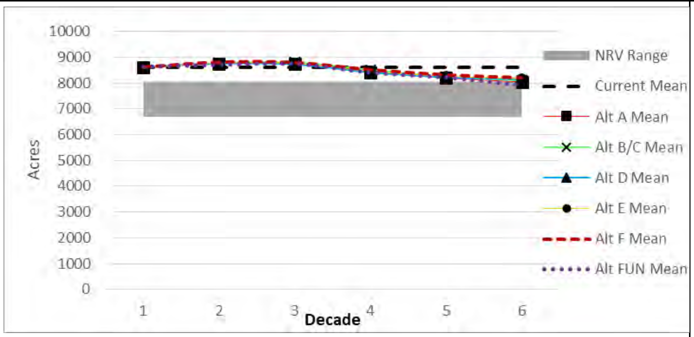
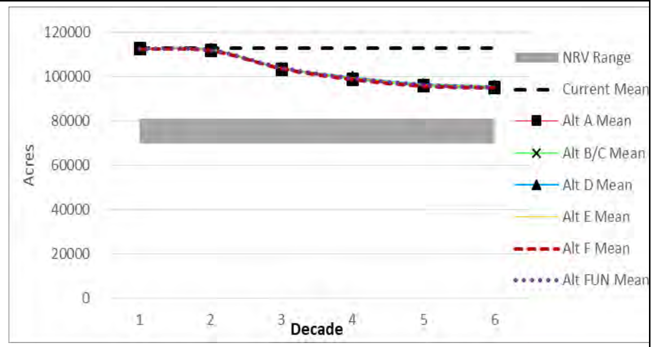


Figure 234. Elk winter hiding cover over time by alternative forestwide

Figure 235. Elk winter habitat by GA over time by alternative, by GA



Snowies	Upper Blackfoot
	

Flammulated owl

Flammulated owl nesting habitat remains generally below or at the low end of the NRV range at most scales of analysis, although the expected trends vary by GA.

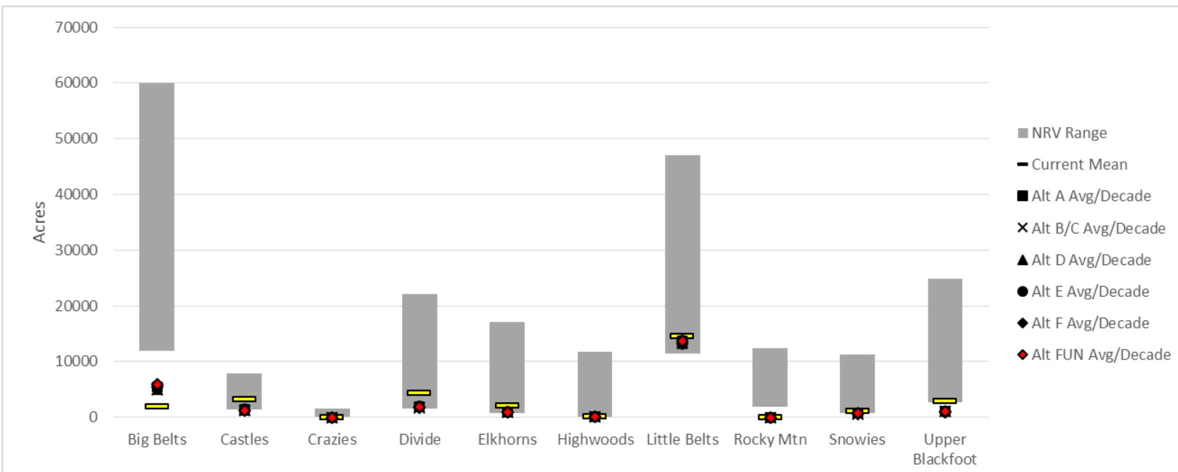


Figure 236. Flammulated owl nesting habitat, average acres/decade for 50 years by alternative

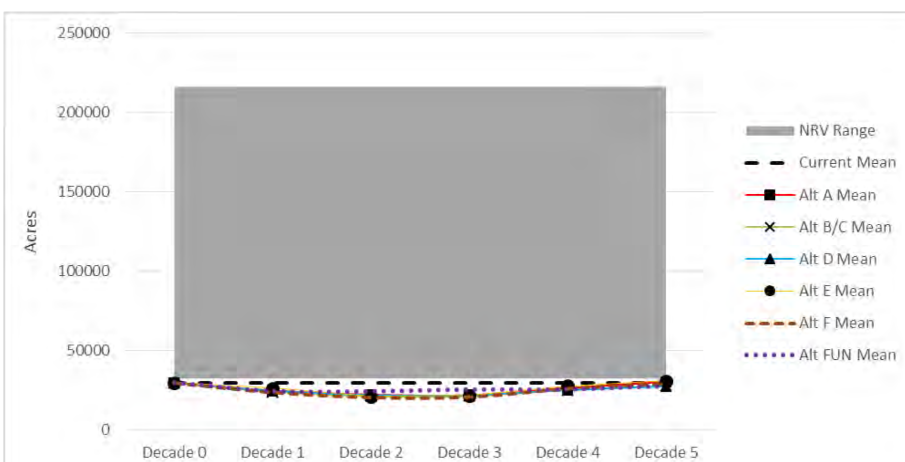
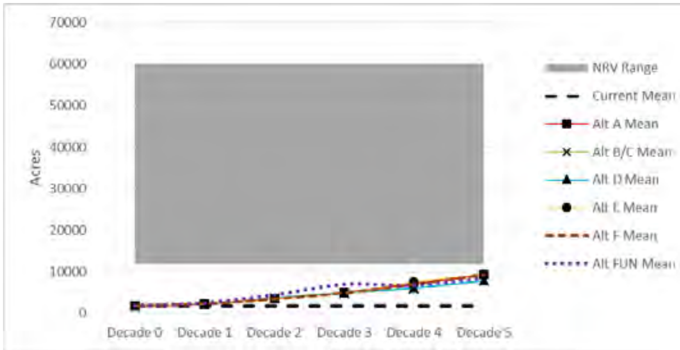


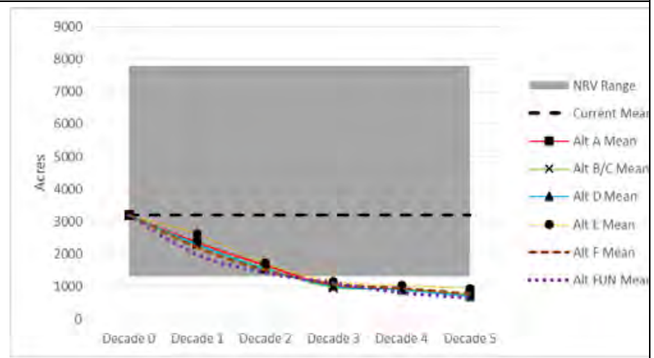
Figure 237. Flammulated owl nesting habitat over time by alternative forestwide

Figure 238. Flammulated owl nesting habitat over time by alternative, by GA

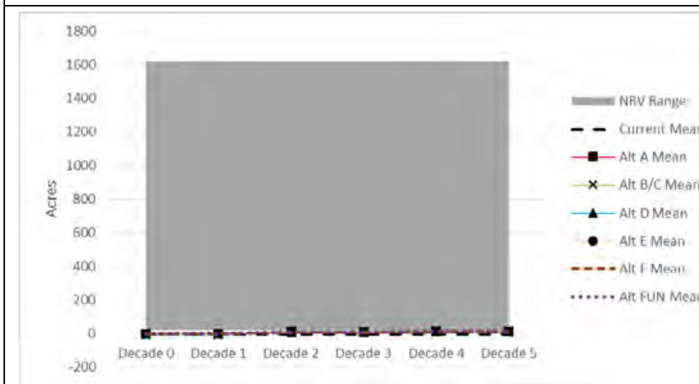
Big Belts



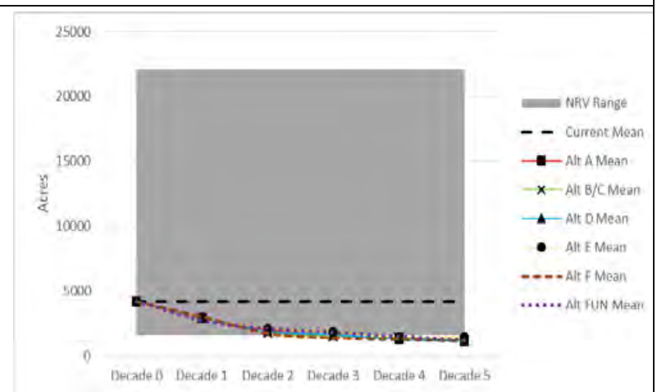
Castles



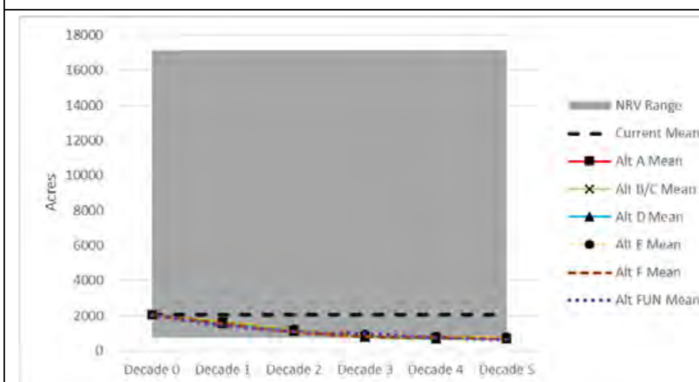
Crazies



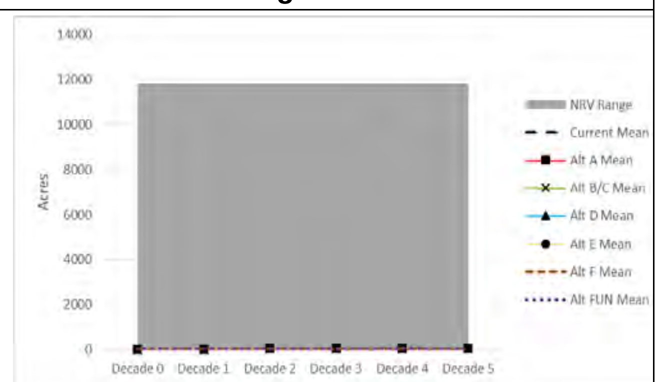
Divide



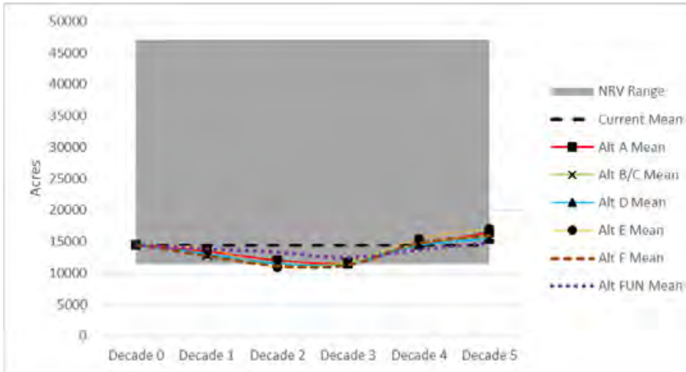
Elkhorns

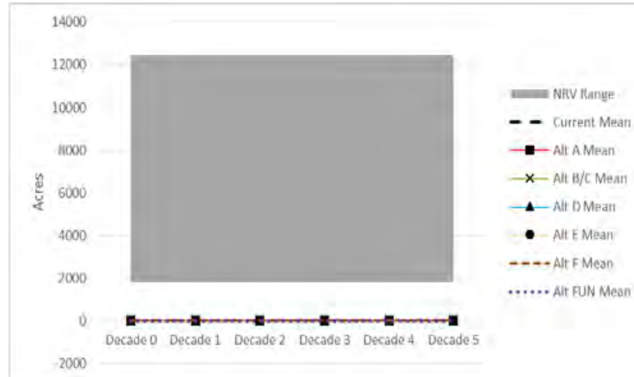


Highwoods

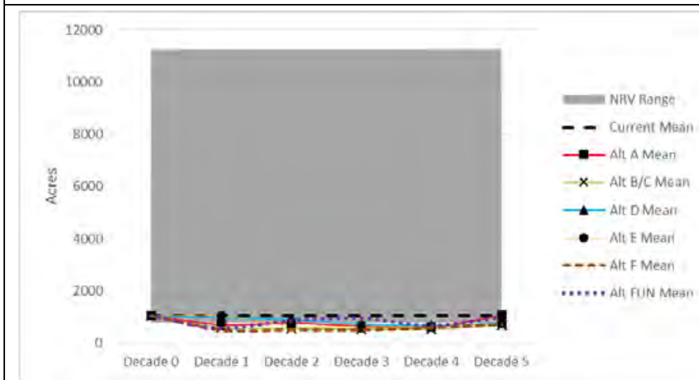


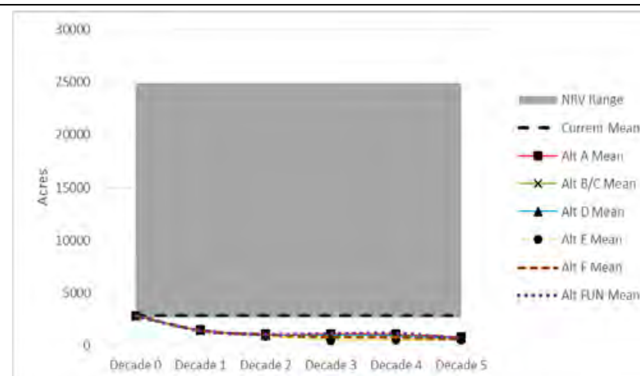
Little Belts	Rocky Mountain Range





Snowies	Upper Blackfoot





Lewis's woodpecker

Generally, this habitat condition increases and/or is maintained within the NRV range at all scales of interest. There is some variance by alternative at the GA scale, indicating that this habitat may be sensitive to influence by vegetation management.

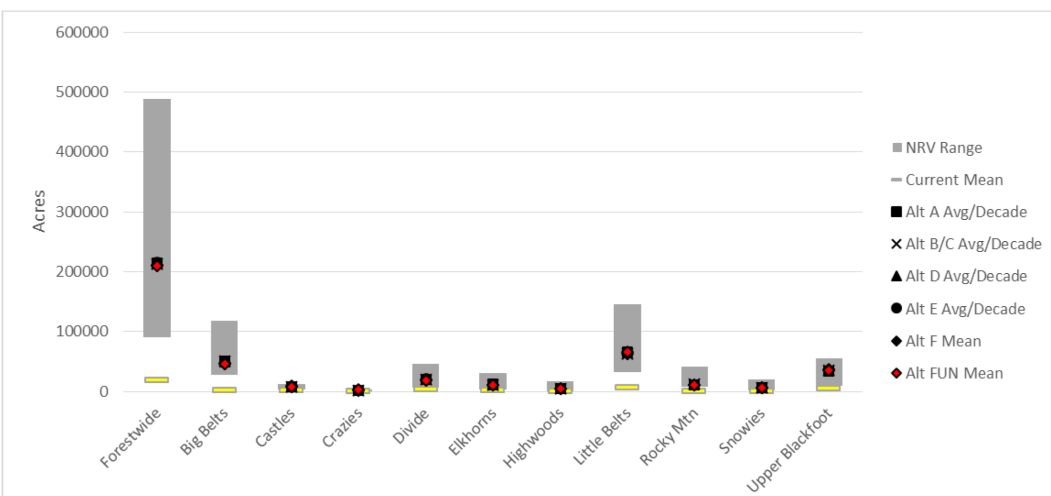


Figure 239. Lewis's woodpecker nesting habitat average acres/decade over 50 years by alternative

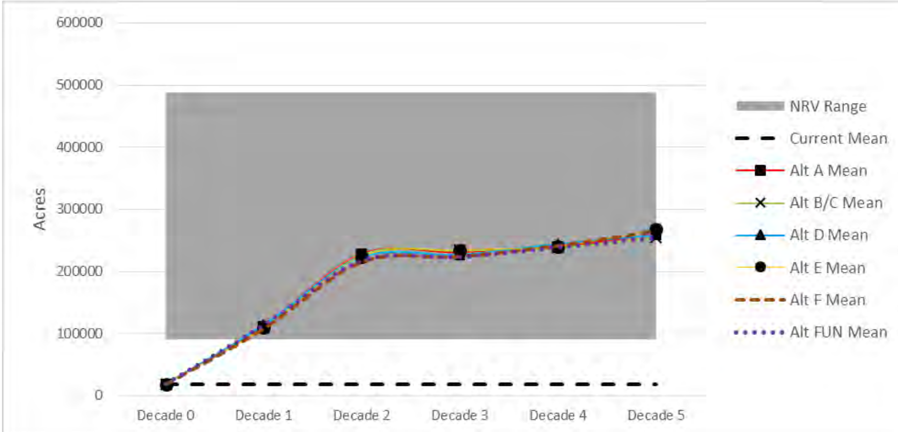
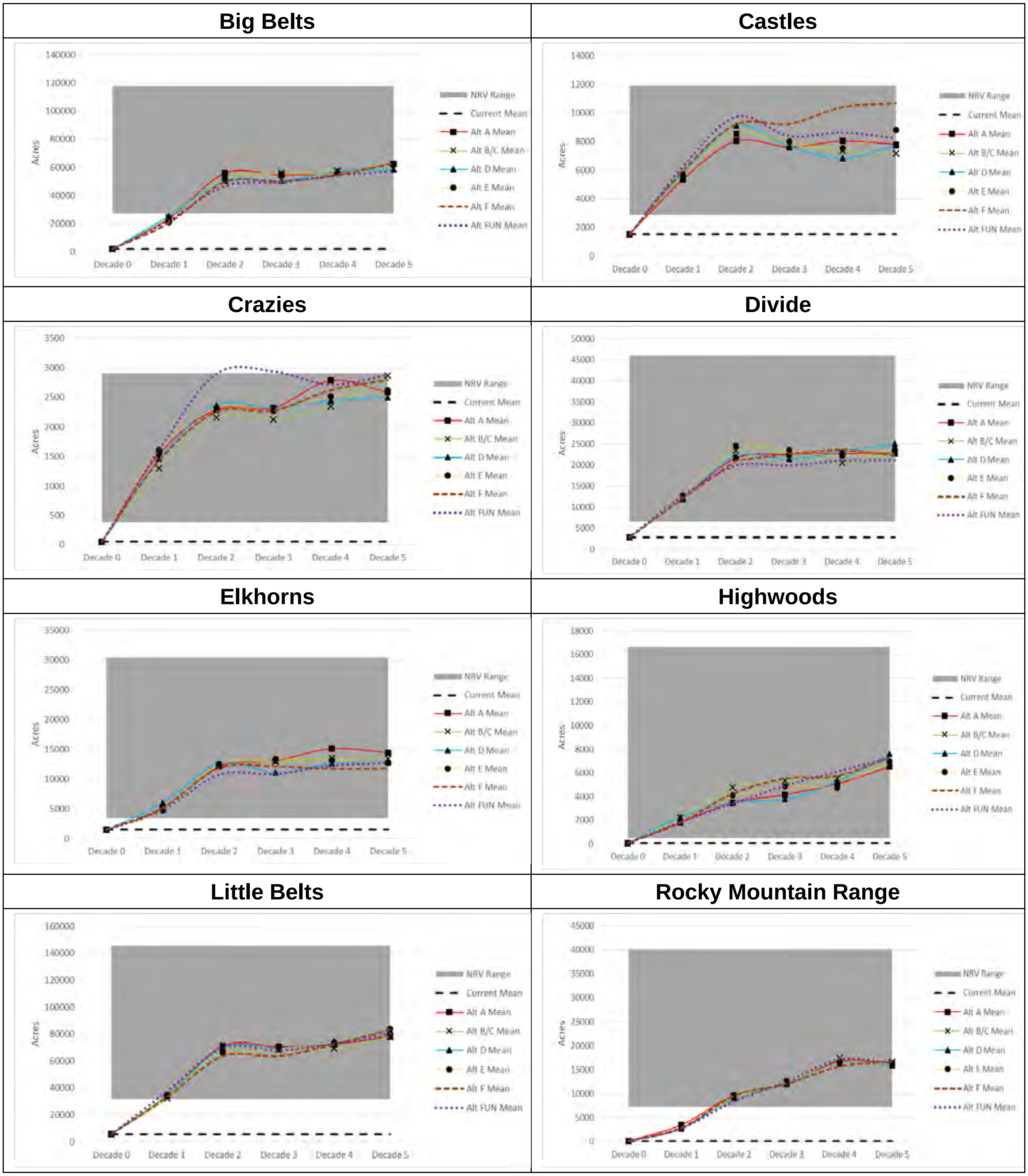
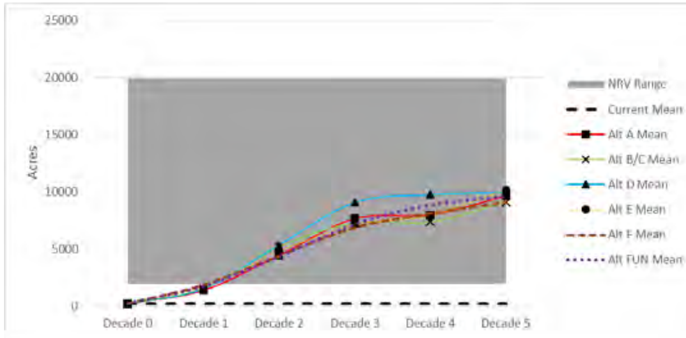


Figure 240. Lewis's woodpecker nesting habitat forestwide over time by alternative

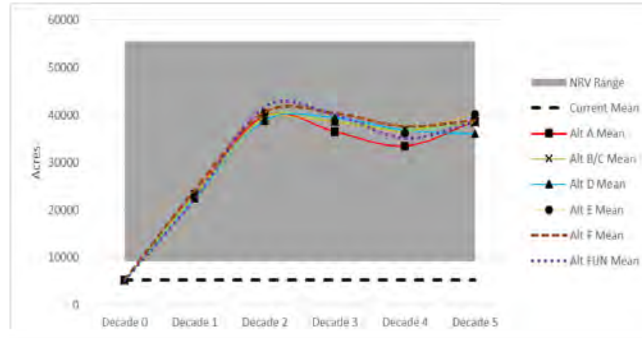
Figure 241. Lewis's woodpecker nesting habitat over time by alternative, by GA



Snowies



Upper Blackfoot



Canada lynx

There is no potential lynx habitat within the Highwoods GA, and therefore no results are shown for that area. "Other" habitat is the remainder of potential habitat that does not meet one of the other habitat criteria; it is not explicitly shown in the figures below. The FEIS and updated NRV lynx modeling results vary from what was disclosed in the DEIS and NRV analysis for several reasons: the potential lynx habitat for the HLC NF was updated; the model input file was updated to reflect changes in vegetation conditions caused by recent fires and management; and several model query errors were corrected.

Stand Initiation

This habitat is limited under warm/dry climate because the model assumes that reforestation will tend to be more open and not gain the high densities needed to qualify as stand initiation habitat. In addition, western spruce budworm activity may be reducing or maintaining lower density classes. The chart below shows the level of this habitat condition, as a percentage of potential lynx habitat, averaged across the 50 year analysis period. These averages are generally within NRV, and generally above the existing condition (likely due to fire). There are negligible difference in alternatives.

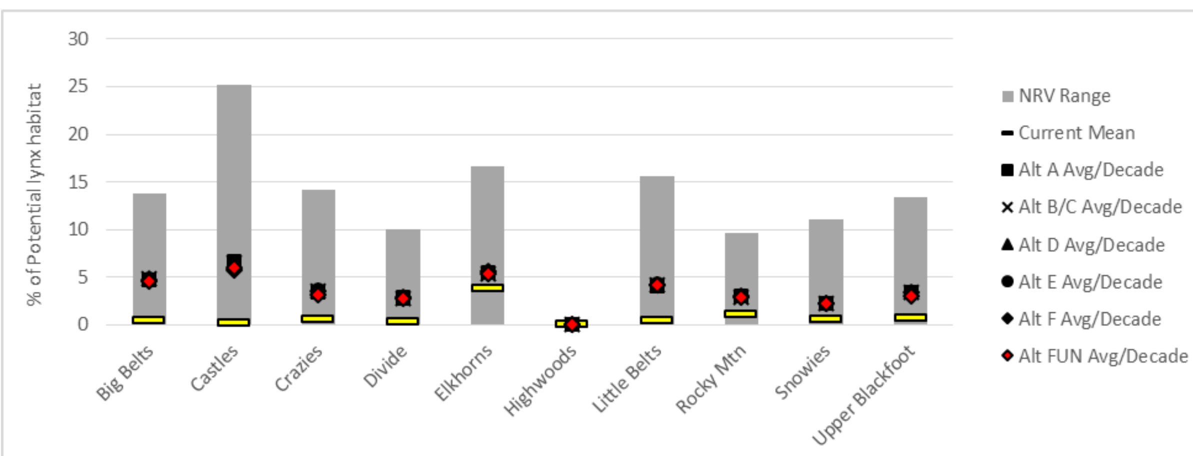
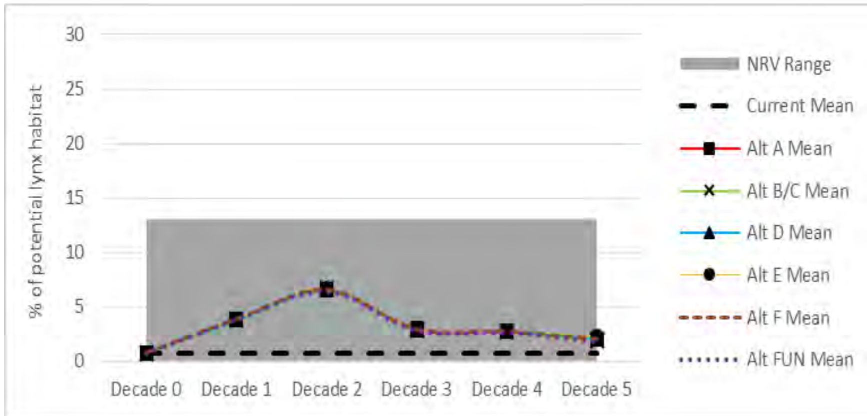
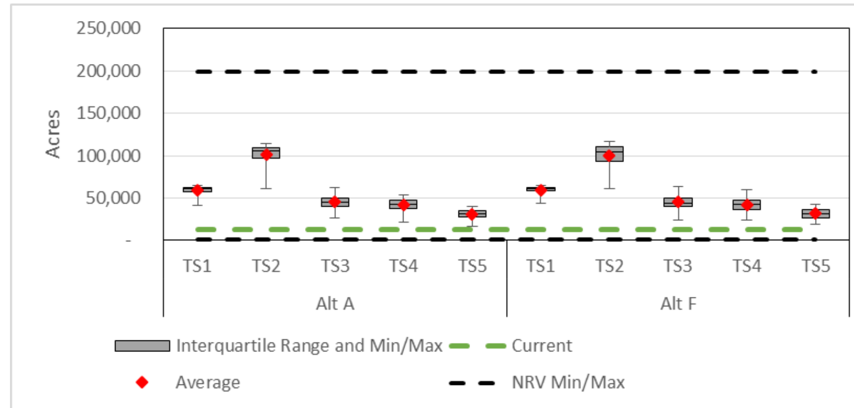


Figure 242. Average amount of stand Initiation Canada lynx habitat across 5 decades, by alternative and GA

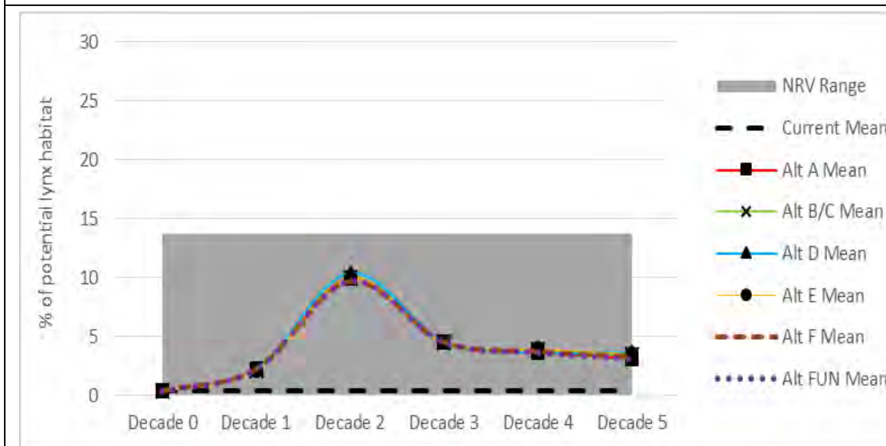
Figure 243. Stand initiation Canada Lynx habitat over 5 decades, by alternative and analysis scale

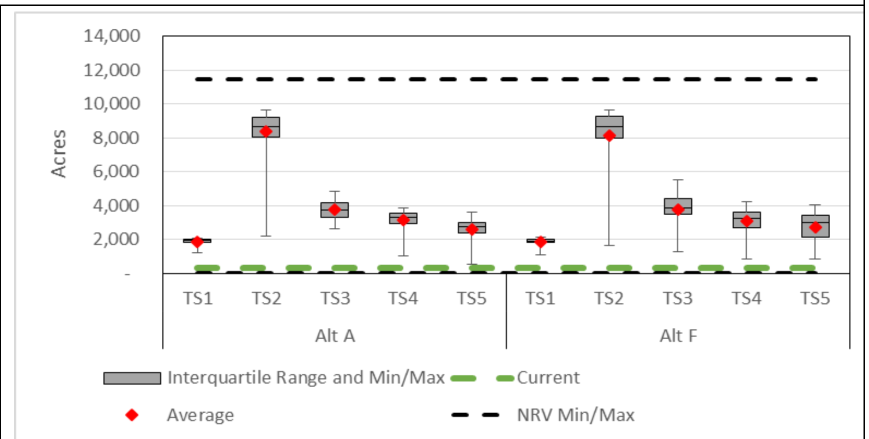
Forestwide



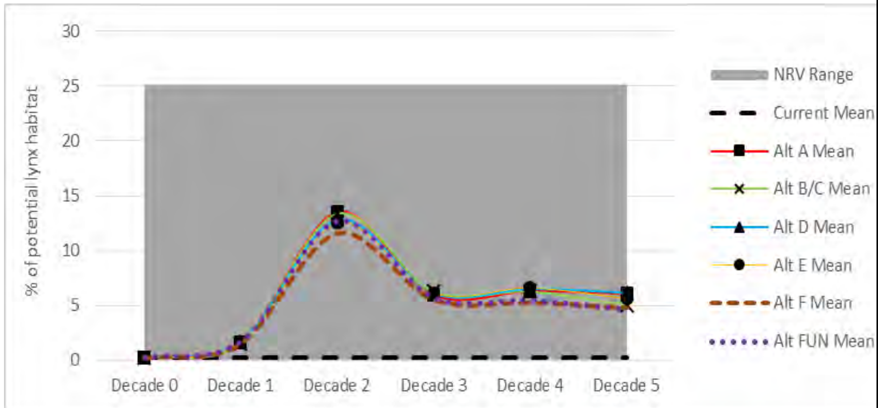


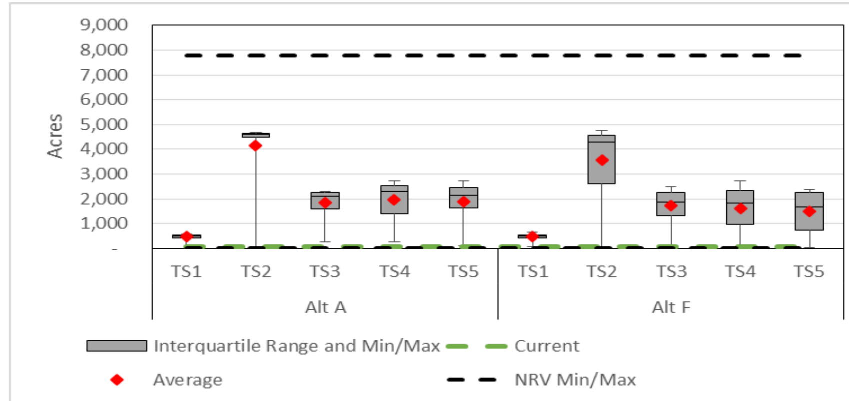
Big Belts



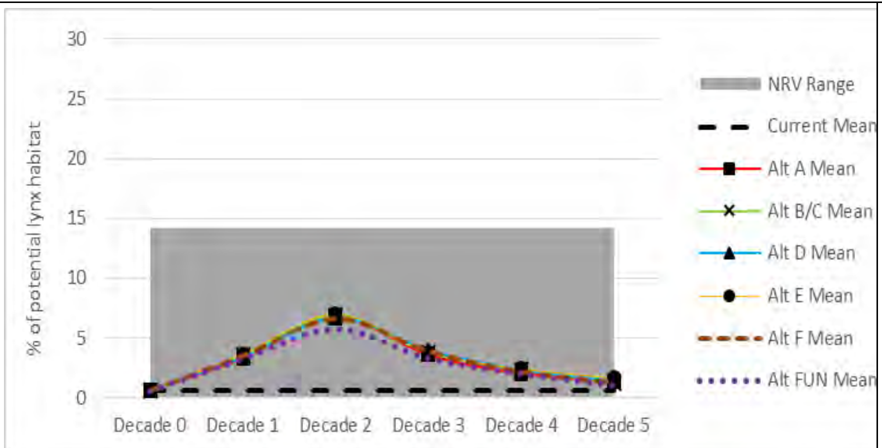


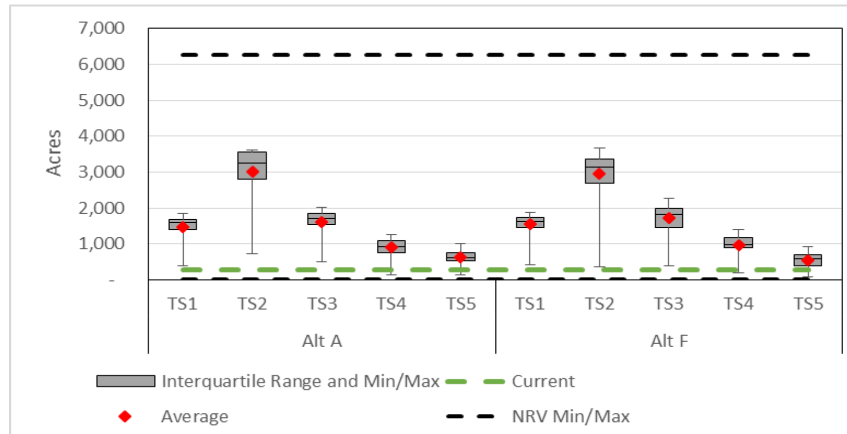
Castles





Crazies





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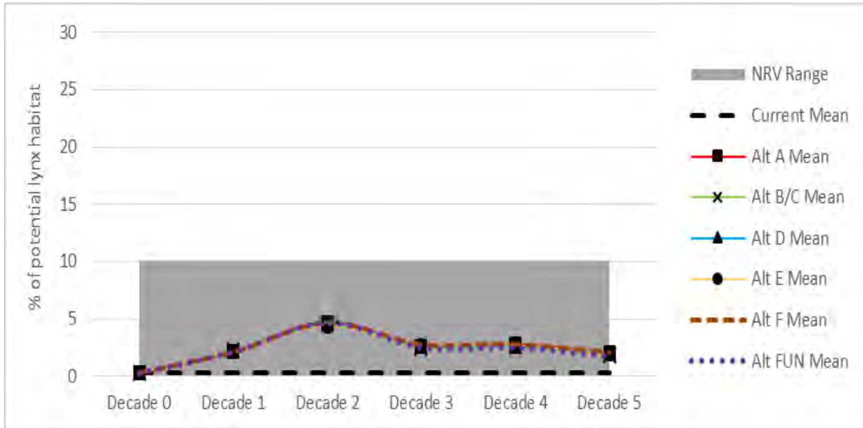
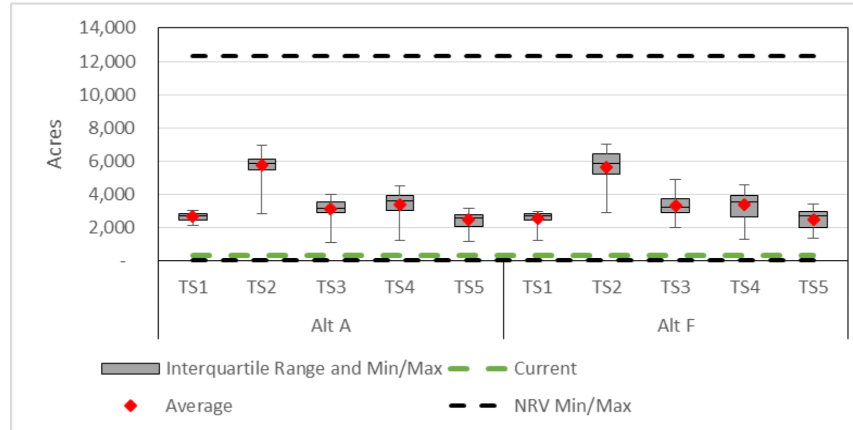
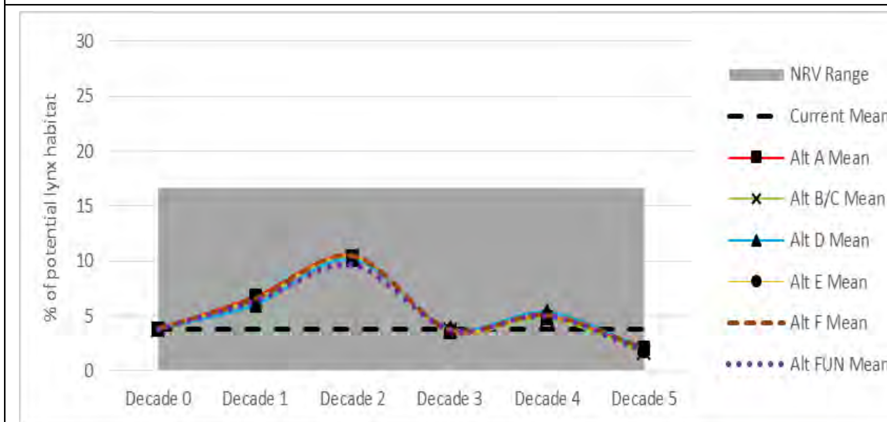
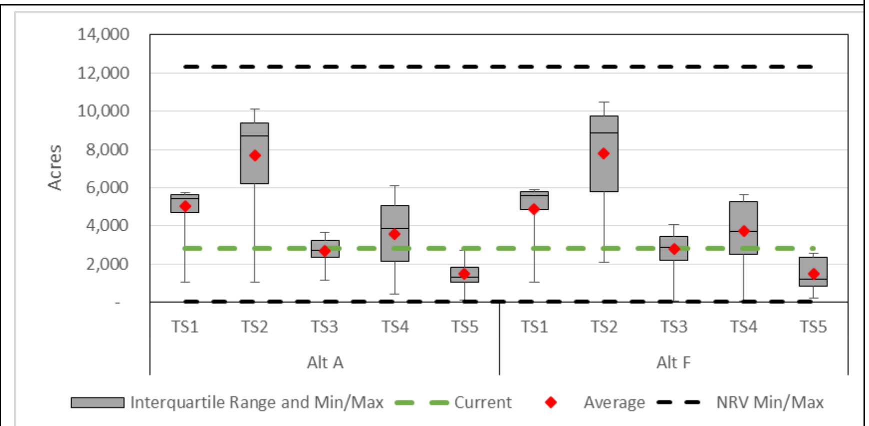


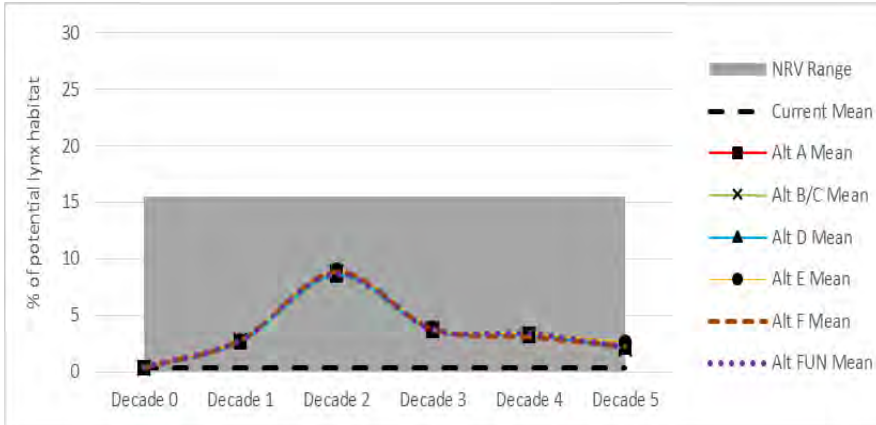


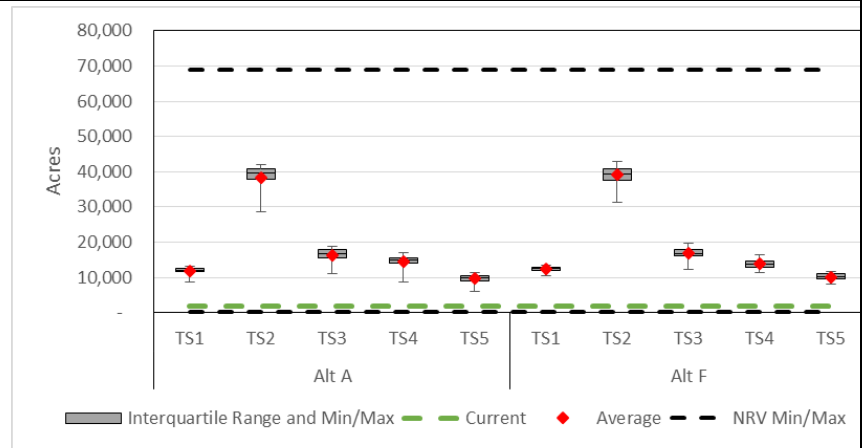
Elkhorns



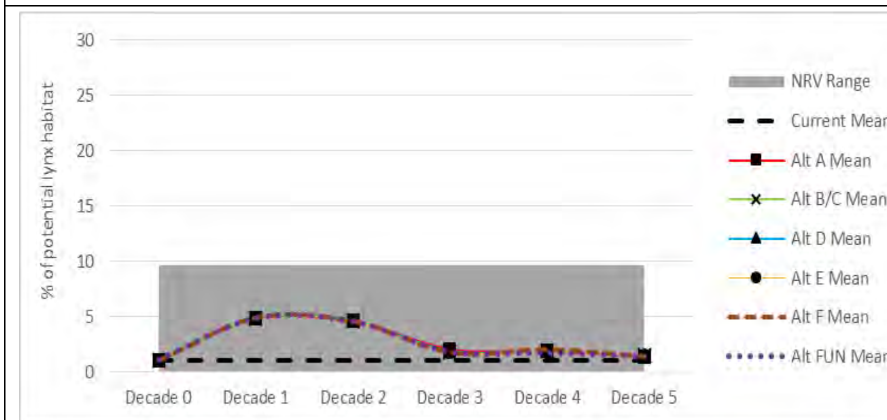


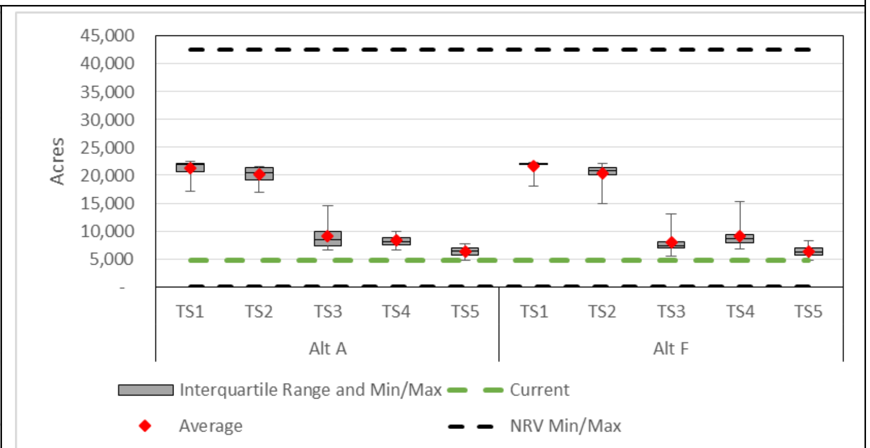
Little Belts



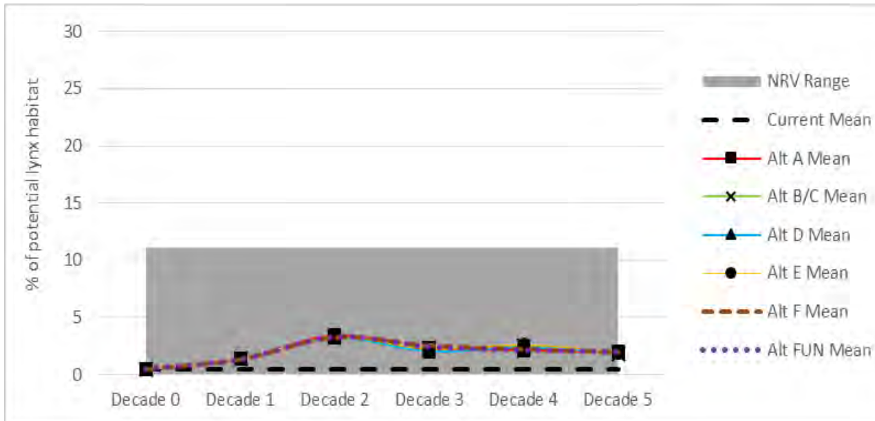


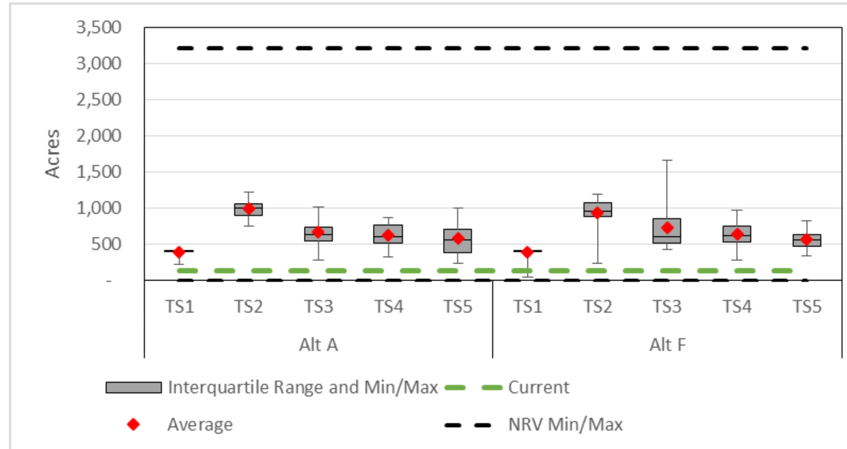
Rocky Mountain Range



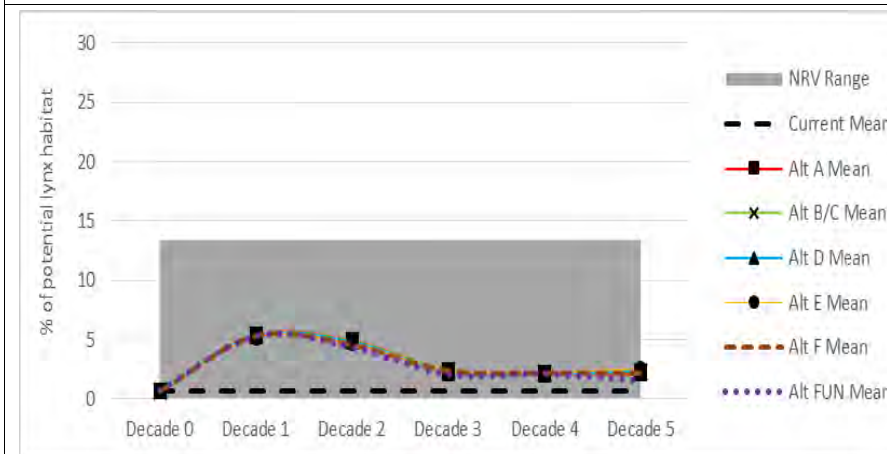


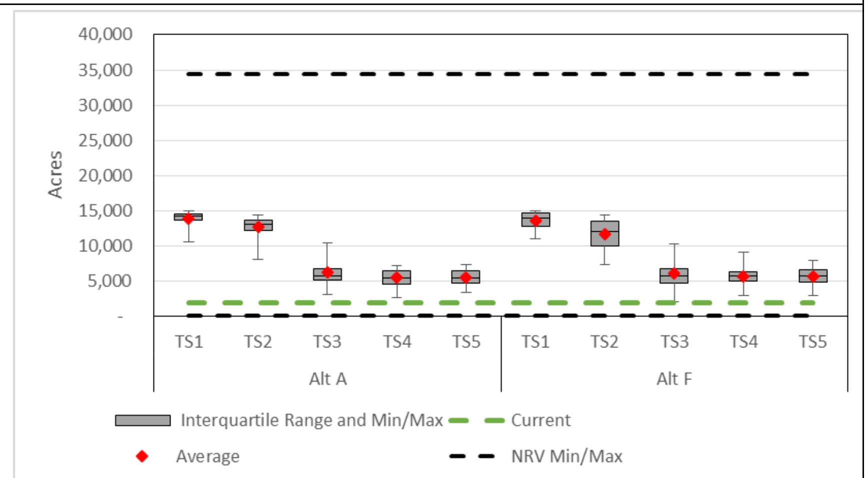
Snowies





Upper Blackfoot





Early stand initiation

In some GAs which are currently unoccupied, the extent of this habitat condition increases above the NRV. This trend is not evident in the forestwide average because of the large contribution in acres found in the large Rocky Mountain Range and Upper Blackfoot GAs, which are elevated now due to recent fire but decline over time toward the desired range. In some GAs, there is some variation across alternatives, although in most cases the magnitude is minor. The chart below shows the level of this habitat condition, as a percentage of potential lynx habitat, averaged across the 50 year analysis period. These averages are generally at the upper end or above the NRV, and there are some difference by alternative.

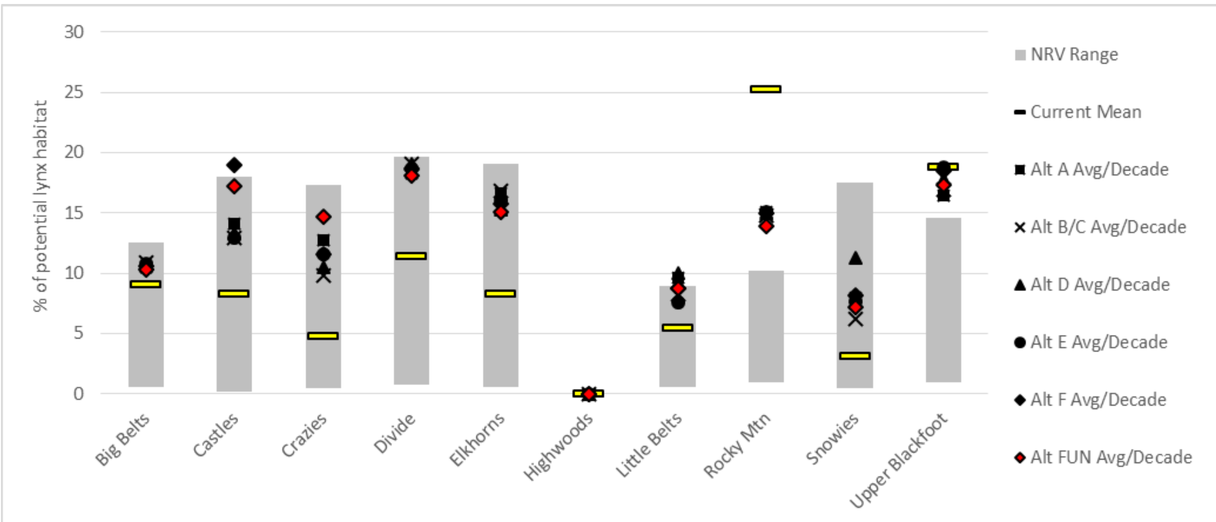
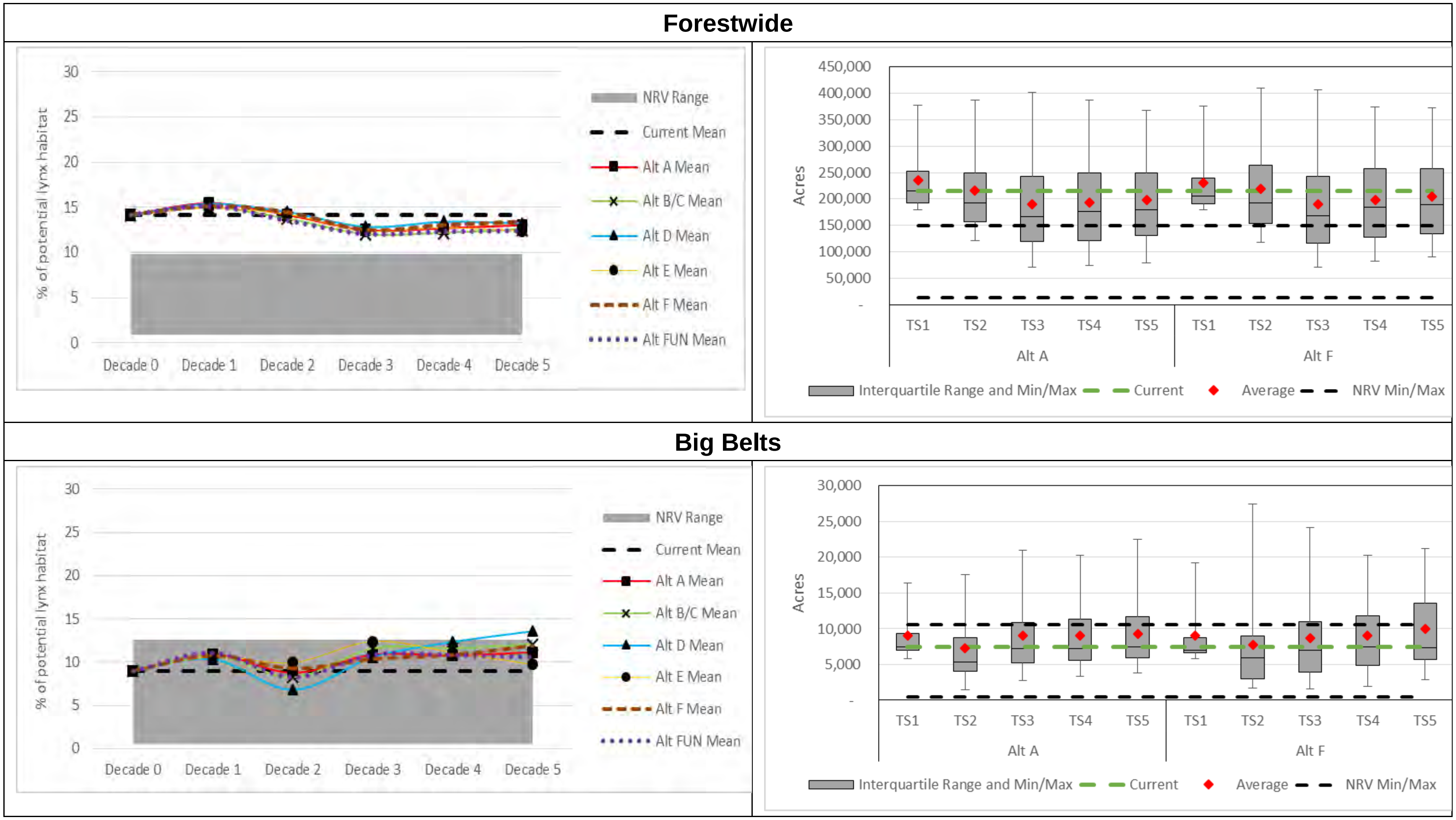
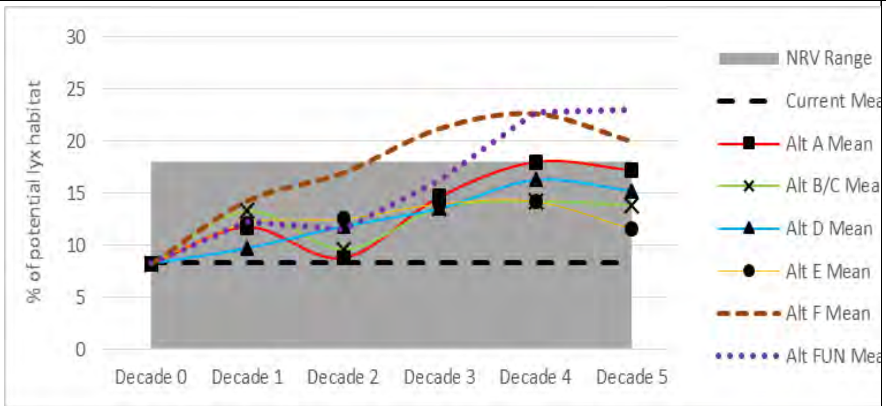


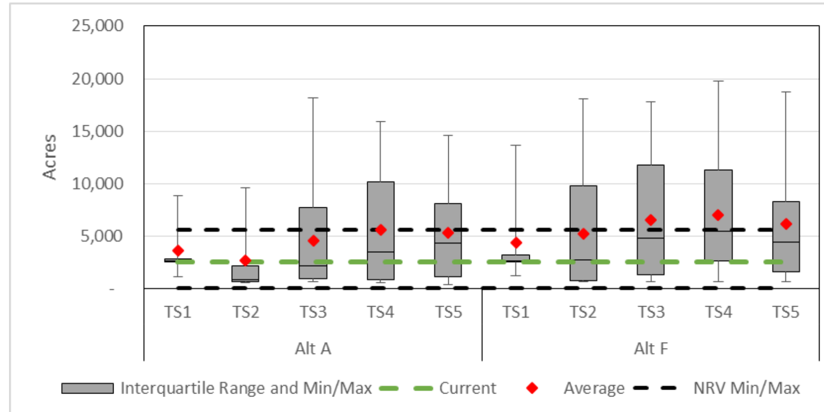
Figure 244. Early stand initiation Canada lynx habitat across 5 decades, by alternative and GA

Figure 245. Early stand initiation Canada Lynx habitat over 5 decades, by alternative and analysis scale

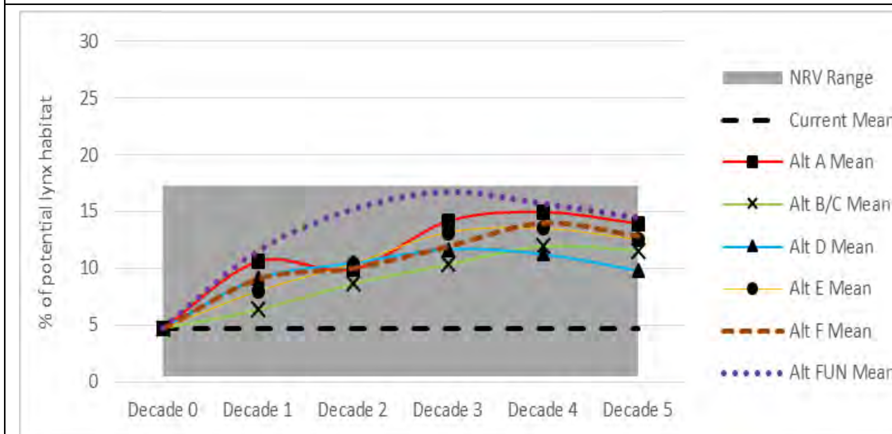


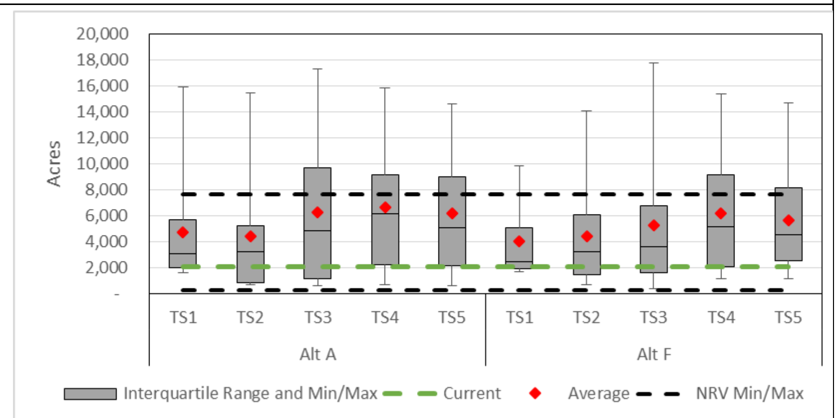
Castles



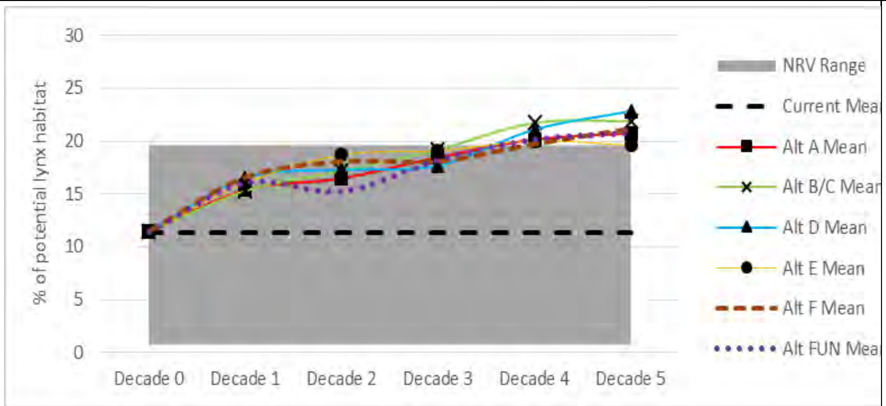


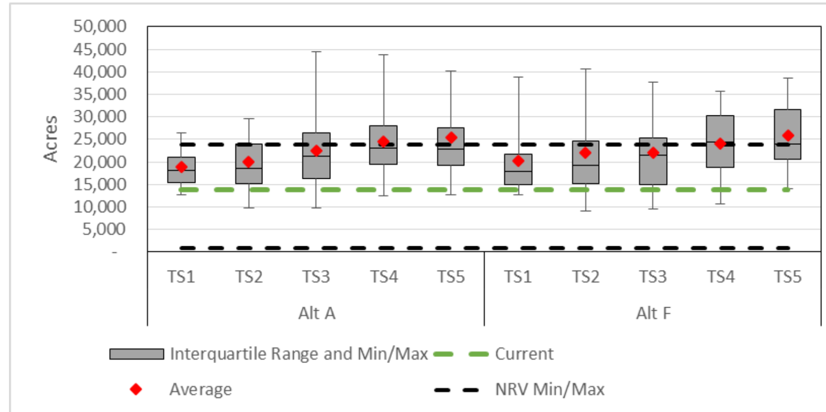
Crazies



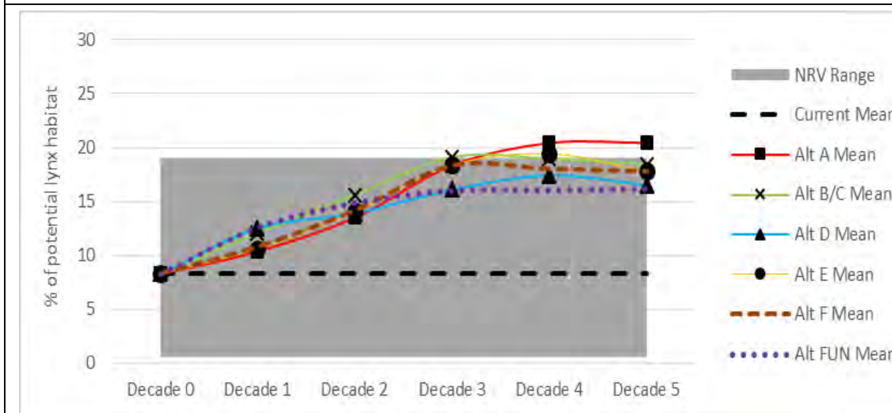


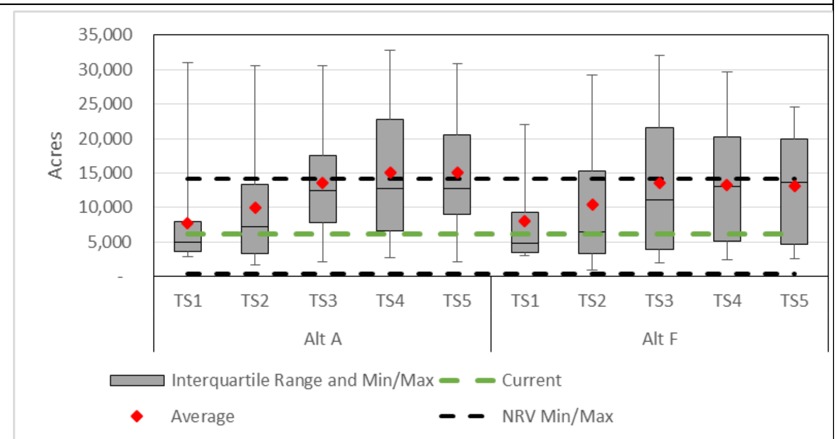
Divide



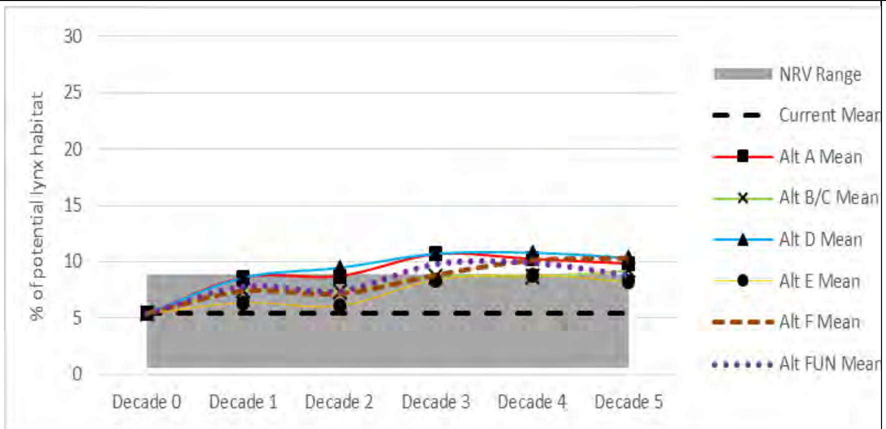


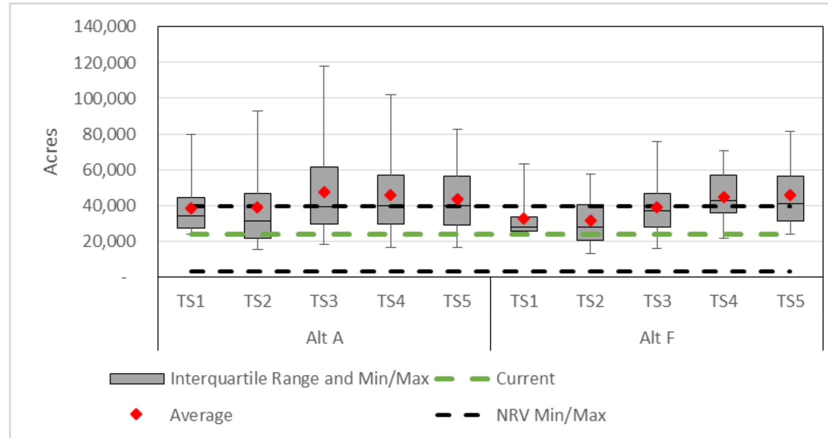
Elkhorns



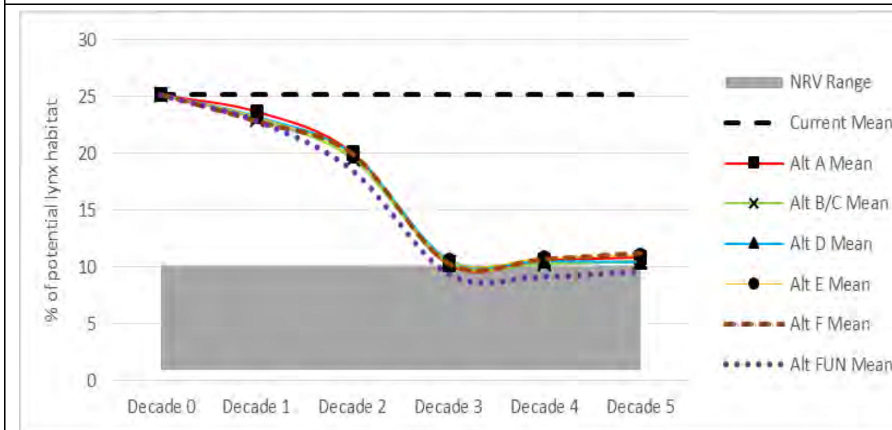


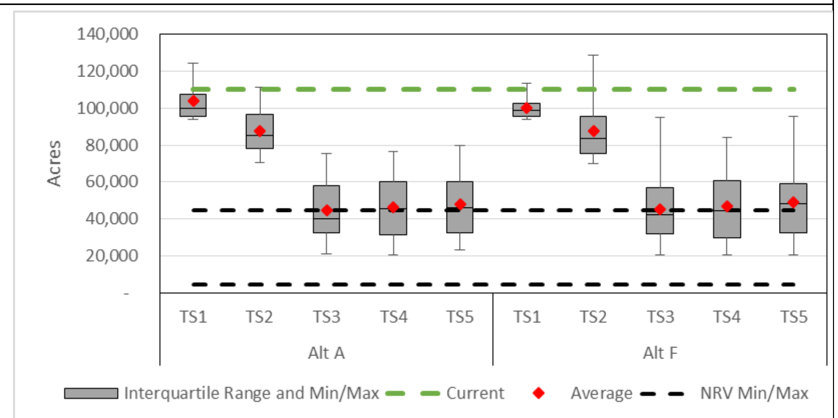
Little Belts



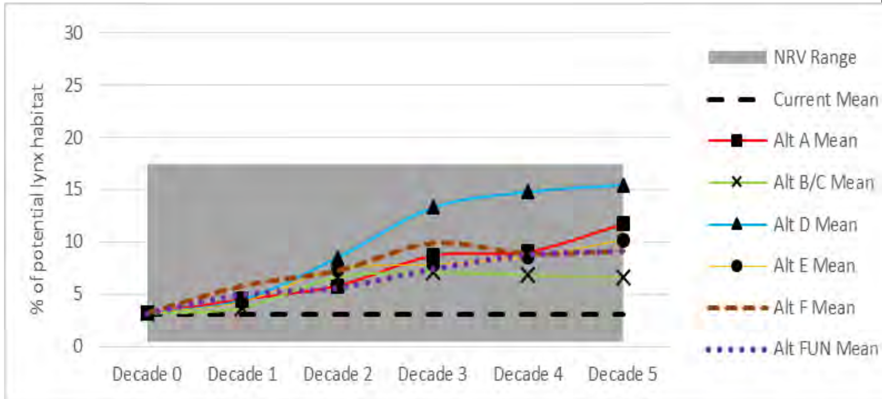


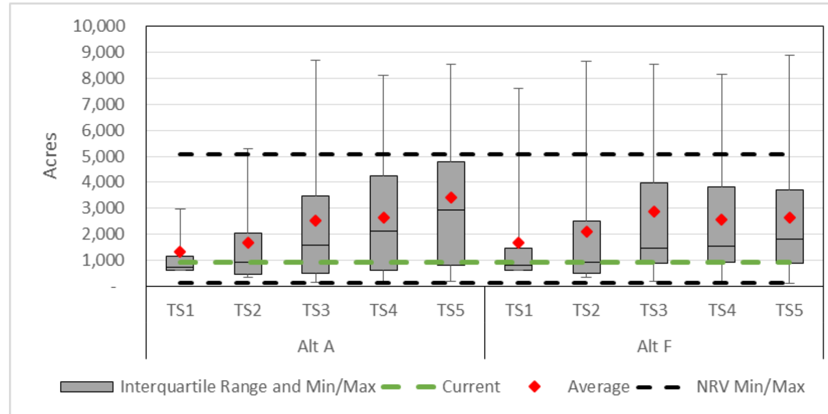
Rocky Mountain Range



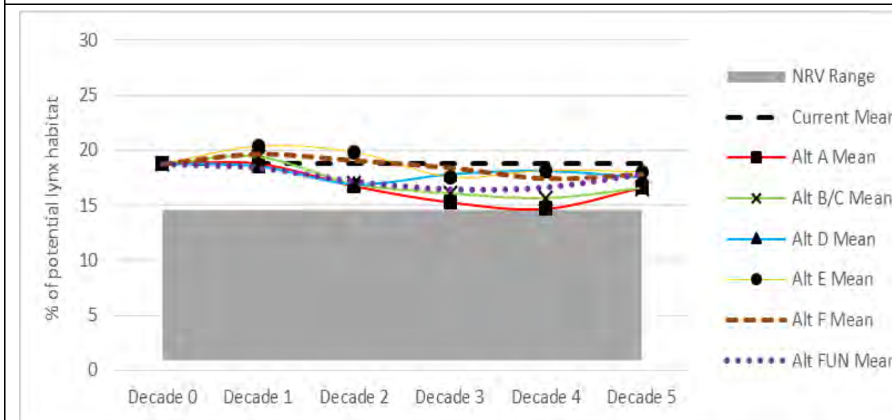


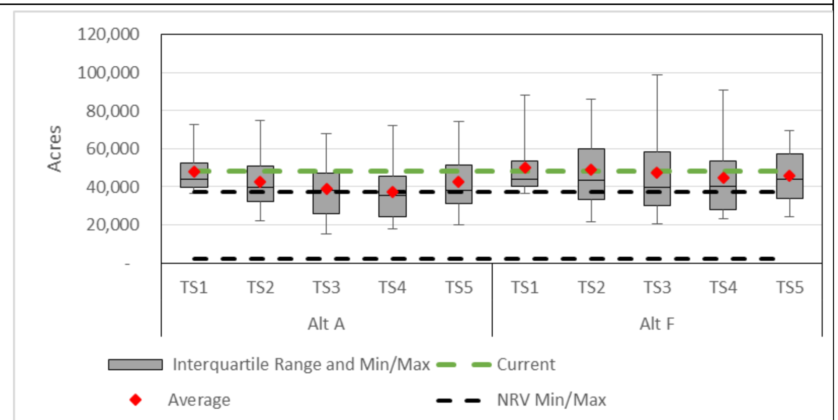
Snowies





Upper Blackfoot





Mature multistory

The model projects that Canada lynx mature multistory habitat will stay below the NRV. The chart below shows the level of this habitat condition, as a percentage of potential lynx habitat, averaged across the 50 year analysis period. It varies by GA as to whether the alternatives improve or worsen this trend. All alternatives appear to be similar.

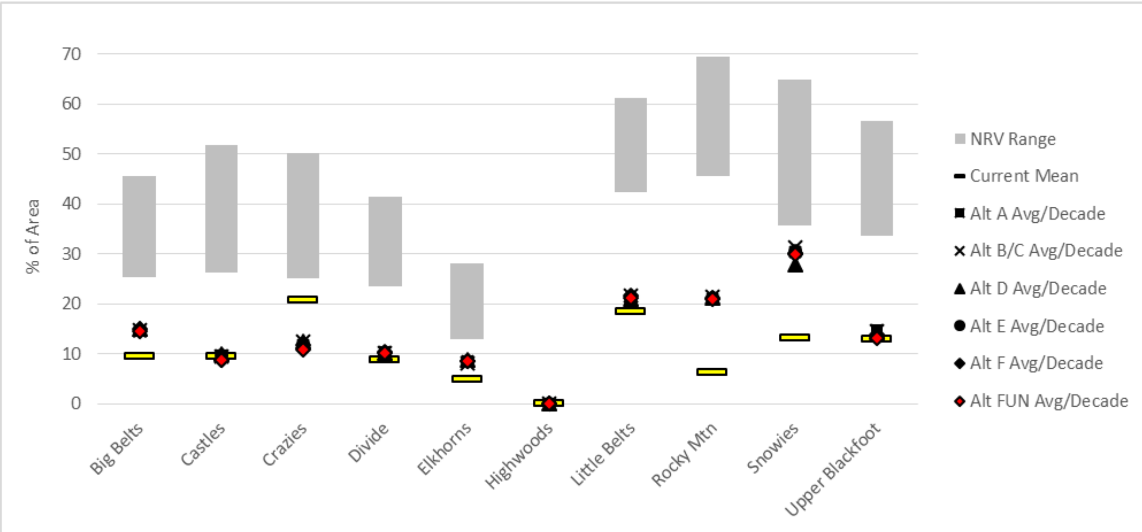
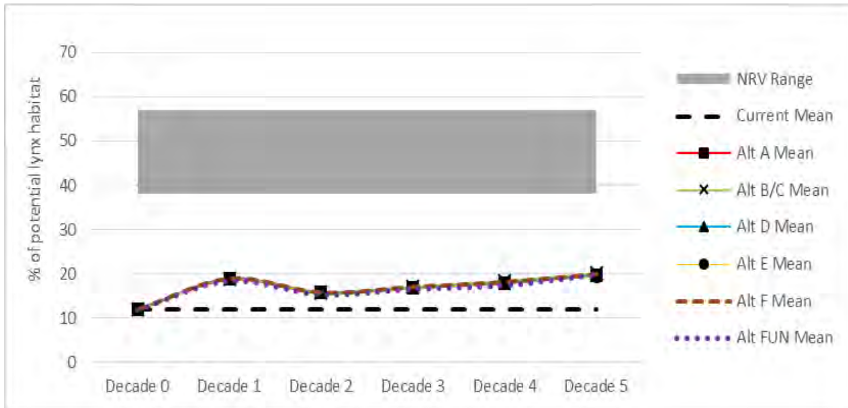
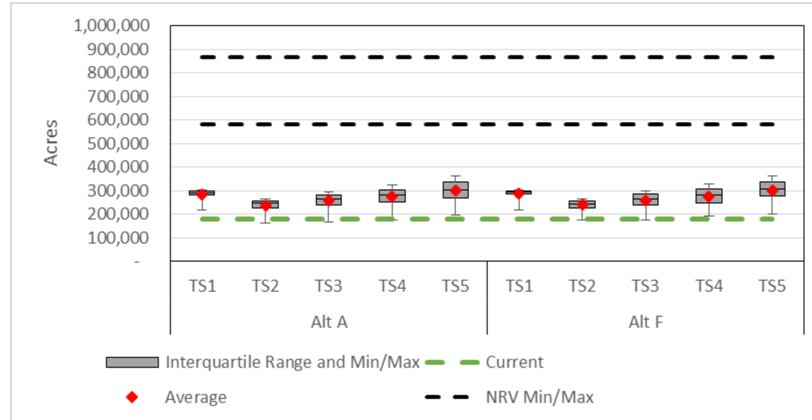


Figure 246. Mature multistory Canada Lynx habitat across all 5 decades, by alternative and GA

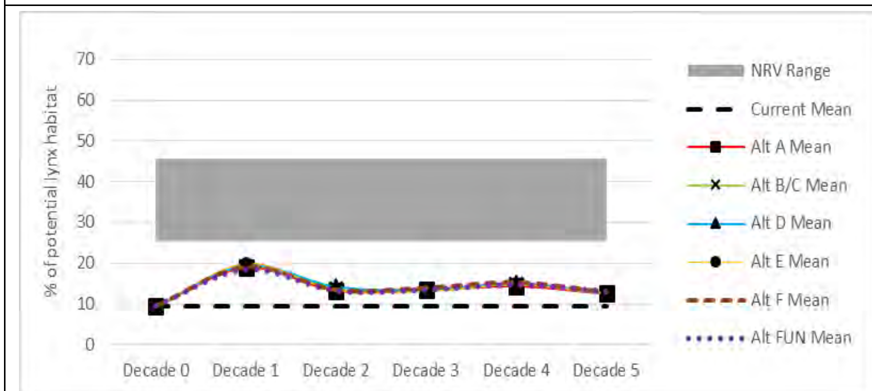
Figure 247. Mature multistory Canada Lynx habitat over 5 decades, by alternative and analysis scale

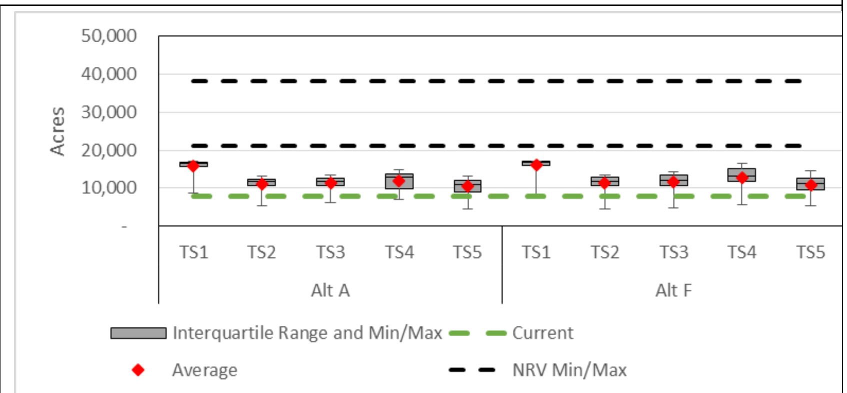
Forestwide



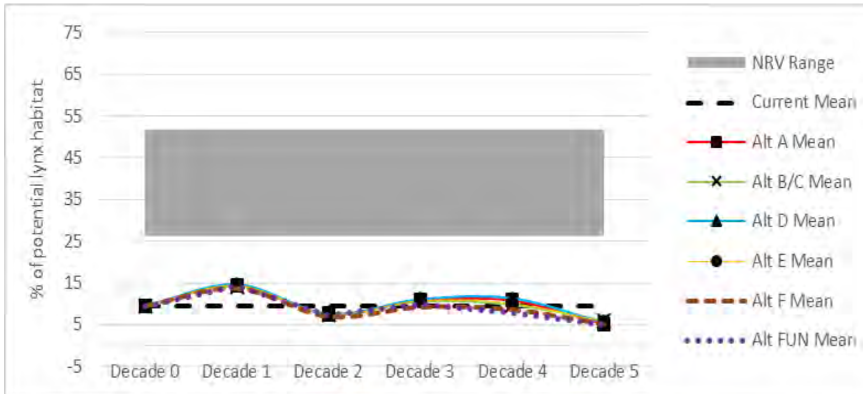


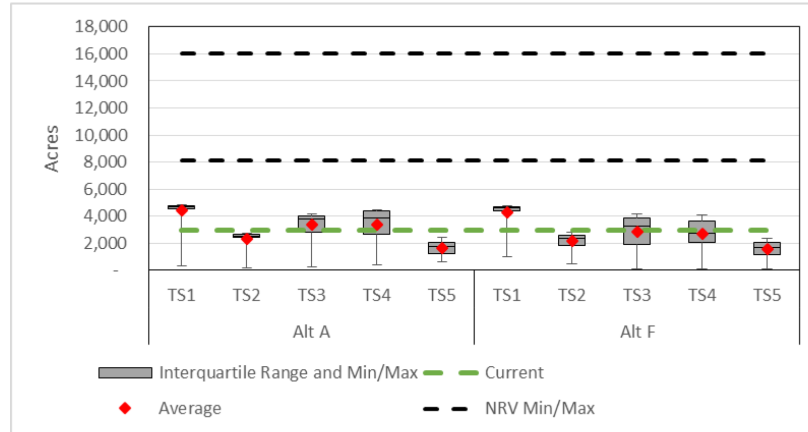
Big Belts



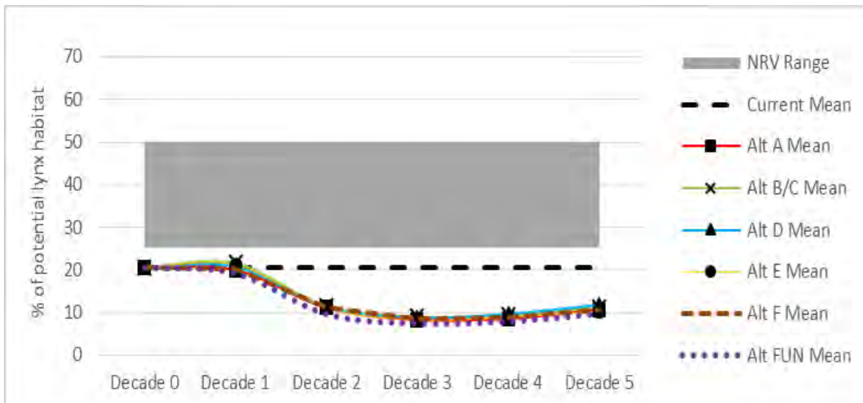


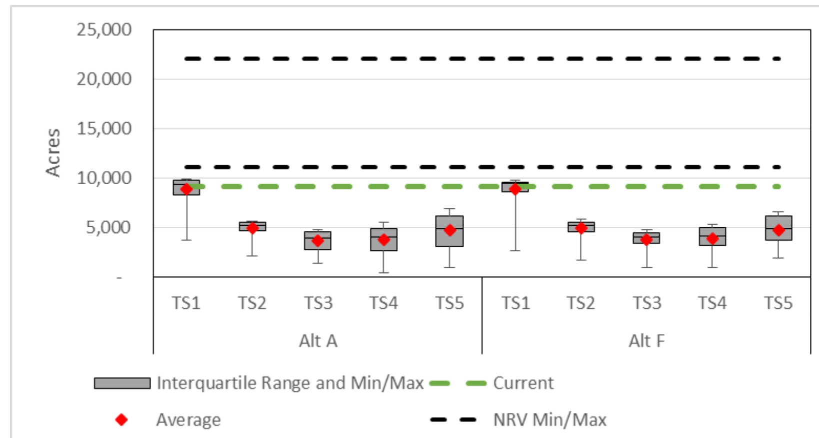
Castles



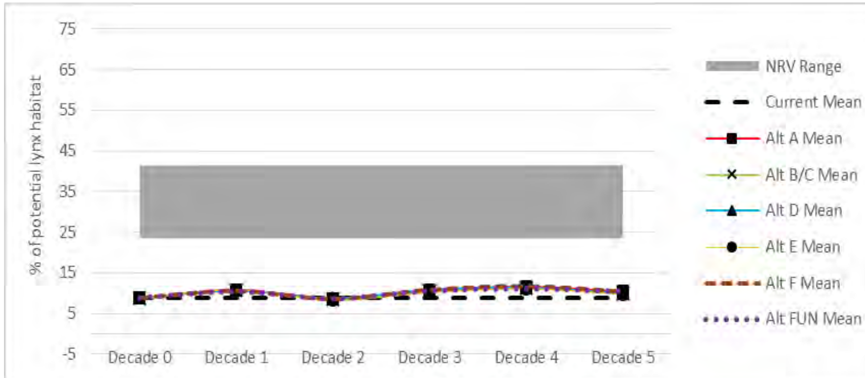


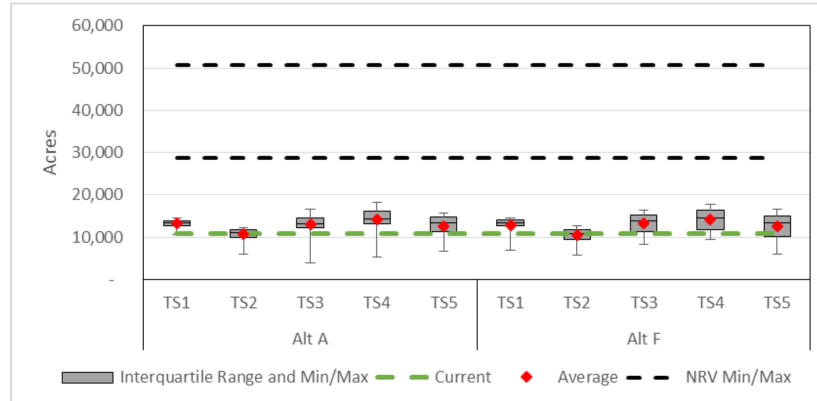
Crazies



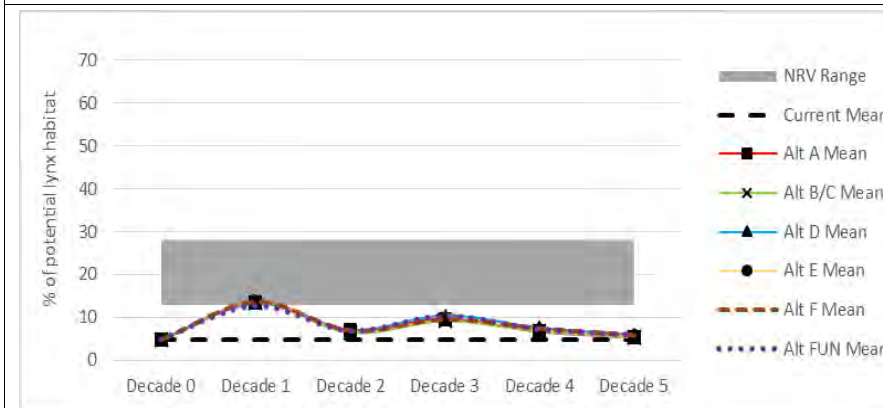


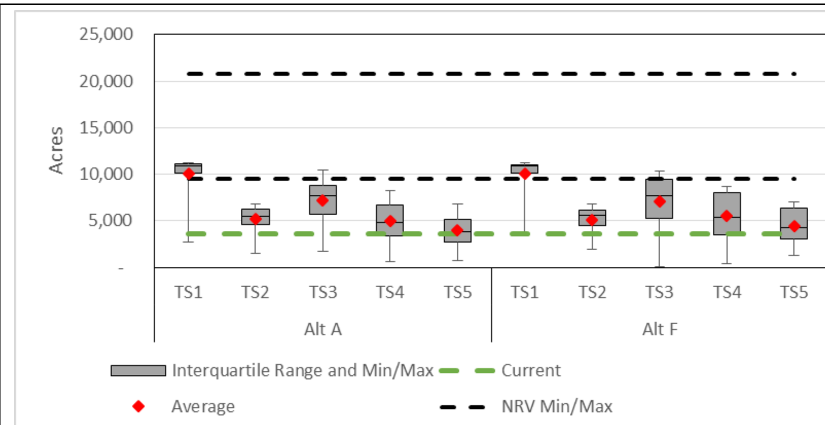
Divide



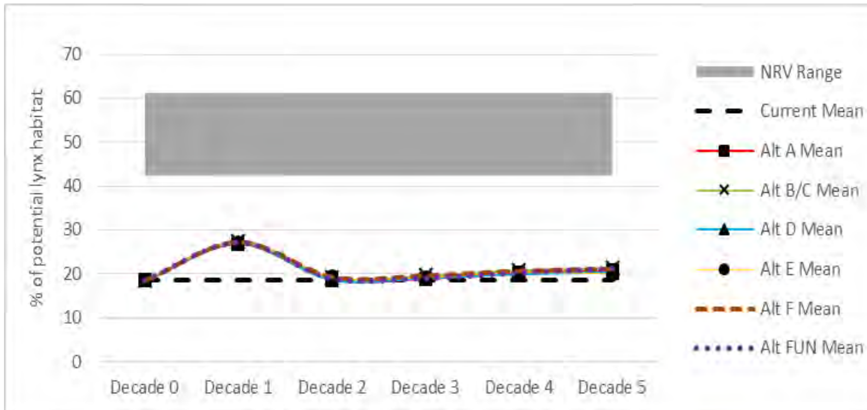


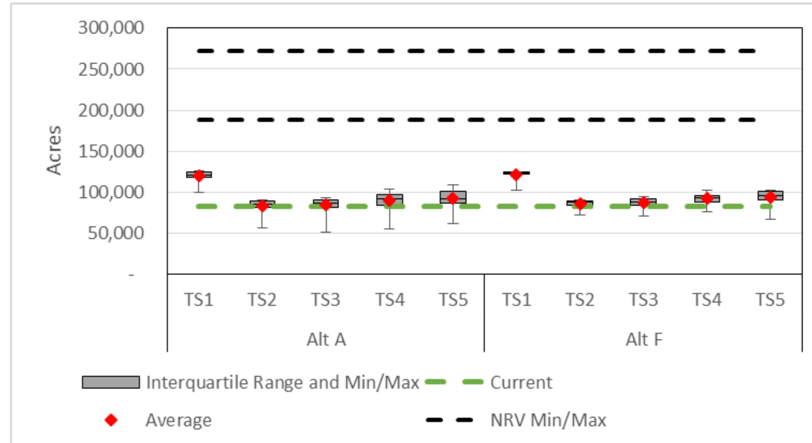
Elkhorns



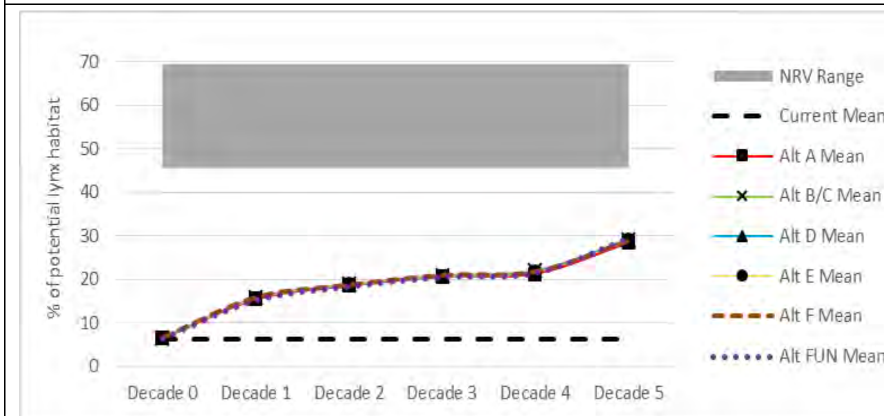


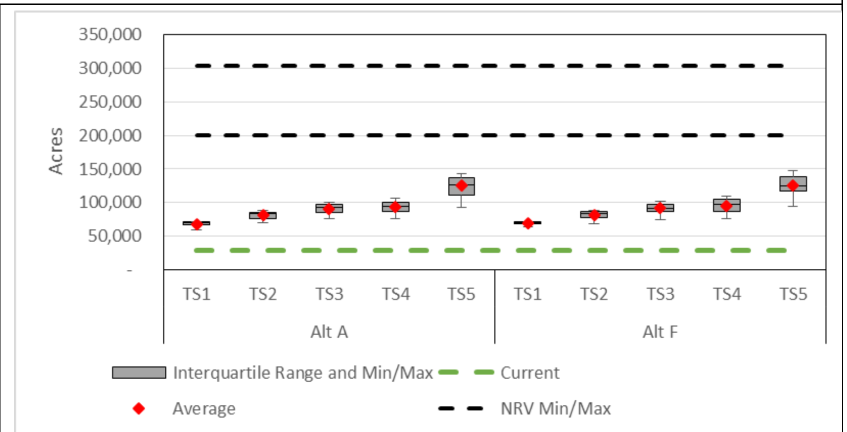
Little Belts



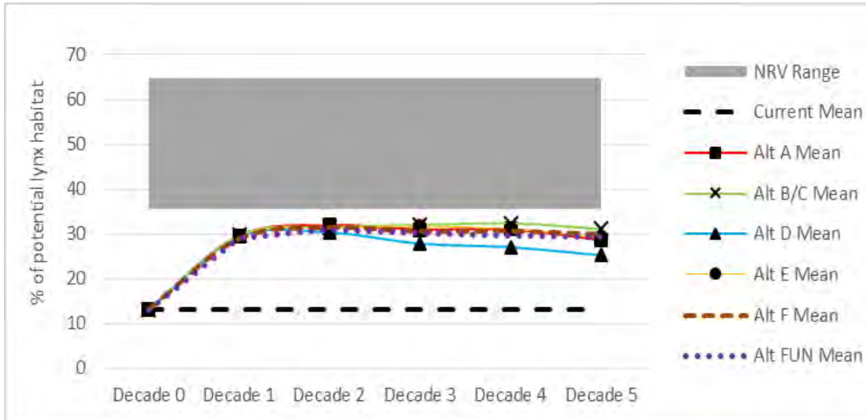


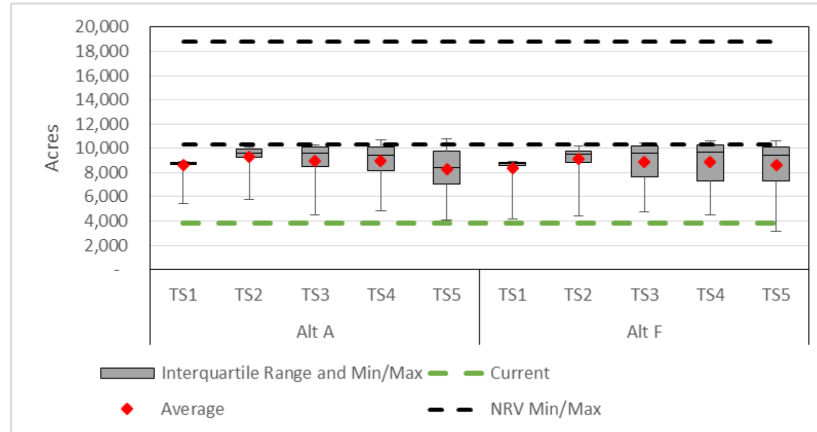
Rocky Mountain Range



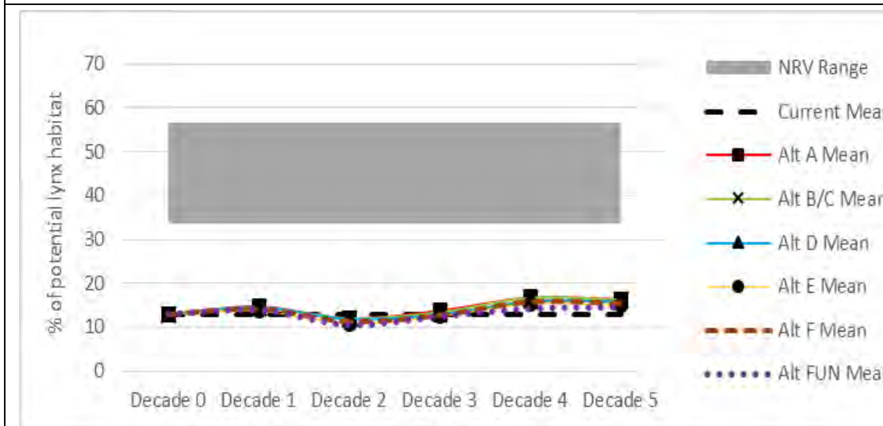


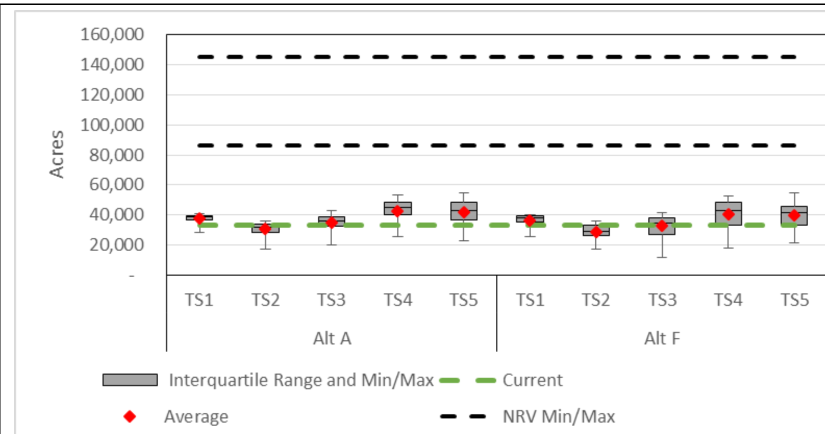
Snowies





Upper Blackfoot





Literature

Barber, J., Bush, R., & Berglund, D. (2011). *The Region 1 existing vegetation classification system and its relationship to Region 1 inventory data and map products* (Numbered Report 11-10). Retrieved from Missoula, MT: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5332073.pdf

Barrett, S. W. (2005). *Role of fire in the Elkhorn Mountains: Fire history and fire regime condition class - Townsend ranger district, Helena National Forest* (Contract No. 53-03H6-04-014).

Bartos, D. L. (2001). *Landscape dynamics of aspen and conifer forests.* Paper presented at the Sustaining Aspen in Western Landscapes, Grand Junction, CO.

Bate, L. J., Wisdom, M. J., & Wales, B. C. (2007). Snag densities in relation to human access and associated management factors in forests of Northeastern Oregon, USA. *Landscape and Urban Planning, 80*(3), 278-291. doi:http://dx.doi.org/10.1016/j.landurbplan.2006.10.008

Bollenbacher, B., Bush, R., Hahn, B., & Lundberg, R. (2008). *Estimates of snag densities for eastside forests in the northern region* (08-07 v2.0). Retrieved from Missoula, MT:

Brewer, L. T., Bush, R., Canfield, J. E., & Dohmen, A. R. (2009). *Northern goshawk northern region overview key findings and project considerations*. Retrieved from Missoula, MT: http://fsweb.r1.fs.fed.us/wildlife/wwfrp/TESnew.htm

Brown, J. K., Reinhardt, E. D., & Kramer, K. A. (2003). *Coarse woody debris: Managing benefits and fire hazard in the recovering forest* (General Technical Report RMRS-GTR-105). Retrieved from Ogden, UT: https://www.fs.fed.us/rm/pubs/rmrs_gtr105.pdf

Brown, S. R., Jr. (2014). *Helena - Lewis & Clark National Forest – Vmap 2014 tree dominance type (dom40), tree canopy cover, tree size class, and lifeform accuracy assessment. Region Onevegetation classification, mapping, inventory and analysis report.* (NRGG14-01).

Bull, E. L., Parks, C. G., & Torgersen, T. R. (1997). *Trees and logs important to wildlife in the interior Columbia River basin* (General Technical Report PNW-GTR-391). Retrieved from

Bush, R., Berglund, D., Leach, A., Lundberg, R., & Zeiler, J. D. (2006). *Overview of R1-FIA summary database, Region 1 vegetation classification, mapping, inventory and analysis report*. Retrieved from Missoula, MT: http://fsweb.r1.fs.fed.us/forest/inv/fia_data/r1_sum_db.htm

Bush, R., & Lundberg, R. (2008). *Wildlife habitat estimate updates for the Region 1 conservation assessment* (08-04 v1.0). Retrieved from Missoula, MT:

Bush, R., & Reyes, B. (2014). Overview of FIA and intensified grid data: Region One vegetation classification, mapping, inventory and analysis report. *Report 14-13 v2.0.* Retrieved from http://fsweb.r1.fs.fed.us/forest/inv/fia_data/index.shtml

Bush, R., & Reyes, B. (2020). *Estimates of Snag and Live-Tree Densities for Eastern Montana Forests in the Northern Region based on FIA Hybrid 2011 Analysis Dataset. Region 1 Vegetation Classification, Mapping, Inventory, and Analysis Report*.

Campbell, R. B., Jr., & Bartos, D. L. (2000, 13-15 June). *Aspen ecosystems: objectives for sustaining biodiversity.* Paper presented at the Sustaining Aspen in Western Landscapes Symposium, Grand Junction, CO.

Cheng, E., Hodges, K. E., & Mills, L. S. (2015). Impacts of fire on snowshoe hares in Glacier National Park, Montana, USA. *Fire Ecology, 11*(2), 119-135. doi:http://dx.doi.org/10.4996/fireecology.1102119

Chew, J. D., Moeller, K., & Stalling, C. (2012). *SIMPPLLE Version 2.5 user's guide*. Retrieved from Fort Collins, CO: https://www.treesearch.fs.fed.us/pubs/40241

Cilimburg, A. (2006). *Northern region landbird monitoring program 2005 flammulated owl surveys final report* (FS - 13669). Retrieved from University of Montana, Missoula, MT 59812:

Clough, L. T. (2000). *Nesting habitat selection and productivity of northern goshawks in west-central Montana.* (M.S. M.S. thesis). University of Montana, Missoula, MT.

Franklin, J. R., Berg, D. R., Thorburgh, D. A., & Tappeiner, J. C. (1997). Alternative silvicultural approaches to timber harvesting: Variable retention harvest systems. In K. A. Kohrm & J. F.

Franklin (Eds.), *Creating a forestry for the 21st century* (pp. 111-139). Washington, DC: Island Press.

Golladay, S. W., Martin, K. L., Vose, J. M., Wear, D. N., Covich, A. P., Hobbs, R. J., . . . Shearer, A. W. (2016). Achievable future conditions as a framework for guiding forest conservation and management. *Forest Ecology and Management, 360,* 80-96.

Graham, R. T., Harvey, A. E., Jurgensen, M. F., Jain, T. B., Tonn, J. R., & Pagedumroese, D. S. (1994). *Managing coarse woody debris in forests of the Rocky Mountains*. (0146-3551).

Green, P., Joy, J., Sirucek, D., Hann, W., Zack, A., & Naumann, B. (1992). *Old-growth forest types of the northern region (errata corrected 02/05,12/07,10/08/,12/11)* (R-1 SES 4/92). Retrieved from Missoula, MT:

Halofsky, J. E., Peterson, D. L., Dante-Wood, S. K., Hoang, L., Ho, J. J., & Joyce, L. A. (2018a). *Climate change vulnerability and adaptation in the northern Rocky Mountains part 2*. (General Technical Report RMRS-GTR-374). Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station

Halofsky, J. E., Peterson, D. L., Dante-Wood, S. K., Hoang, L., Ho, J. J., & Joyce, L. A. (2018b). *Climate change vulnerability and adaptation in the northern Rocky Mountains: Part 1*. (Gen. Tech. Rep. RMRSGTR-374). Fort Collins, CO: Department of Agriculture, Forest Service, Rocky Mountain Research Station

Halofsky, J. E., Peterson, D. L., Dante-Wood, S. K., Hoang, L., Ho, J. J., & Joyce, L. A. (2018c). *Climate change vulnerability and adaptation in the northern Rocky Mountains: Part 2*. (Gen. Tech. Rep. RMRSGTR-374). Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station

Halofsky, J. E., Peterson, D. L., Dante-Wood, S. K., Hoang, L., Ho, J. J., & Joyce, L. A., editors (Eds.). (in press). *Climate change vulnerability and adaptation in the northern Rocky Mountains* (1 ed. Vol. RMRS-GTR-xxx). Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station.

Hansen, A. J., Olliff, T., Carnwath, G., Miller, B. W., Hoang, L., Cross, M., . . . Soderquist, B. (2018). *Vegetation climate adaptation planning in support of the Custer Gallatin National Forest Plan revision*. Bozeman, MT: Montana State University, Landscape Biodiversity Lab

Harris, R. B. (1999). *Abundance and characteristics of snags in western Montana forests* (General Technical Report RMRS-GTR-31). Retrieved from Ogden, UT:

Hessburg, P. F., & Agee, J. K. (2003). An environmental narrative of inland northwest United States forests, 1800–2000. *Forest Ecology and Management*, *178*, 23-59. doi:http://dx.doi.org/10.1016/S0378-1127(03)00052-5

Hessburg, P. F., Agee, J. K., & Franklin, J. F. (2005). Dry forests and wildland fires of the inland northwest USA : Contrasting the landscape ecology of the pre-settlement and modern eras. *Forest Ecology and Management*, *211*, 117-139. doi:http://dx.doi.org/10.1016/j.foreco.2005.02.016

Heyerdahl, E. K., Miller, R. F., & Parsons, R. A. (2006). History of fire and Douglas-fir establishment in a savanna and sagebrush–grassland mosaic, southwestern Montana, USA. *Forest Ecology and Management*, *230*(1–3), 107-118. doi:http://dx.doi.org/10.1016/j.foreco.2006.04.024

ILBT. (2013). *Canada lynx conservation assessment and strategy (3rd ed.)*. Retrieved from Missoula, MT: https://www.fs.fed.us/biology/resources/pubs/wildlife/index.html

Interagency Lynx Biology Team. (2013). *Canada lynx conservation assessment and strategy*. Retrieved from Missoula, MT:

Janssen, J. R. (1949). *A survey of old growth Douglas-fir stands in the Big Belt Mountains of Montana*. Missoula, MT: U.S. Department of Agriculture, Forest Service, Region One

Jones, J. (2004). *US Forest Service--Region One potential vegetation type (PVT) classification of western Montana and northern Idaho*. Retrieved from Kalispell, MT:

Kashian, D. M., Turner, M. G., Romme, W. H., & Lorimer, C. G. (2005). Variability and convergence in stand structural development on a fire-dominated subalpine landscape. *Ecology, 86*(3), 643-654.

Keane, R. E., Tomback, D. F., Aubry, C. A., Bower, A. D., Campbell, E. M., Cripps, C. L., . . . Smith, C. M. (2012). *A range-wide restoration strategy for whitebark pine (Pinus albicaulis)* (General Technical Report RMRS-GTR-279). Retrieved from Fort Collins, CO:

Kitchen, K. A. (2010). *The influence of douglas-fir and Rocky Mountain juniper on Wyoming and mountain big sagebrush cover in southwest Montana.* (Master of Science Master's thesis). Montana State University, Bozeman, MO.

Kosterman, M. K. (2014). *Correlates of Canada lynx reproductive success in northwestern Montana.* (Master's thesis). University of Montana, Missoula, Montana. Retrieved from http://scholarworks.umt.edu/cgi/viewcontent.cgi?article=5406&context=etd

Lyon, J. L., & Christensen. (1992). *A partial glossary of elk management terms* (INT-288).

McGarigal, K., & Romme, W. H. (2012). Modeling historical range of variability at a range if scales: An example application. In J. A. Wiens, G. D. Hayward, H. D. Safford, & C. M. Giffen (Eds.), *Historical environmental variation in conservation and natural resource management* (1 ed., pp. 128-145): John Wiley & Sons, Ltd.

Means, R. E. (2011). Synthesis of lower treeline limber pine (pinus flexilis) woodland knowledge, research needs, and management considerations. In R. E. Keane, D. F. Tomback, M. P. Murray, & C. M. Smith (Eds.), *The future of high-elevation, five-needle white pines in western North America: Proceedings of the High Five Symposium*. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Mello, K. (1978). *Survey Results of Mountain Goat Population In The Big Snowy Mountains, Montana*. Harlowton, Montana: U.S. Department of Agriculture

Milburn, A., Bollenbacher, B., Manning, M., & Bush, R. (2015). *Region 1 existing and potential vegetation groupings used for broad-level analysis and monitoring*. Retrieved from Missoula, MT: http://fsweb.r1.fs.fed.us/forest/inv/r1_tools/R1_allVeg_Groups.pdf

Millar, C. I., & Stephenson, N. L. (2015). Temperate forest health in an era of emerging megadisturbance. *Science, 349(6250)*, 823-826.

MNHP-MTFWP. Montana field guide. Retrieved from http://fieldguide.mt.gov/default.aspx. from Montana Natural Heritage Program and Montana Fish, Wildlife and Parks http://fieldguide.mt.gov/default.aspx

Nelson, M. D., Johnson, D. H., Linkhart, B. D., & Miles, P. D. (2009). *Flammulated owl (otus flammeolus) breeding habitat abundance in ponderosa pine forests of the United States.* Paper presented at the Fourth International Partners in Flight Conference: Tundra to Tropics, McAllen, Texas.

Pfister, R. D., Kovalchik, B. L., Amo, S. F., & Presby, R. C. (1977). *Forest habitat types of Montana*. Retrieved from Ogden, UT: https://www.fs.fed.us/rm/pubs_int/int_gtr034.pdf

Randall, C. (2010). *A Suggested Rate of Mortality for Mpb in Lodgepole and Ponderosa Pine*.

Randall, C., & Bush, R. (2010). *R1 forest insect hazard rating system user guide for use with inventory data stored in FSVEG and/or analyzed with the forest vegetation simulator* (Numbered Report 10-05).

Randall, C., Steed, B., & Bush, R. (2011). *Revised R1 forest insect hazard rating system user guide for use with inventory data stored in FSVEGand/or analyzed with the forest vegetation simulator* (Numbered Report 11-06).

Rice, C. G., & Gay, D. (2010). Effects of Mountain Goat Harvest on Historic and Contemporary Populations. *Northwestern Naturalist, 91*, 40-57.

Samson, F. B. (2006). *A conservation assessment of the northern goshawk, black-backed woodpecker, flammulated owl, and pileated woodpecker in the Northern Region, U.S. Department of Agriculture, Forest Service*. Retrieved from Missoula, MT:

Shepperd, W. D. (1996). *Response of aspen root suckers to regeneration methods and post-harvest protection* (Research Paper RM-RP-324). Retrieved from Fort Collins, CO:

Squires, J. R., Decesare, N. J., Kolbe, J. A., & Ruggiero, L. F. (2010). Seasonal resource selection of Canada lynx in managed forests of the northern Rocky Mountains. *The Journal of Wildlife Management, 74*(8), 1648-1660. doi:http://dx.doi.org/10.2193/2009-184

Timberlake, T., Joyce, L. A., Schultz, C., & Lampman, G. (2018). *Design of a workshop process to support consideration of natural range of variation and climate change for land management planning under the 2012 planning rule*. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station

U.S. Department of Agriculture, Forest Service. (2007). *Northern Rockies lynx management direction final environmental impact statement*. Retrieved from Missoula, MT:

U.S. Department of Agriculture, Forest Service. (2012). National forest system land management planning

Final rule and Record of Decision. *Federal Register, 77*(68), 21162-21276. Retrieved from https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5362536.pdf

U.S. Department of Agriculture, Forest Service. (2013). *Custer, Gallatin, Helena, and Lewis and Clark National Forests. Framework for project-level effects analysis on elk.*

U.S. Department of Agriculture, Forest Service, Northern Region. (2015). *Assessment of the Helena and Lewis & Clark National Forests*. Retrieved from Helena, MT:

U.S. Department of the Interior, Fish and Wildlife Service. (2010). Endangered and threatened wildlife and plants; 90–day finding on a petition to list *Pinus albicaulis* (whitebark pine) as endangered or threatened with critical habitat. *Federal Register, 75*(138), 42033-42039.

Urza, A. K., Sibold, J. S., & Gilliam, F. (2016). Climate and seed availability initiate alternate post-fire trajectories in a lower subalpine forest. *Journal of Vegetation Science, 28*(1), 43-56. doi:10.1111/jvs.12465

USDA. (2015). *Forest Service handbook (FSH) 1909.12, land management planning handbook*. Retrieved from Washington, DC: https://www.fs.fed.us/im/directives/

USFWS. (1998). *Endangered and threatened wildlife and plants; Notice of 12-month finding on a petition to list the northern goshawk in the contiguous United States west of the 100th meridian*. Retrieved from https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_021351.pdf

Vanderzanden, D., Brown, S., Ahl, R., & Barber, J. (2010). *Eastside R1-vmap accuracy assessment (Lewis and Clark, Helena, Custer and Gallatin National Forests)* (Numbered Report 10-6).

Vose, J. M., Clark, J. S., Luce, C. H., & Patel-Weynand, T. (2016). *Effects of drought on forests and rangelands in the United States: A comprehensive science synthesis* (WO-93b).

Westerling, A. L., Hidalgo, H. G., Cayan, D. R., & Swetnam, T. W. (2006). Warming and earlier spring increase western U.S. forest wildfire activity. *Science, 313*(5789), 940-943. doi:http://dx.doi.org/10.1126/science.1128834

Wong, C. M., & Daniels, L. D. (2016). Novel forest decline triggered by multiple interactions among climate, an introduced pathogen and bark beetles. *Global Change Biology*. doi:http://dx.doi.org/10.1111/gcb.13554

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