# Appendix B. Methodologies and Modeling Results

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# Introduction

This appendix includes the methodologies used by all of the resource areas analyzed. They are arranged in the same order as the resources in chapter 3.

In addition, for some resource areas, detailed modeling results (figures and tables) are included to supplement the conclusions summarized in the DEIS. The modeling results are generated from several vegetation models (SIMPPLLE and Spectrum). The methodologies for these models are detailed in the Terrestrial Vegetation and Timber sections respectively. The model outputs are inserted into the appropriate resource sections which reference them in the DEIS, including Fire and Fuel Management, Terrestrial Vegetation, Old Growth, Snags and Downed Wood, At-Risk Terrestrial Wildlife, Elk, and Timber.

# Aquatic Ecosystems

The approach used in this analysis is to take a programmatic look at the outcomes that may result from implementing the proposed management direction in each alternative. For estimating the effects at the programmatic-forest plan level, the assumption has been made that the kinds of resource-management activities allowed under the plans direction are reasonably foreseeable future actions to achieve the goals and objectives. However, the specific location, design, and extent of such activities are not known at the time plans are revised. Project-level decisions are made based on site-specific analysis (project level) basis. Therefore, the discussions here refer to the potential for the effect to occur and are in many cases only estimates. The effects analyses are useful when comparing and evaluating alternatives, but is not intended to be applied directly to specific locations on the forest.

The forest plan prescribes no specific activity in any location; potential spatial and temporal effects to water quality cannot be attributed to any specific watershed. In other words, the cumulative effects of a program at the forest plan scale as opposed to the effects from a project at the project scale can only be discussed in terms of general programmatic tendencies either toward improved or declining water quality or fisheries habitat at no specific site. Therefore, the potential cumulative effects from forest programs to water quality are generally discussed at the basin or HLC NF level. The temporal scale for this analysis is limited to the life of this plan, generally 10 to 15 years.

## Analysis Area

The analysis area for the watershed, soils and aquatic species include all the lands within the boundary of the HLC NF and connected waterways. The connected river systems are included because migratory bull trout and westslope cutthroat trout that emerge from Forest streams move downstream to reach sexual maturity and then return to their natal streams to complete the spawning cycle and depend on connectivity for their survival.

The Forest Plan area is located within two HUC Regions:

- The Missouri Region (HUC = 10) is on the eastern side of the Continental Divide. Within this region, the plan area is located in 3 subregions: Missouri Headwaters (HUC=1002), Missouri-Marias (HUC=1003), and Missouri-Musselshell (HUC=1004). Within these subregions, the plan area is located in 14 fourth level watersheds. Within these fourth level watersheds the plan area is located within 88 fifth level watersheds which are further broken down into 301 sixth level watersheds.
- The Pacific Northwest Region (HUC = 17) drains to the west. Within this region, the plan area is located in one subregion, the Kootenai-Pend Oreille- Spokane (HUC=1701). Within this subregion, the plan area is located in two fourth level watersheds: Upper Clark Fork and Blackfoot River.

> Within these fourth level watersheds, the plan area is within 16 fifth level watersheds which are further broken down into 72 sixth level subwatersheds.

The analysis scale varies by resource and uses the fourth, fifth and sixth level watershed scales to assess current conditions across the HLC NF.

# Air Quality

The air quality analysis relies on existing and most current analysis, research, and planning documents. We used information from several government, academic and private partnership consortiums that have conducted air quality emissions inventories, modeled pollution impacts and work on air quality planning on a regional scale in and around the HLC NF area. There is a great deal of extensive and complex data available and this assessment only summarizes information relevant to the HLC NF forest plan revision.

Quantitative values for wildland fire smoke impacts are difficult to predict. Potential emissions from wildfires are difficult to predict as they would vary depending upon site-specific vegetation and fuels conditions, ignitions, weather, and available suppression resources. Emissions estimate models are available for estimating smoke emission from prescribe fire.

# Fire and Fuel Management

Fire is a primary natural disturbance process within the HLC NF ecosystems that changes vegetation conditions. Fuels management consists of management activities designed to alter vegetation conditions to achieve desired results. Therefore, the analysis process for determining vegetation conditions, past, present and future provide the basis for the analysis of fire and fuels treatments within this section of the environmental impact statement. This process is briefly discussed below. Please refer to the Terrestrial Vegetation section for greater detail.

The vegetation management strategy for the HLC NF is to manage the landscape to maintain or trend towards vegetation desired condition. Modeling was used to estimate extent and effects of disturbance processes (such as fire) into the past (to develop a natural range of variation, or NRV) and into the future (to project future wildfire under a suppression scenario). Fire (planned and unplanned), insects (e.g., bark beetles), disease (e.g., root disease), weather events (drought, windthrow), and harvest treatments are the main drivers of vegetative change, interacting with climate and the process of vegetative succession. The main analytical models used were the SIMPPLLE model (SIMulating Patterns and Processes at Landscape scaLEs) (Chew, Moeller, & Stalling, 2012) and the Spectrum model (ERG, 2015).

Simulation modeling (SIMPPLLE) was used to estimate wildfire activity on the HLC NF for five decades into the future. Best available information was used to build the fire suppression logic and assumptions within the model, including corroboration with actual data, and professional experience and knowledge.

All alternatives contain objectives for treating (mechanical and wildland fire) vegetation to improve structure and composition, including reducing surface fuels, ladder fuels, and canopy density.

## SIMPPLLE model results for future wildfire

The SIMPPLLE model is defined and discussed in the Terrestrial Vegetation section of this appendix; the results for projected wildfire acres burned are shown here. SIMPPLLE is used to estimate the probable extent and severity of wildfire in the future, taking into account expected climate, vegetation treatments, and fire suppression actions. The average acres projected do not imply an “even flow” of acres affected over time. The acres burned would vary by decade. These modeled estimates are based on best available information, but have a high level of uncertainty.

**Figure 1. Mean acres per decade affected by wildfire, by alternative, across five decades**

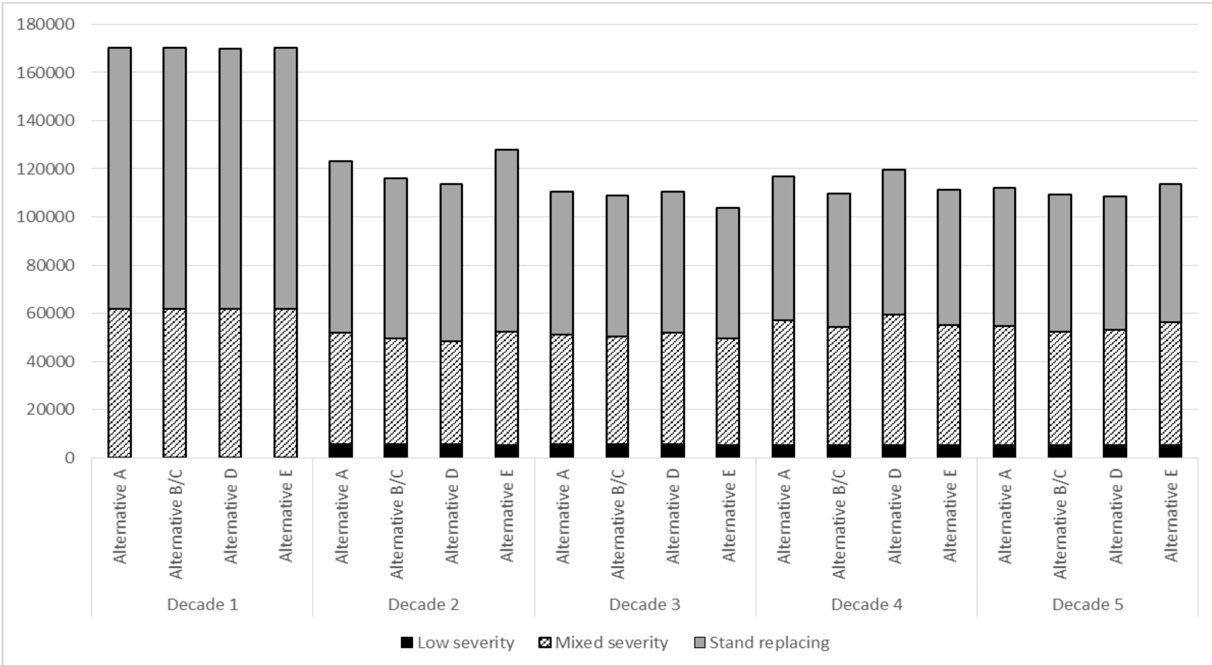


**Figure 2. Mean acres per decade affected by low severity fire, by alternative**

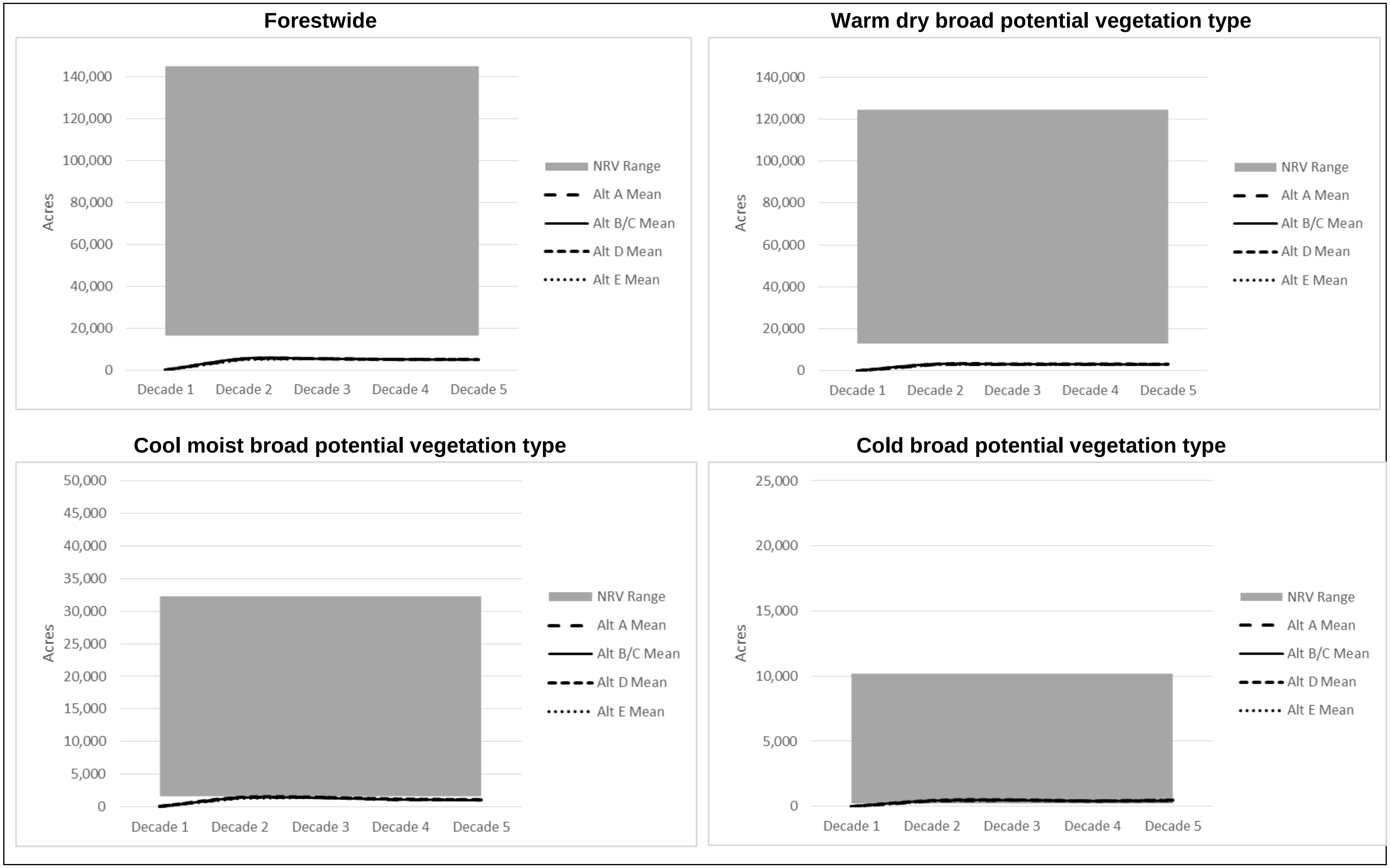


**Figure 3. Mean acres per decade affected by mixed severity fire, by alternative**

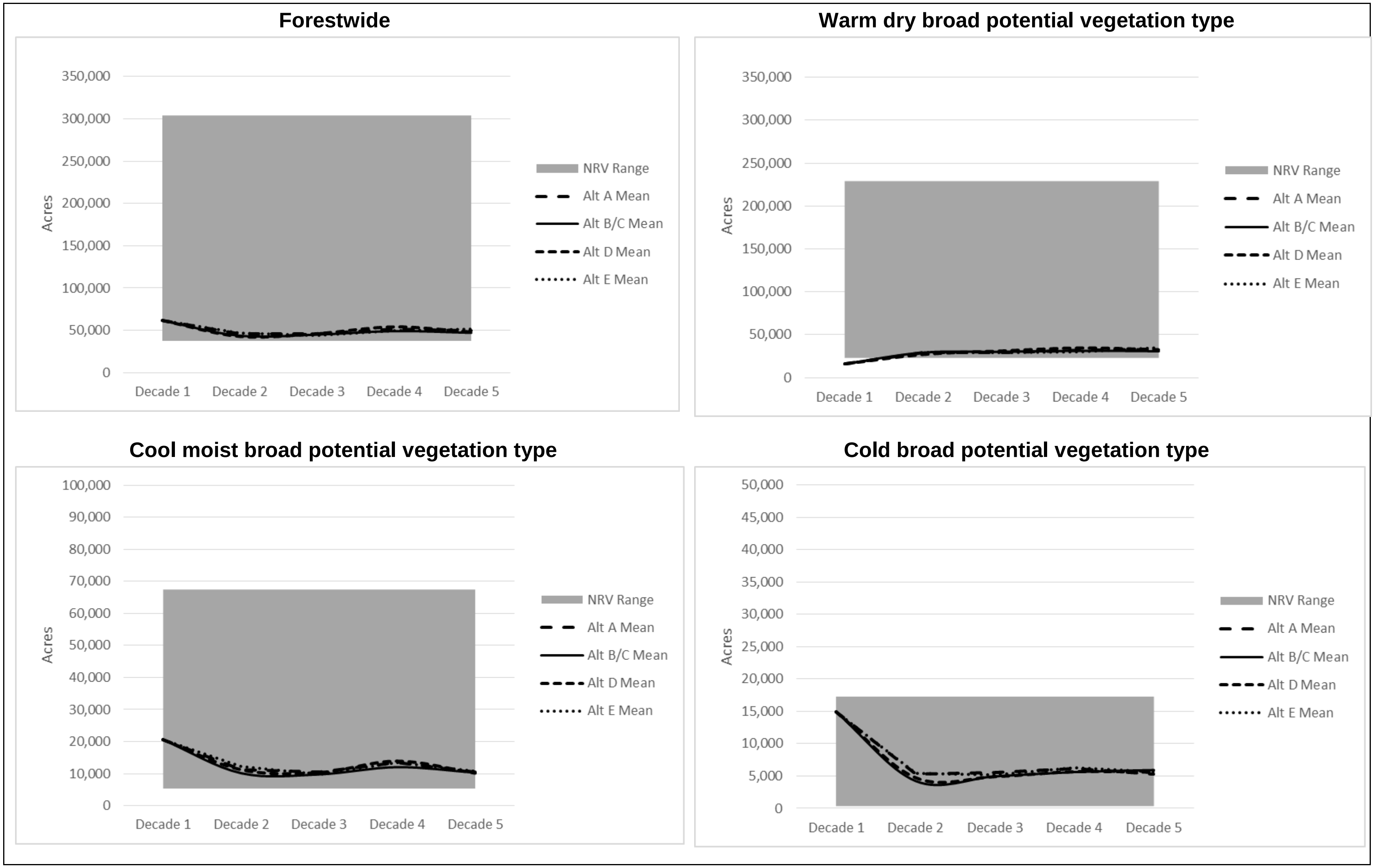
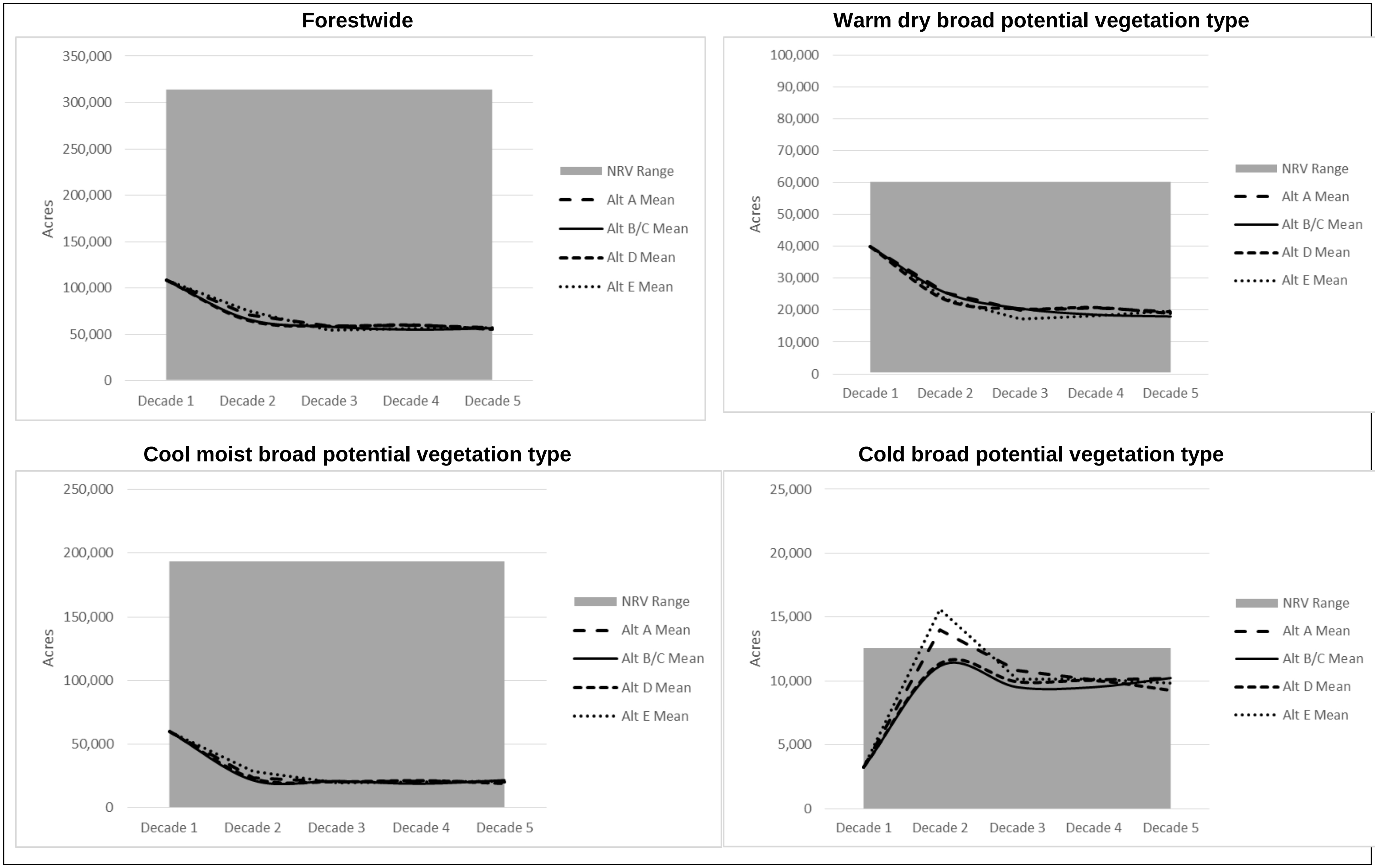


**Figure 4. Average acres per decade affected by stand replacing fire, by alternative**



# Terrestrial Vegetation

## Introduction

Biodiversity conservation focuses on the need to conserve dynamic, multi-scale ecological components, structures, and processes that sustain a full complement of native species and their supporting ecosystems. The terrestrial vegetation section documents the coarse filter analysis of the terrestrial ecosystems. Other sections focus on species-specific conditions and management strategies, or the “fine filter”.

The affected area for terrestrial vegetation is the lands administered by the HLC NF. This area represents the NFS lands where changes may occur to vegetation as a result of management activities or natural events. Information is summarized at three scales:

1. Forestwide, to provide information on the broad scale context;
2. Broad potential vegetation group, because indicators vary by site capability;
3. Geographic area because the unique disturbance history and human uses of each area has and will continue to influence vegetation.

The affected area for cumulative effects also includes lands of other ownership within and immediately adjacent to the forest boundaries.

## Data sources for vegetation analysis

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. Forest Inventory and Analysis (FIA) plot data meets these criteria and are used to quantify the existing condition of vegetation.
- 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.
- 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*

Forest Inventory and Analysis (FIA) data comes from measurements taken at a set of points established on a nationwide systematic grid across all ownerships. The sample design and data collection methods are scientifically designed, publicly disclosed, and repeatable. These plots are systematic, spatially balanced, and statistically reliable for providing unbiased estimates of forest conditions for use 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:

- estimate the existing condition;
- validate the reliability of spatial datasets and/or build logic to update those datasets;
- seed spatial datasets with the information required by vegetation models;
- provide the tree lists needed for yield table development

### Forest Inventory and Analysis 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, resulting in 459 plots for the entire plan area.

Starting with annual plots collected in 2006, the Northern Region has contracted with the FIA program to collect the "All Condition Inventory" (Bush & Reyes, 2014). This inventory supplements the base plots by measuring plots and portions thereof that do not meet the definition of "forested". This effort is providing additional data for nonforested vegetation. At this time, only a subset of the base grid plots have information collected on non-forested plots.

The base grid is used to summarize conditions for the entire planning area, and to represent geographic areas (GAs) that do not have a grid intensification completed (described below). Many base grid plots have not been re-measured since the recent mountain pine beetle outbreak; the most recent plot measurement dates range from 1996 to 2011, with about half being measured prior to the outbreak beginning in 2006. Therefore, conclusions drawn from this data are supplemented by additional information. In addition, plots that have changed due to fire or harvest are excluded from estimates.

### Forest Inventory Analysis Grid Intensification

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 powerful 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 (Bush & Reyes, 2014). This dataset is referred to as "intensified grid", or "4x grid". Plots are established across all national forest system lands, 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, as shown in Table 1. There are no 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 that is used to summarize the GAs. Both datasets are reviewed to summarize the Elkhorns GA because the intensified grid covers the bulk of the area.

**Table 1. FIA and FIA 4x Intensified grid sample status by geographic area, as of 2016**

| Geographic Area | Base FIA Plots | 4x Grid Installation Date | 4x Plots Installed | 4x Plots Yet to Install | Total Plots Used for 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 | 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 Range | 1222 | 2012-Ongoing | 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 and are 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.

Like the base grid, the intensified plots are on a 10-year re-measurement cycle. However, shortly after installation began 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, as shown in Table 1. 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 non-forested plot data. The primary weakness is that it is not complete on the Rocky Mountain Range GA. Plots are only installed on national forest system 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 (Bush & Reyes, 2014). The forest inventory analysis and intensified grid plots, described above, are summarized using this tool. Based on the measured data, a suite of standardized classification algorithms populate attributes of interest to the Northern Region (Barber, Bush, & Berglund, 2011; Bush & Reyes, 2014). The database structure includes:

- Oracle tables reside at a data center which warehouse summarized and attributed data based on inventory data residing in the database, FSVeg. The Oracle tables contain attributes collected at the site; derived attributes such as the R1 Existing Vegetation Classifications (Barber et al., 2011), R1 Wildlife habitat models, old growth; and associations to spatial datasets used for analysis.

- Access databases house a subset of the data in the Oracle Tables for a specified set of inventory data is called an *analysis dataset*. This database contains queries and reports that are built off of the Oracle Tables. The analysis datasets used for this DEIS include:
  a. F12_F15Partial_IntGrid_4x_Hybrid_2016COMBINED, which includes the latest measurements of the intensified grid plus base plots in areas with a completed intensified grid.
  b. 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 (Bush & Reyes, 2014). The form is a front-end application which allows users to derive estimates. 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 is used, and refined through field sampling and verification. This geospatial dataset includes all watershed areas that intersect with national forest system lands on the HLC NF; private lands within 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 VMap 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 2 (S. R. Brown, Jr, 2014), which are within national mapping standards.

**Table 2. 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% |

### *Potential Vegetation Mapping and Classification*

Potential vegetation types (PVTs) are assemblages of habitat types, which are an aggregation of ecological sites of similar biophysical environments (such as climate, aspect, soil characteristics) that produce plant communities of similar composition, structure and function. The Northern Region has identified potential vegetation groups that are recommended for use at the broad levels to provide consistent analysis and monitoring, as described by Milburn and others (2015). These groups are used in the HLC NF revised forest plan. The three broad PVTs found in the plan area are warm dry, cool moist, and cold. The classification for each is provided in appendix D of the Draft Plan. PVTs provide the basis for development of desired conditions and other plan components.

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 used for this DEIS 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, and is a mid-level depiction of ecological condition.

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 vegetation 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; this logic is available in the project record.

### *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 (e.g., ownership, inventoried roadless areas, wilderness areas, wildland urban interface). 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 Spectrum; and compile the spatial data used for the SIMPPLLE model.

## Terrestrial vegetation desired conditions

Forest plan direction must provide for ecological integrity while contributing to social and economic sustainability (USDA, 2012). To achieve this, desired conditions have been developed for key vegetation components. Desired conditions describe, to the best of our ability, what would maintain ecosystem integrity while contributing to social and economic sustainability. Though the forest plan provides direction for a relatively short period of time (the next 15 years), desired conditions were developed with the long-term view in mind 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.

An analysis of the natural range of variation (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 understand 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 natural range of variation, and additional factors were considered in the development of desired conditions.

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 and production of forest products).

Research has been done that 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 currently have the capability to predict such possible shifts at the local scale. By basing the desired conditions around the full range of natural variation, with a focus on maintaining the full suite of ecosystem diversity and components that enhance resilience to disturbance, the Draft Plan would guide management toward maintaining functioning ecosystems in the face of uncertainty.

### *Natural range of variation (NRV) analysis*

The SIMPPLLE model was used to estimate the NRV, which is the variation of ecological characteristics and processes over scales of time and space that are appropriate for a given management application. This concept is used as a tool for assessing ecological integrity. The NRV is displayed as a range of a given condition (minimum and maximum) in proportion of area forestwide, by broad PVT, and by GA. The primary attributes modeled included vegetation composition, size class, density class, and vertical structure class. The natural extent and severity of disturbances such as wildfire and insect outbreaks was also provided, as well as an analysis of the natural size of early successional forest openings. The results of this analysis provided the basis for the development of desired conditions.

When considering the period of time over which to evaluate the natural range of variation, “the pre-European influenced reference period considered should be sufficiently long, often several centuries…and should…include short-term variation and cycles in climate” (USDA, 2015). To meet this intent, vegetation conditions 1,000 years into the past were modeled. This reference period allowed the HLC NF to simulate the conditions associated with much of the time period known as the Medieval Climate Anomaly (about 950 to 1250), as well as the other end of the climate spectrum known as the Little Ice Age (early 1300s to about 1870s). The inclusion of the Medieval Climate Anomaly is valuable in that it might indicate conditions and processes that could occur in the modern climate regime. SIMPPLLE was run under a scenario that included natural ecological processes and disturbances, and their interaction with climate, using the Palmer Drought Severity Index as the indicator of past climate. Data for this index is reconstructed for localized points, and the data point nearest the HLC NF was used to evaluate the climate. The data was categorized into three climate scenarios: wetter, dryer, and normal, and the appropriate scenario was applied to each modeling period (decade). Key model processes, such as wildfire, insects, and disease function differently depending on the climate scenario. Thirty simulations were run to capture the variability and uncertainties associated with potential disturbances.

The SIMPPLLE model is also used to project vegetation change into the future, as affected by anticipated treatments, natural disturbances and climate change. These results can be compared to the natural range of variation and the desired conditions to evaluate relative differences between alternatives.

### *Desired conditions for vegetation key ecosystem characteristics*

This section describes the relationship between the existing condition and the desired condition range for all key ecosystem characteristics that were included in the terrestrial vegetation analysis. The source of the data for the current condition is FIA data and intensified grid data expressed as an estimated mean percent, with a lower and upper bound estimate provided at a 90% confidence interval.

#### Species composition: cover types and tree species presence

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 3 describes the desired trend for composition.

**Table 3. Desired trend of composition by R1 broad PVT**

| Broad PVT | Desired trend of cover types | Desired trend of tree species distribution |
|---|---|---|
| Warm Dry | The most substantial gap between existing and desired condition for cover type exists in this group. There is less of the ponderosa pine cover type (which includes limber pine dominance types) than desired, and more Douglas-fir dominated types. Changing these proportions would provide habitat for wildlife and forests resilient to fire and drought. Other cover types such as Engelmann spruce, lodgepole pine, and aspen are desired where moisture is less limiting. Desired conditions would promote complex 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. | The distribution of limber pine, aspen, and ponderosa pine are below the desired condition, and Engelmann spruce is above. Increases in ponderosa, limber, and aspen will be supported by future warm climate and fire. Ponderosa pine is highly drought tolerant and when stressed is generally less susceptible than Douglas-fir to pathogens. Douglas-fir is likely to experience greater stress with drying conditions. |
| Cool Moist | An increase in the lodgepole pine cover type is desired, with a decrease in mixed mesic conifer (dominated by Douglas-fir). The desired condition would favor lodgepole pine and whitebark pine over Douglas-fir and Engelmann spruce given expected climate and wildfire. All cover types suited to these sites, especially aspen, should be present to achieve diversity at multiple scales. 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. The western larch cover type is limited within its natural range to the Upper Blackfoot GA. | Distribution of Douglas-fir, Engelmann spruce, and subalpine fir are all above the desired range, while lodgepole pine and aspen are slightly below. Increases in lodgepole and aspen are desired. Infrequent, large fires characteristic of this setting will favor these species over those with low fire resistance. |
| Cold | Desired conditions are to increase the whitebark pine cover type, focusing on sites best suited (e.g. open ridges and harsher aspects). On sites where whitebark pine is | Whitebark pine distribution is much lower than desired, and should increase with a decrease |

| Broad PVT | Desired trend of cover types | Desired trend of tree species distribution |
|---|---|---|
| | capable of surviving, there should be a decrease in subalpine fir, and to a lesser extent Engelmann spruce. Subalpine fir may be the most common species and 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. | in subalpine fir and spruce. Lodgepole pine is also above the desired range and should be limited to warmer sites. |
| Nonforested | The desired condition is to maintain or increase the extent of nonforested plant communities, primarily grass, shrub, and riparian grasses/shrubs. Nonforested cover types will be promoted with future warm and dry climate. Although modeling is limited for these types, the subsequent section provides more description of the existing and desired conditions for non-forested potential vegetation groups, cover types, and specific species. | It is desirable to limit the encroachment of coniferous tree species onto nonforested potential vegetation types. |

The following figures display the current condition and desired range of proportions of cover types and tree species presence forestwide and by each broad PVT. Tree species presence is also analyzed at the GA scale. The plot data (existing condition) includes cover types labeled as “none”, which include both nonforested types as well as forested types that were recently disturbed and have not yet reforested.

**Figure 5. Cover type current and desired condition, forestwide**

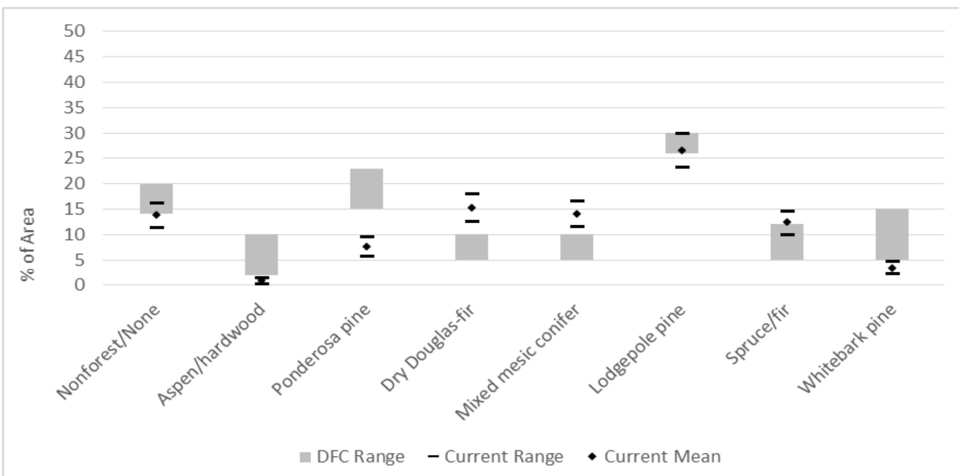


**Figure 6. Cover type current and desired condition, warm dry broad PVT**

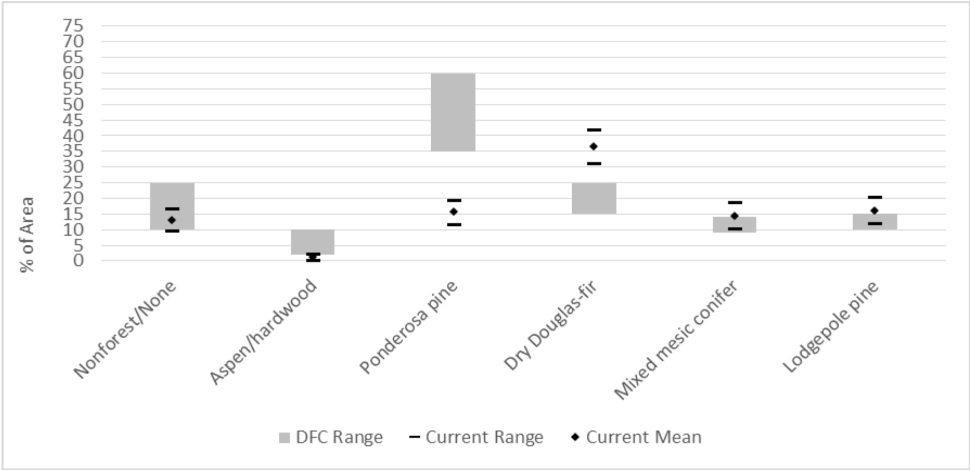



**Figure 7. Cover type current and desired condition, cool moist broad PVT**

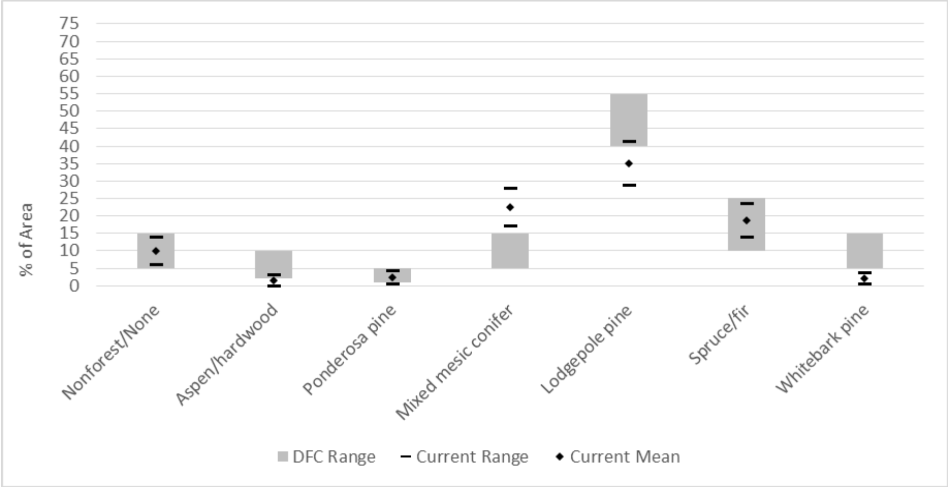



**Figure 8. Cover type current and desired condition, cold broad PVT**

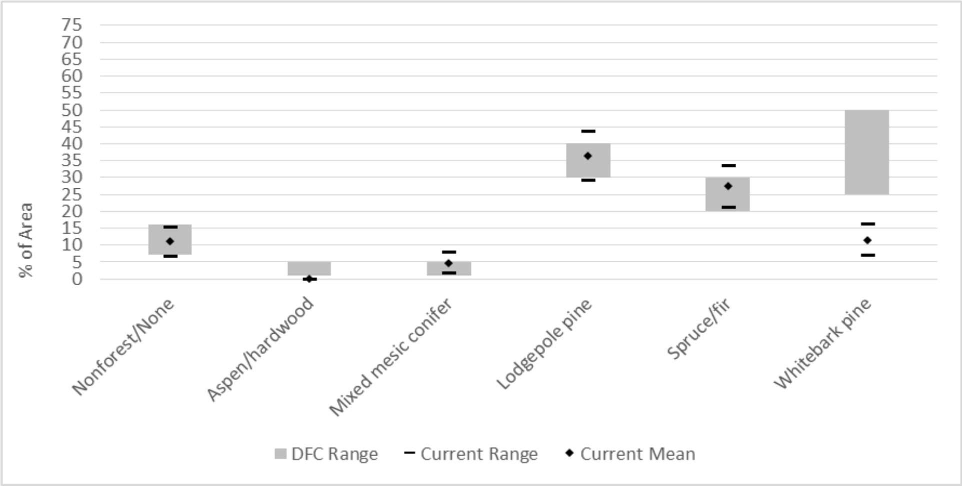


**Figure 9. Current and desired condition for nonforested cover types by GA**

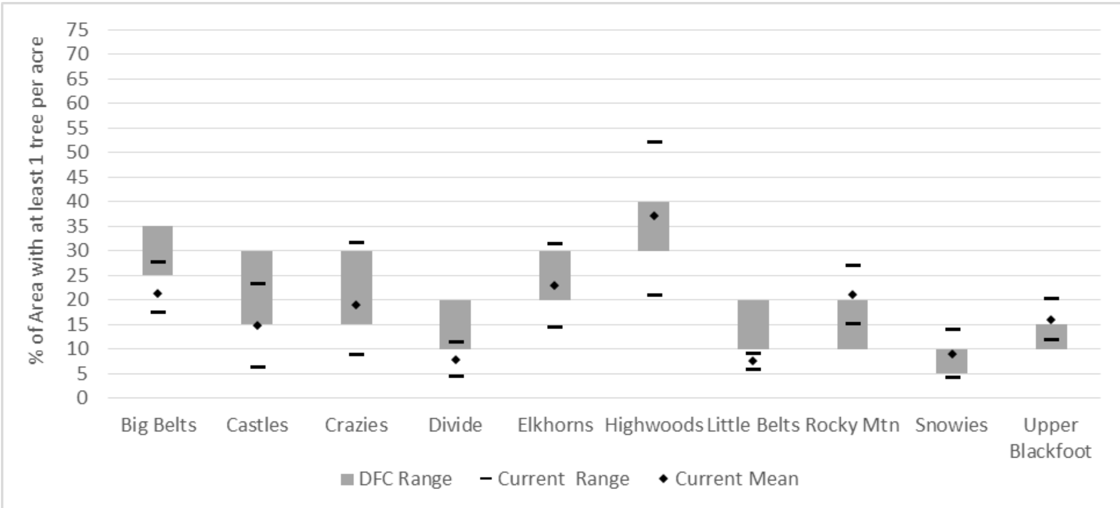



**Figure 10. Tree species presence current and desired condition, forestwide**

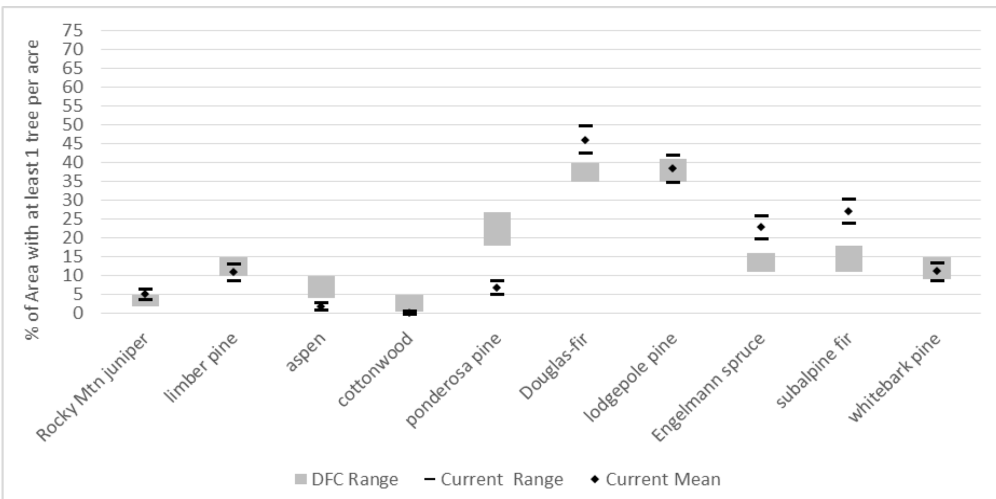



**Figure 11. Tree species presence current and desired condition, warm dry broad PVT**

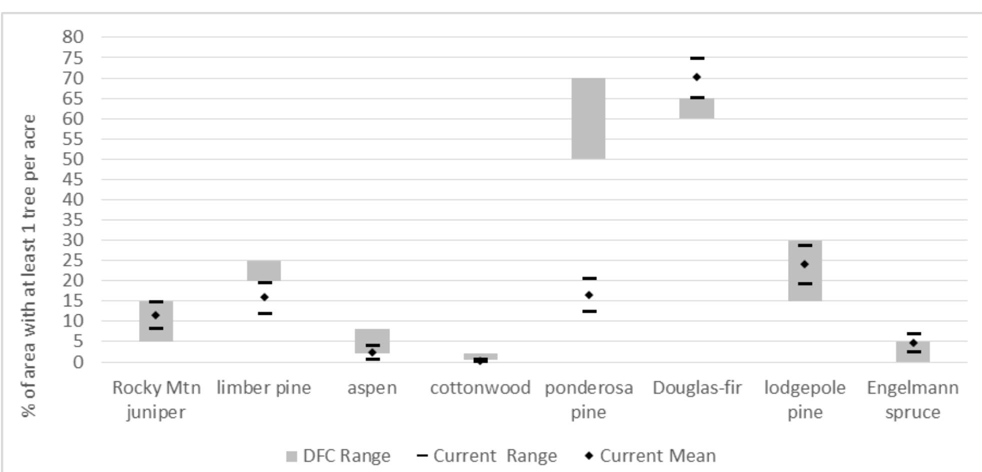


**Figure 12. Tree species presence current and desired condition, cool moist broad PVT**

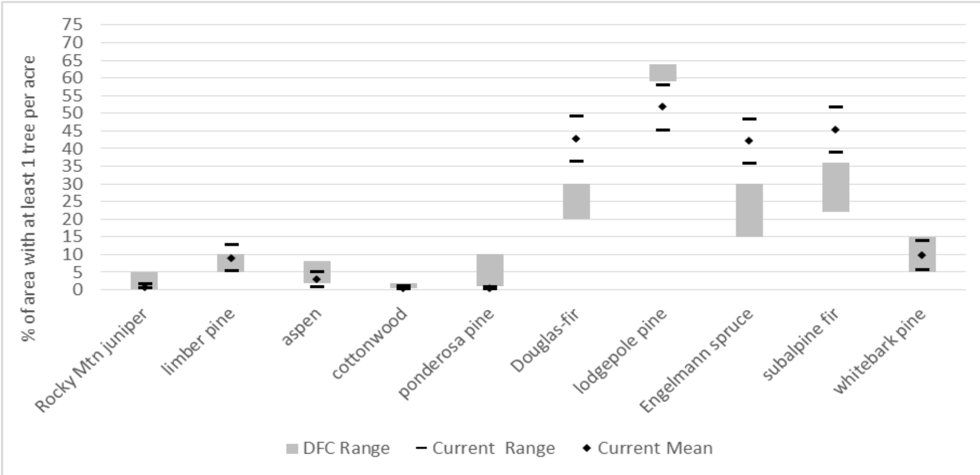



**Figure 13. Tree species presence current and desired condition, cold broad PVT**

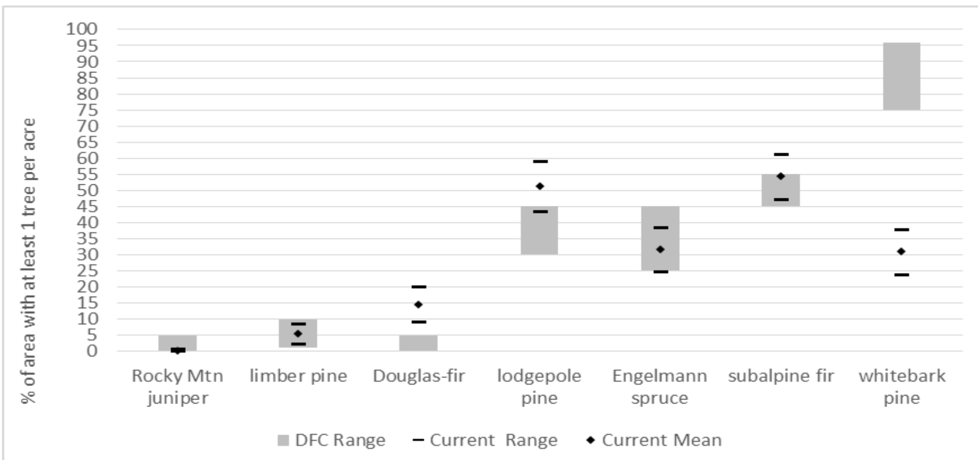



**Figure 14. Current and desired condition for limber pine presence by GA**

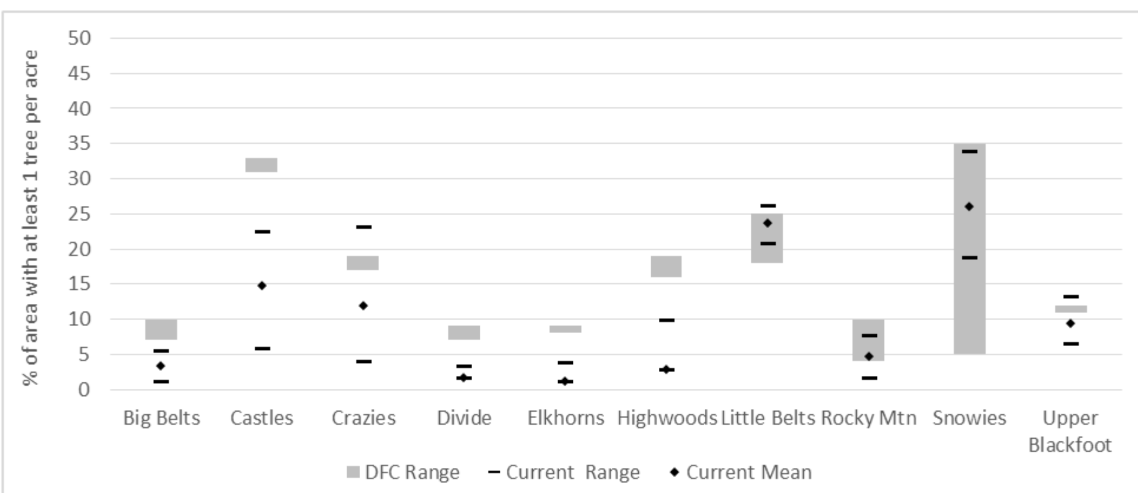


**Figure 15. Current and desired condition for Rocky Mountain juniper presence by GA**

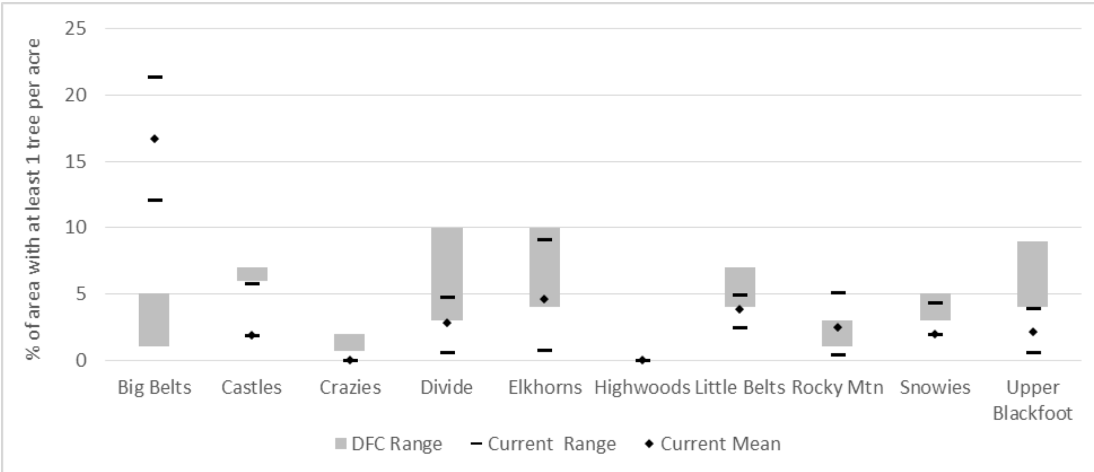



**Figure 16. Current and desired condition for ponderosa pine presence by GA**

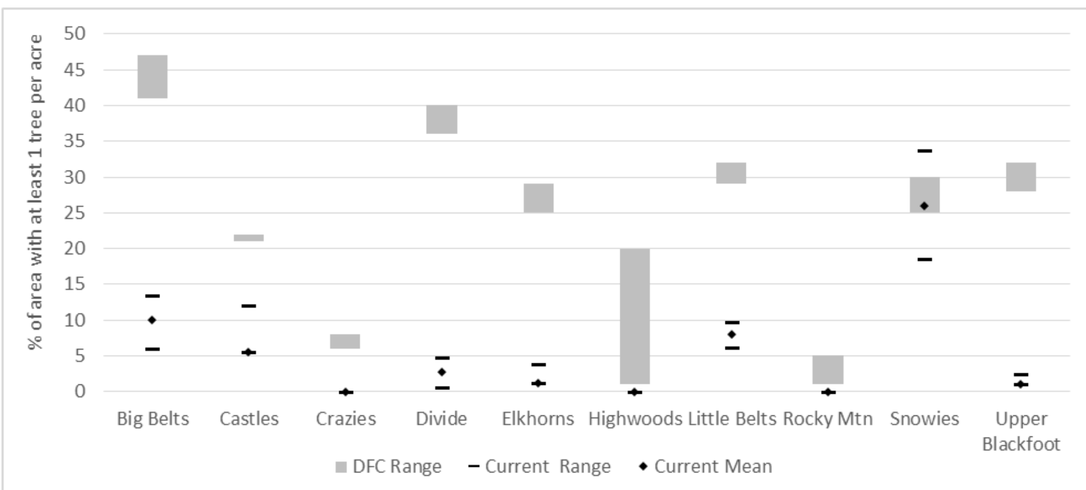



**Figure 17. Current and desired condition for Douglas-fir presence by GA**

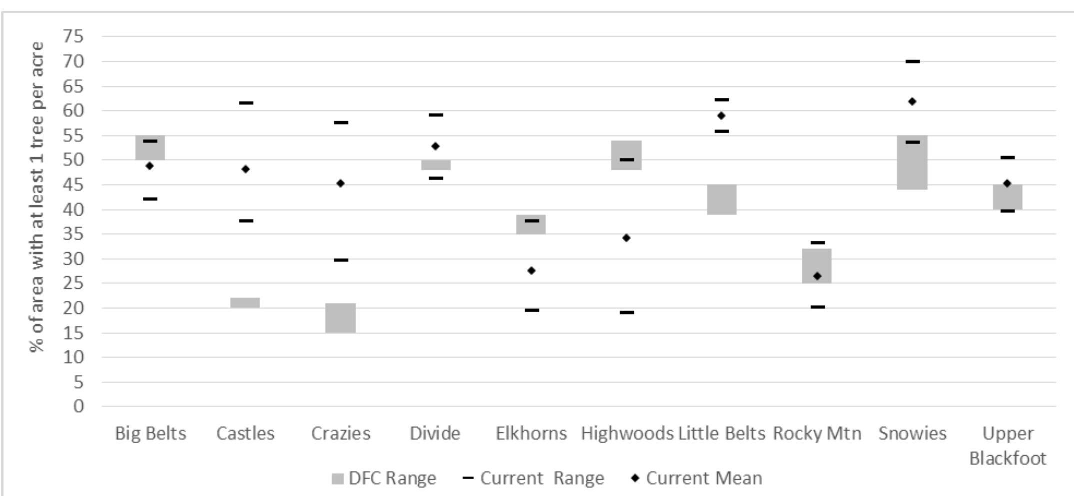


**Figure 18. Current and desired condition for aspen presence by GA**

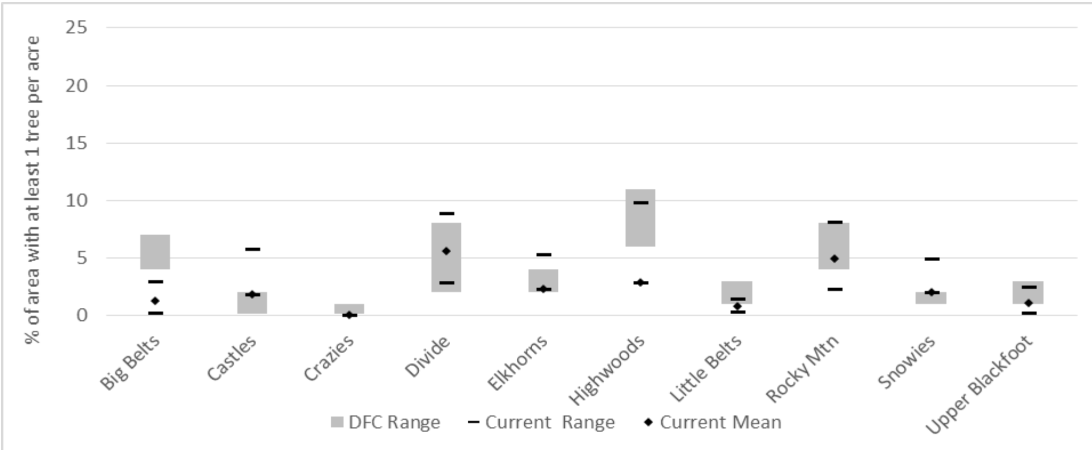



**Figure 19. Current and desired condition for lodgepole pine presence by GA**

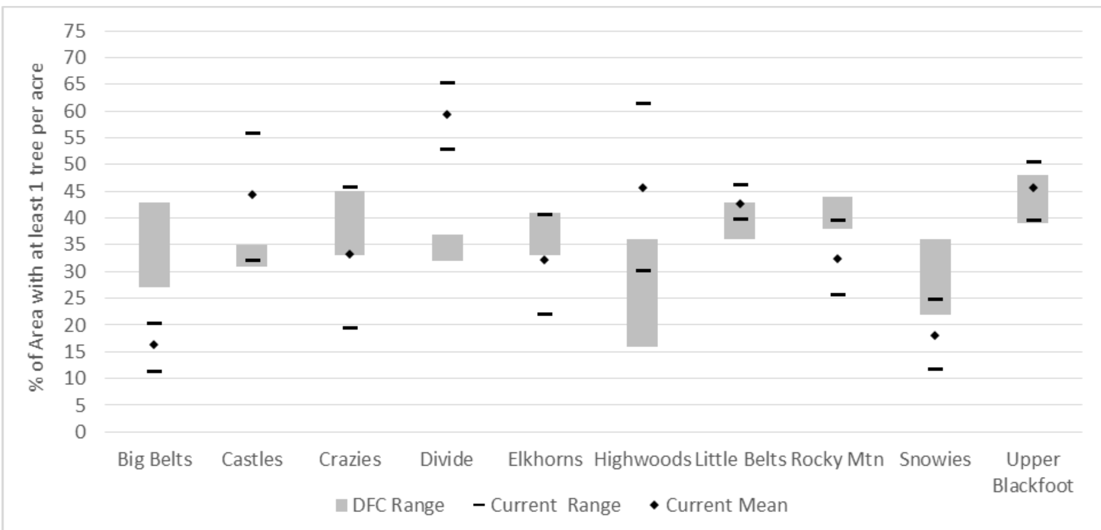



**Figure 20. Current and desired condition for Engelmann spruce presence by GA**

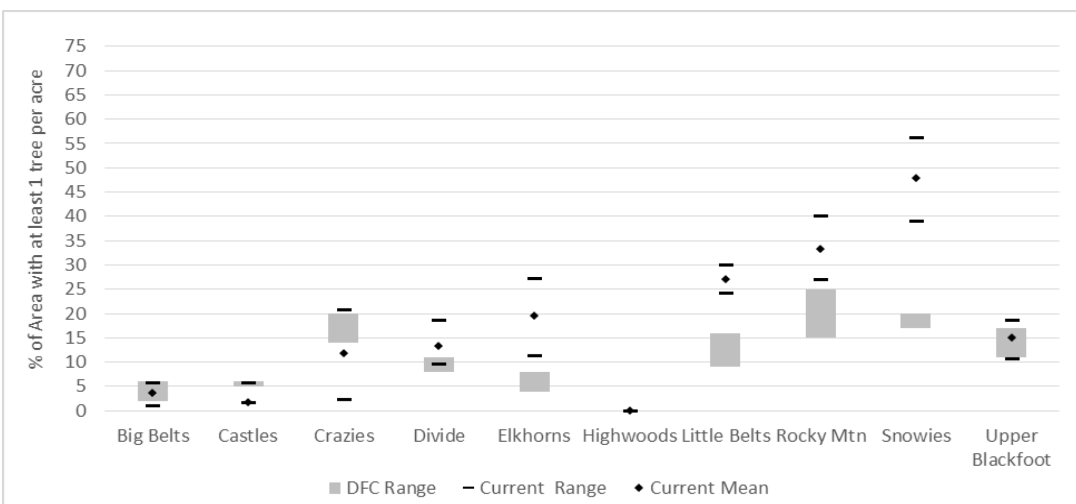


**Figure 21. Current and desired condition for subalpine fir presence by GA**

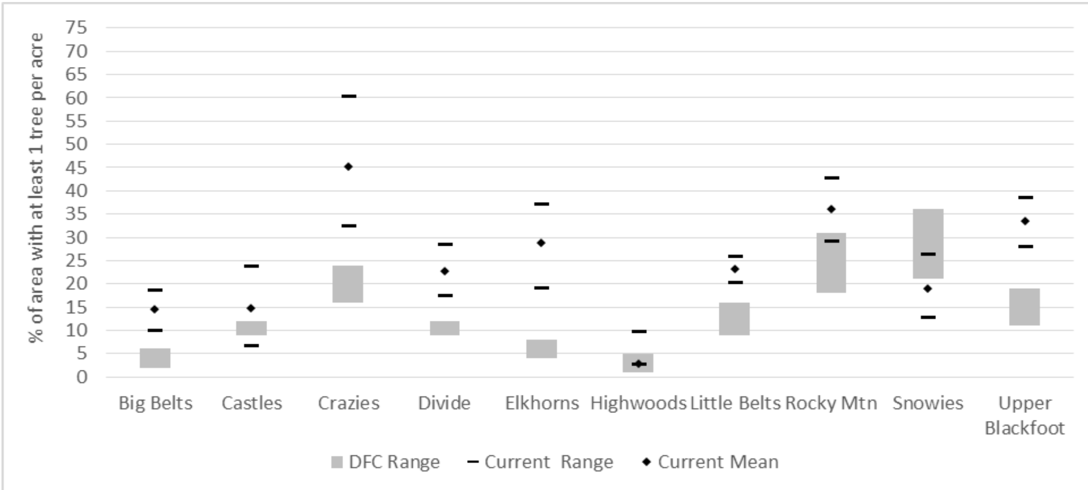
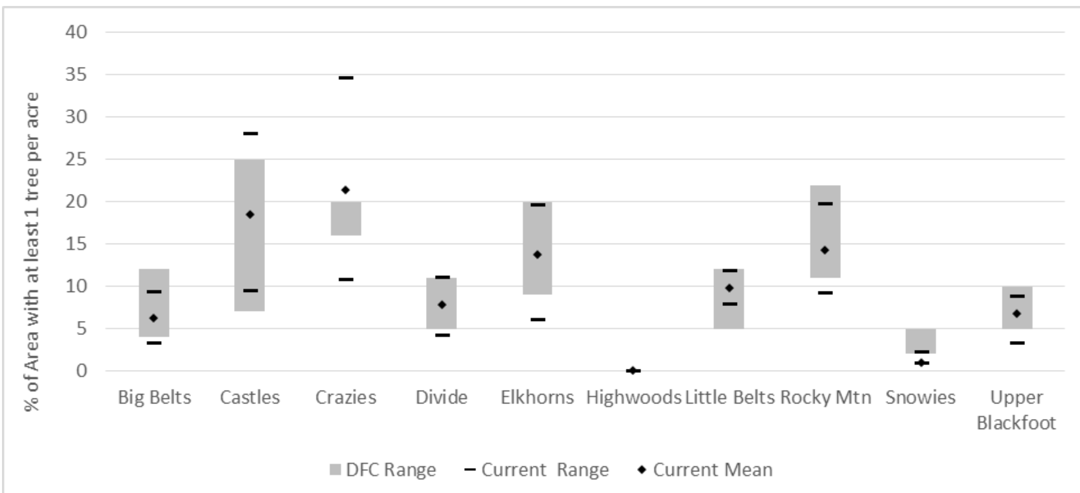



**Figure 22. Current and desired condition for whitebark pine presence by GA**




### Forest size class

The primary desired shift in size class is an increase in the large size class and a decrease in the small size class. Modeling indicates that large and very large size classes were at the lower end of their natural ranges of variation during warm/dry periods such as those expected in the future; however, this level still exceeds the existing condition. A wide range of seedling/sapling forests is desired because this class fluctuates according to the size and frequency of stand replacing disturbances. Substantial proportions of the forest should be in the mid-successional stages of development (small to medium size classes), where they can remain for long time periods. Less dense forests or forests on more productive sites may transition up to large size class relatively quickly (e.g., 100 years from fire event), while higher density forests or those on harsh growing sites may take much longer. Some forest types (such as lodgepole pine) may remain in the small and medium classes their entire lifespan. A limited amount of the very large forest size class is possible based on the species and growing conditions found on the HLC NF. Many forest stands will never achieve a very large size class, due to growing conditions and/or disturbances. The table below describes the desired trend for forest size class by broad PVT.

**Table 4. Desired trend of forest size class by broad PVT**

| Broad PVT | Desired trend of forest size class |
|---|---|
| Warm Dry | The existing proportion of small and medium size classes are well above the natural range of variation and desired condition, while the large class is substantially below. The very large class is also underrepresented. 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 (for example ponderosa pine and Douglas-fir). In sheltered riparian areas, groves of large Engelmann spruce could develop. The warm dry group is the most substantially departed from the natural range of variation, congruent with our understanding of the effects of fire exclusion in these types. The desired condition reflects a fire regime characterized by more frequent low to mixed severity fires, with all forest size classes relatively well represented. |
| Cool Moist | The abundance of the small tree class is only slightly above the natural range of variation and desired condition. The existing proportion of large and very large size classes are somewhat below the desired range but not to the extent as warm dry sites. In large part, this is due to this potential vegetation group being 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 sheltered, moist settings. |
| Cold | The existing proportion of the small tree size class is above the desired range, and the large tree size class is below. Unlike the other potential vegetation groups, the very large tree class is within the natural range of variation, likely 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, tolerant of the moderate or low severity fires that typically occurred. Large subalpine fir and Engelmann spruce would develop in riparian areas and moist basins. |

The following series of figures display the current condition and desired range in proportion of size classes forestwide and by each broad PVT.

**Figure 23. Forest size class current and desired conditions, forestwide.**

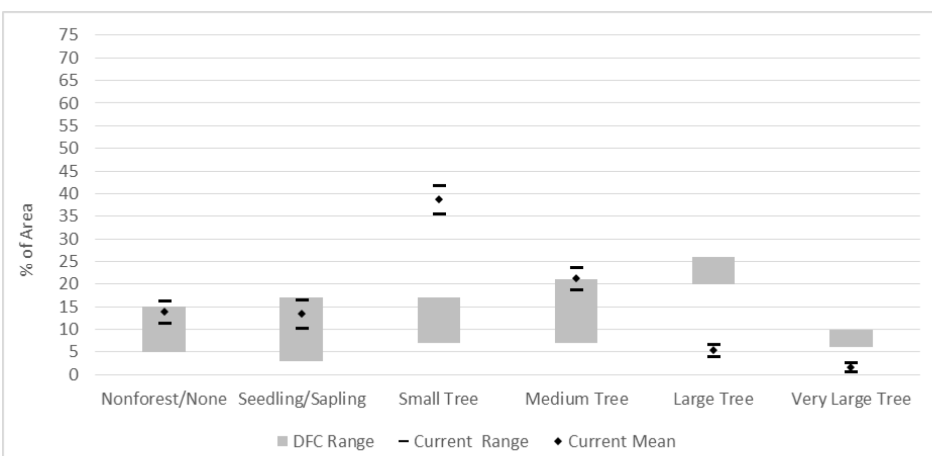


**Figure 24. Forest size class current and desired conditions, warm dry broad PVT**

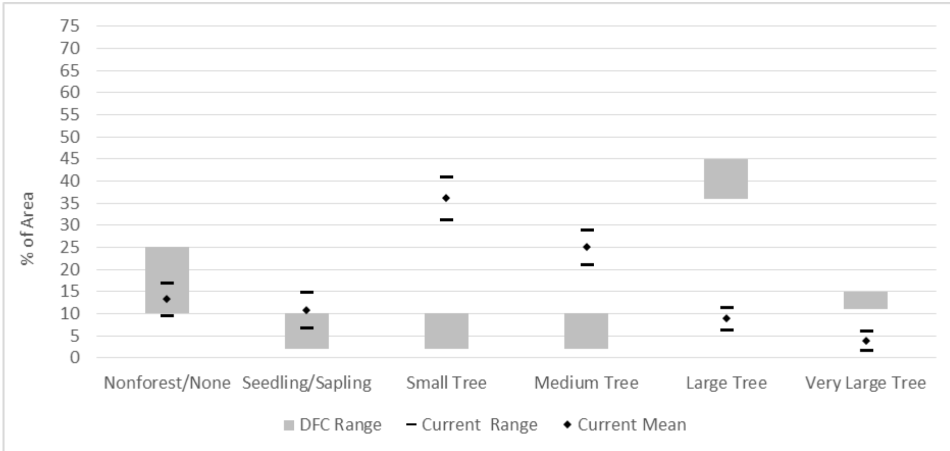



**Figure 25. Forest size class current and desired conditions, cool moist broad PVT**

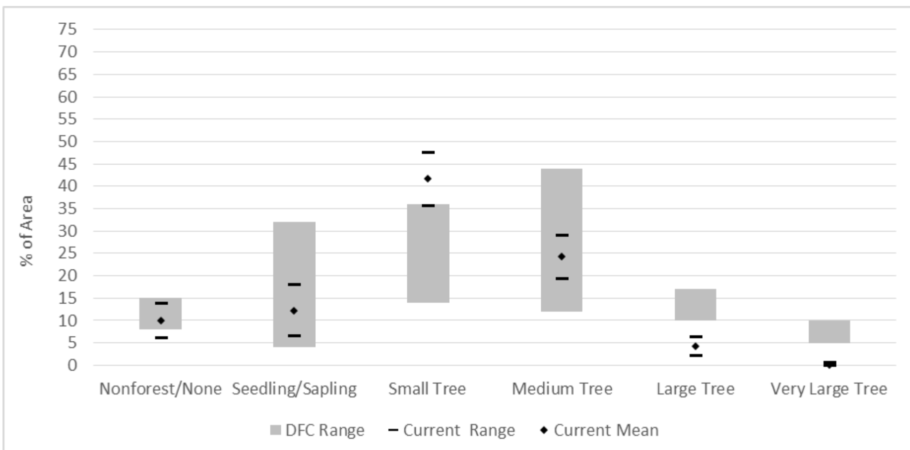
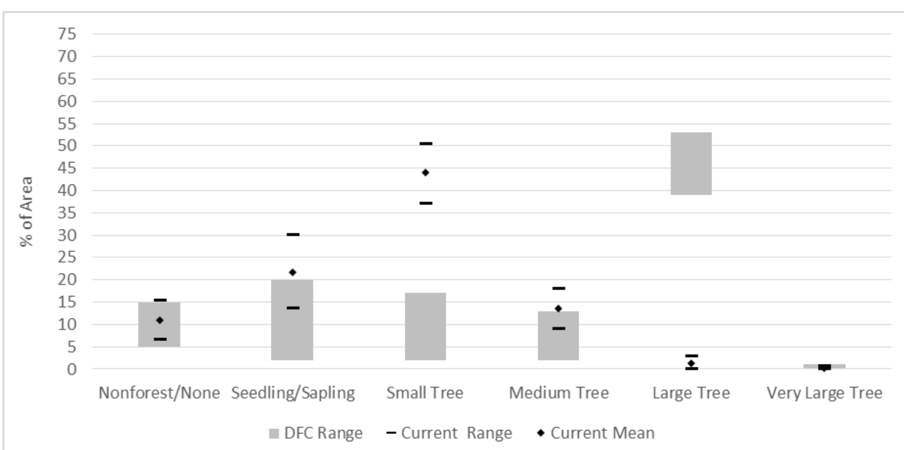



**Figure 26. Forest size class current and desired conditions, cold broad PVT**




### Large and very large live tree concentrations

While the proportion of very large tree concentrations across the landscape are slightly lower than desired, the large tree concentrations are much more so, especially in the warm dry and cold broad PVTs.

**Figure 27. Current and desired condition for large tree concentrations forestwide and by broad PVT**

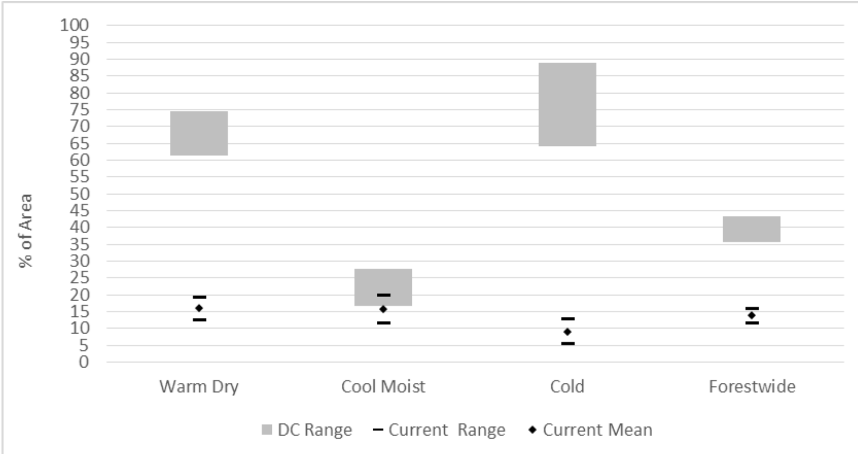
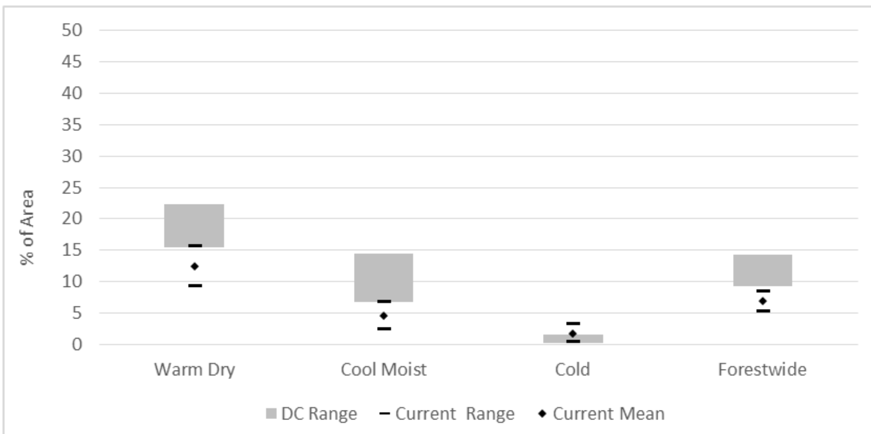



**Figure 28. Current and desired condition for very large tree concentrations forestwide and by broad PVT**




### Large and very large live trees per acre

The final indicator for large and very large trees is the average trees per acre. These trees may be clumped or scattered, rare individuals that are not captured in either the size class or concentration criteria. It is desirable to maintain or increase the area and/or density of the large and very large live trees however they are distributed. Due to their longevity, fire resistance, and contribution to ecosystem resilience, the most desired species of these are Douglas-fir and ponderosa pine.

The following figures display the current condition and desired range of large and very large trees per acre forestwide and by snag analysis groups as defined by Bollenbacher and others (2008). Snag analysis groups are appropriate because they split apart lodgepole pine dominated areas. This provides a more accurate depiction of the ability of sites to produce large and very large live trees. Lodgepole pine is smaller in size and shorter lived than the other tree species.

Figure 29. Current and desired condition for large trees per acre forestwide and by snag analysis group

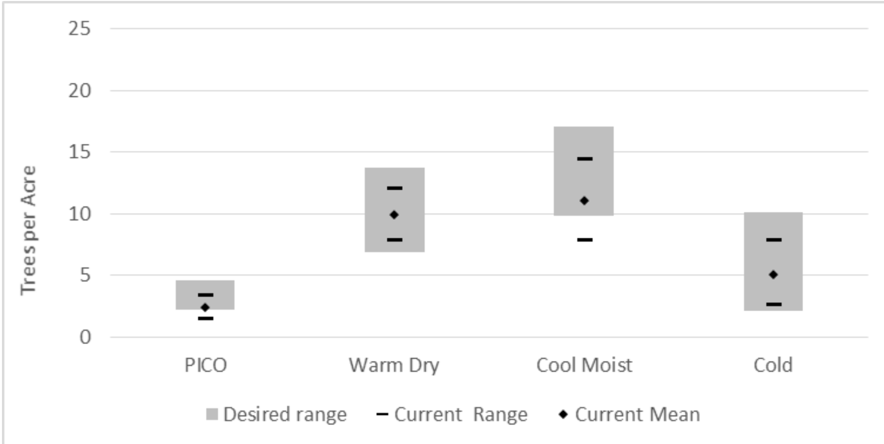
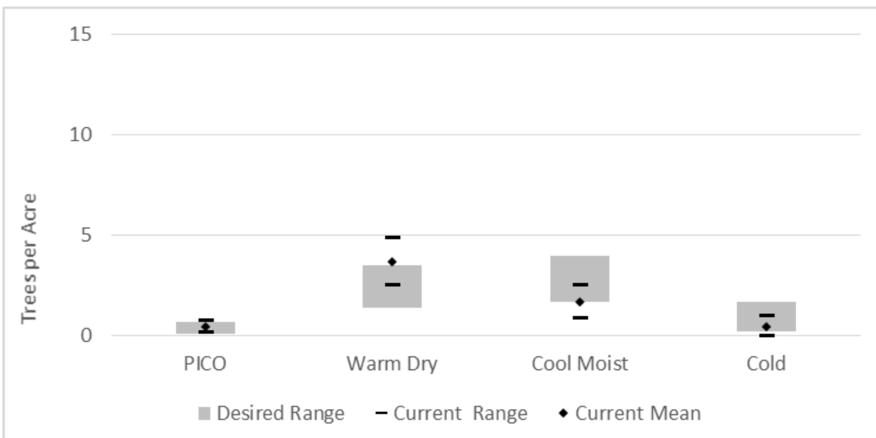



Figure 30. Current and desired condition for very large trees per acre forestwide and by snag analysis group




### Forest density and vertical structure class

The NRV analysis indicated that the low/medium canopy cover class was common forestwide, especially on the warm dry broad PVT. Fire exclusion has resulted in higher canopy densities in dry cover types which would otherwise have been maintained at more open densities by frequent low intensity fire. 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 removed trees and 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. In pine dominated forests, the mountain pine beetle outbreak may have recently caused changes in the forestwide averages. It is likely that some of high density pine areas have shifted into open classes. The table below displays the desired conditions for density classes and associated vertical structures.

Table 5. Desired condition for forest density and vertical structure

| Broad PVT | Desired condition of density class and vertical structure |
|---|---|
| Warm Dry | These sites historically supported more open forests than what is present today. It is desirable to increase the proportion of low/medium and reduce the high density class. |

| Broad PVT | Desired condition of density class and vertical structure |
|---|---|
| | 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. |
| Cool Moist | The medium/high density class is lower than the desired range and the high density class is higher. This may be indicative of dense understories of shade tolerant trees developing under lodgepole pine canopies 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 the most common species present, lodgepole pine. Multi-storied forests are also important, and are likely most often found in spruce/fir cover types. |
| Cold | The desired trend is similar to the warm dry broad potential vegetation group. In the past, fire promoted more open and uneven-aged whitebark pine forests. Single storied forests are likely dominated by lodgepole pine 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 in many areas with fire exclusion and due to the other threats facing whitebark pine such as mountain pine beetle and white pine blister rust. |
| Nonforested | Based on the modeling, it would initially appear that non-forested or savanna areas may be more prevalent today than historically; however, these types were more abundant during warm/dry climate periods. Therefore, a trend of maintaining or increasing non-forested 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). |

The following figures display the current and desired proportions of density classes forestwide and by broad PVT.

**Figure 31. Current and desired percent of area by forest density class, forestwide**

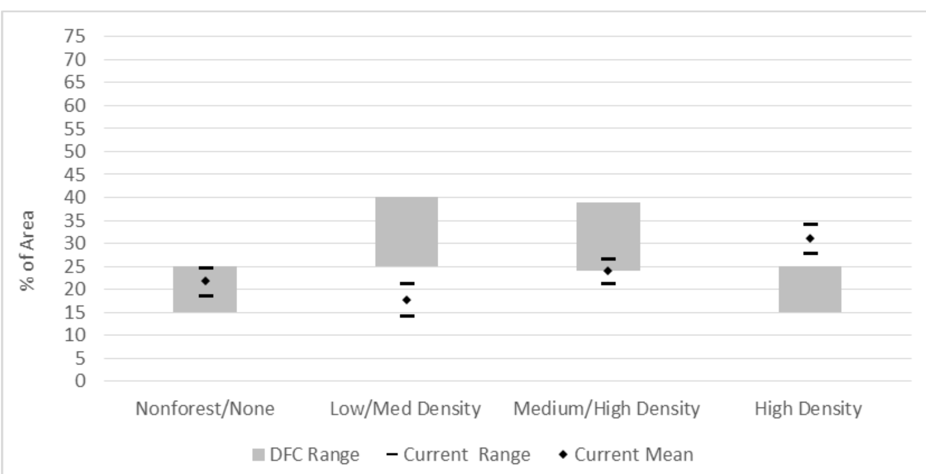


**Figure 32. Current and desired percent of area by forest density class, warm dry broad PVT**

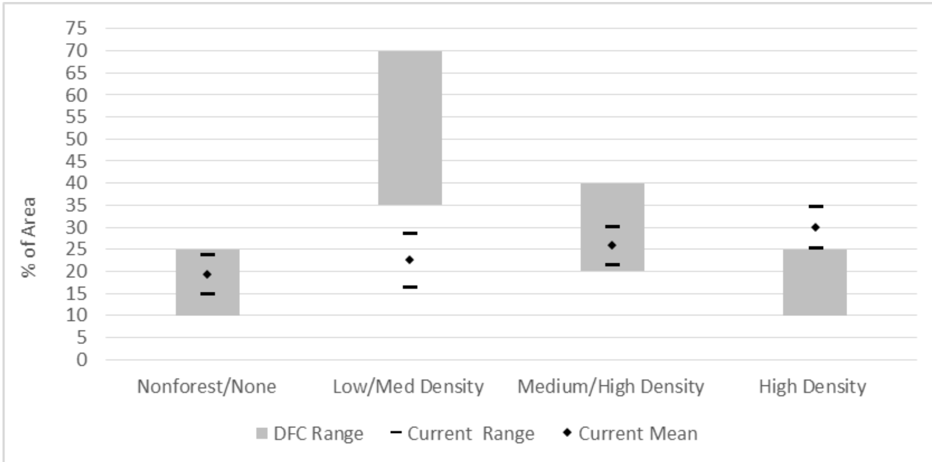



**Figure 33. Current and desired percent of area by forest density class, cool moist broad PVT**

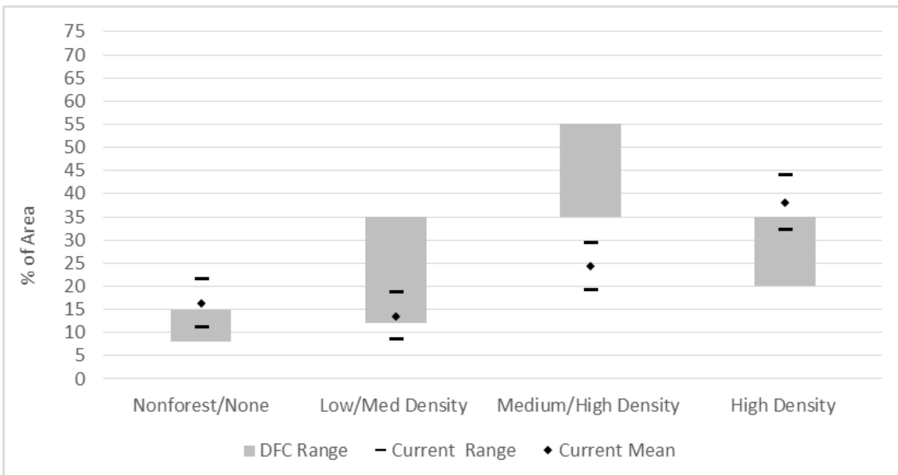
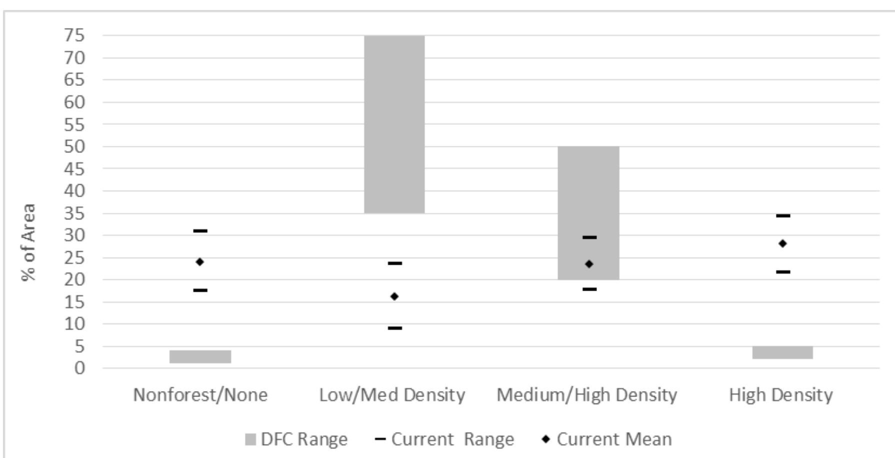



**Figure 34. Current and desired percent of area by forest density class, cold broad PVT**




The following figures display the current proportions of vertical structure classes forestwide and by broad PVT, compared to the NRV. There are no desired conditions developed specifically for this attribute.

**Figure 35. Current proportion of vertical structure classes forestwide compared to the NRV**

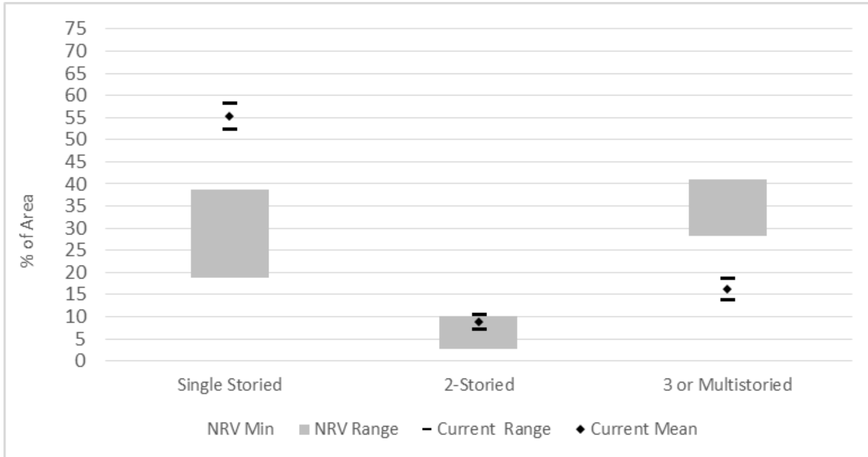



**Figure 36. Current proportion of vertical structure classes in the warm dry broad PVT compared to the NRV**

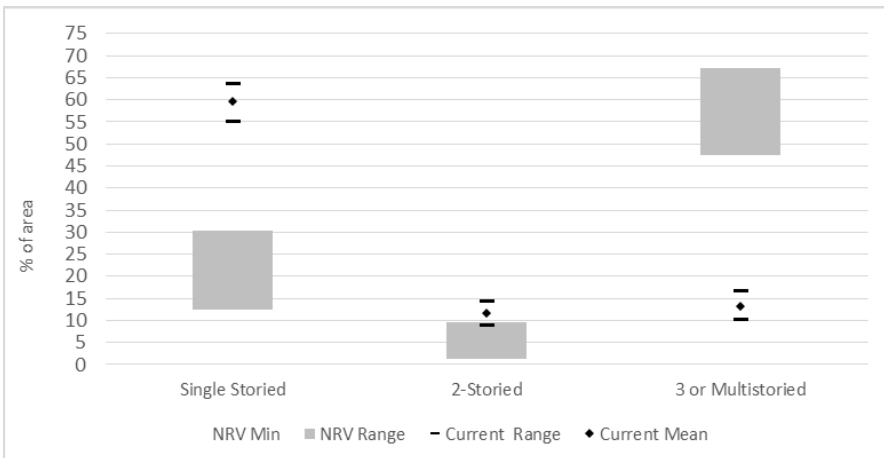



**Figure 37. Current proportion of vertical structure classes in the cool moist broad PVT compared to the NRV**

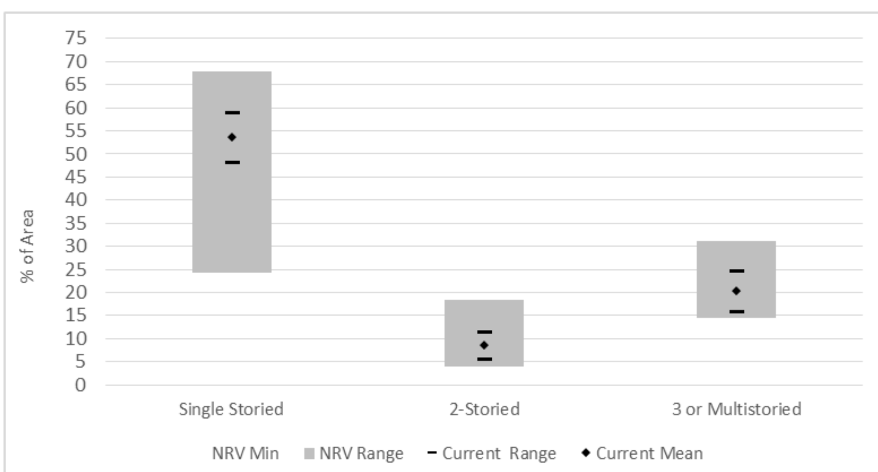
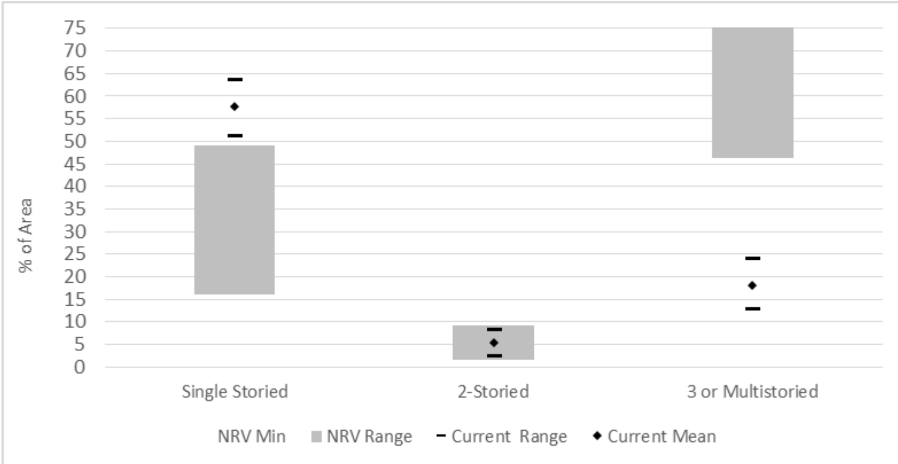


**Figure 38. Current proportion of vertical structure classes in the cold broad PVT compared to the NRV**




### Early successional forest patches

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 because this condition is quantifiable, represents likely patterns of older forests, and is meaningful for many species. Openings in the forest are created after a stand-replacing disturbance, and are the most distinct and easily detectable structural conditions in a forested landscape because they are dominated by grass, forbs, shrubs, and short trees. They are meaningful to many wildlife species and also represent the initiation point in forest development, the foundation upon which rests the pattern of the future forest. Table 6 compares results of the NRV analysis (which is the desired condition) with the current condition. The two indicators used are:

- *Average patch size*, which is a simple arithmetic mean; and
- *Area weighted mean patch size*, in which the mean is weighted based on the size of the patch. This metric reflects the largest average patches that would occur.

An opening was included in the calculation for as long as it remained in the seedling/sapling size class. This provides the full ecological picture of the extent and duration of forest openings. A patch analysis was also run to inform the development of timber standards related to maximum opening sizes that can be created with even-aged timber harvest.

There was rarely if ever a decade historically when there weren't openings created by fire somewhere on the HCL NF. The majority of fires were relatively small (as indicated by the arithmetic average). However, when the big fires did occur, they were very large (as indicated by the area weighted mean). These large fires would typically be associated with warm climatic periods and drought conditions.

**Table 6. Existing and natural range of variation of early successional forest patch size[2] acres**

| Attribute | Forestwide | Warm Dry | Cool Moist | Cold |
|---|---|---|---|---|
| NRV[3] Mean Patch Size of patches | 81<br>(35-139) | 29<br>(21-57) | 95<br>(37-164) | 33<br>(17-68) |
| NRV[3] Area Weighted Mean Patch Size[1] | 10,213<br>(223-72,288) | 174<br>(47-4,210) | 7,833<br>(195-45,694) | 142<br>(24-868) |
| Existing Condition Avg. Patch Size | 113 | 49 | 76 | 39 |

| Attribute | Forestwide | Warm Dry | Cool Moist | Cold |
|---|---|---|---|---|
| Existing Condition Area Weighted Mean of patches | 25,507 | 1,615 | 7,296 | 2,033 |

1 Weighted mean patch size provides an indication of the maximum or largest patch size
2 Patches had a minimum size threshold of 10 acres. Source for all data: SIMPPLLE modeling.

### *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 that is needed for modeling into the past and future. To create the modeling dataset, VMap was updated to be as similar to FIA as possible. Inherent differences remain due to differences in methods such as data collection methods and timing. However, the depictions 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 of desired conditions. The following information discloses the level of similarity between the two data sources of the existing condition and their relationship to the desired condition. Further information is available in the planning record.

- 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 broad PVT and cool moist broad PVT the map and plots closely agree. In the cold broad PVT, VMap closely agrees with FIA for most cover types. However, the map shows lower amounts of lodgepole pine and higher amounts of spruce/fir than the plots. The accuracy of the cold PVT is the most unreliable of all the potential vegetation types because it is present on the smallest area and therefore represented by the fewest plots.
- 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 broad PVT the biggest discrepancy between plots and the map is seen in the medium class, with VMap indicating that more is present. All other classes are similar for both data sources. VMap closely agrees with FIA plots in all cases for the cool moist broad PVT. In the cold broad PVT, VMap shows slightly higher amounts of small and medium size classes, and slightly less grass/shrub, than the FIA plots. However, the data sources agree that a decrease in small and medium with an increase in the large size class is warranted relative to the desired conditions.
- Forestwide, VMap is nearly within the FIA estimate confidence interval for all canopy cover (density) classes except 60%+. Both the map and plots indicate a desired decrease in the 60%+, although the magnitude of the desired change varies. In the warm dry broad PVT, VMap is generally within the confidence interval for plot estimates except the 60%+ is slightly high (to a lesser degree than Forestwide). The sources agree that a decrease in this class is warranted to achieve the desired condition range. Similar to the Forestwide scale, in the cool moist broad 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 broad PVT, VMap shows much less of the nonforested/<10% tree canopy than FIA plots, as well as more of the 60%+ class. The sources agree on a desired trend of increasing the 10-39% class and decreasing the 60%+ class, while the 40-59% class is at the low end of the desired range.

## Modeling and evaluation of vegetation change

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 natural range of variation; 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
- Spectrum
- 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 Spectrum, which assigns the changes to vegetation in those areas based on yield tables.
4. The Spectrum 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 Spectrum 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.

Modeling simulations of vegetation five 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.

In the Spectrum model, vegetation management activities were planned over time in each alternative by considering land allocations, desired conditions, resource constraints, and budget limitations. Spectrum was run with an objective that was in keeping with the theme of the alternative. Outputs from the Spectrum model are displayed in the Timber section of this appendix.

Projected treatments from Spectrum were integrated into the SIMPPLLE model for a spatial analysis of vegetation change over time, interacting with succession, fire, insects, and disease. Thirty simulations were run to capture the variability associated with disturbances. The model was run with a “warmer” climate condition for all modeling periods. The attributes modeled quantitatively include species composition, forest size classes, and forest density.

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 are one tool to help inform the analysis; they provide information of comparative value, and are not intended to be predictive. Model outputs augment other sources of information, including research and professional knowledge.

## SIMPPLLE model design

SIMulating Patterns and Processes at Landscape scaLEs (SIMPPLLE)(Chew, Moeller, & Stalling, 2012) is a model that simulates changes in vegetation on landscapes in response to both natural disturbances and management activities, as they interact with climate. This model was used for two purposes: 1) to calculate the NRV; and 2) to project disturbances and vegetation conditions into the future.

The VMap was the base map used to develop the input map for SIMPPLLE, and it was calibrated with FIA plot data for vegetation species and size classes. Broad PVTs, GAs, ownership, and other features such as wildland urban interface 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 ten years, and simulations are made for multiple timesteps. The logic assumptions in the model come from a variety of sources, including expert opinion, empirical data, 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. These include modification of successional pathways, regeneration logic, insect/disease probabilities, and fire logic. There remains uncertainty due to the ecological complexities and lack of ability to predict the future. 30 model simulations were run to capture the variability and uncertainties.

Please refer to the planning record document, *Helena-Lewis & Clark NF SIMPPLLE Modeling for Forest Plan Revision* for more detailed metadata. In addition, results for the NRV modeling are displayed in a report in the planning record, *Helena and Lewis & Clark National Forest Natural Range of Variation Analysis for Forest Plan Revision, Summary Report March 2017*”. The sections below display results from the future modeling of alternatives for the DEIS. For all results, the mean of all 30 runs is shown.

## SIMPPLLE model results for terrestrial vegetation

### *Future Insects and Disease*

SIMPPLLE is used to estimate the probable extent and severity of insects and disease in the future, taking into account expected climate, vegetation treatments, and fire suppression. The average acres projected do not imply an “even flow” of acres affected over time. The acres infested would vary by decade. These estimates have a high level of uncertainty.

**Figure 39. Mean acres per decade affected by insects, by alternative, across five decades**

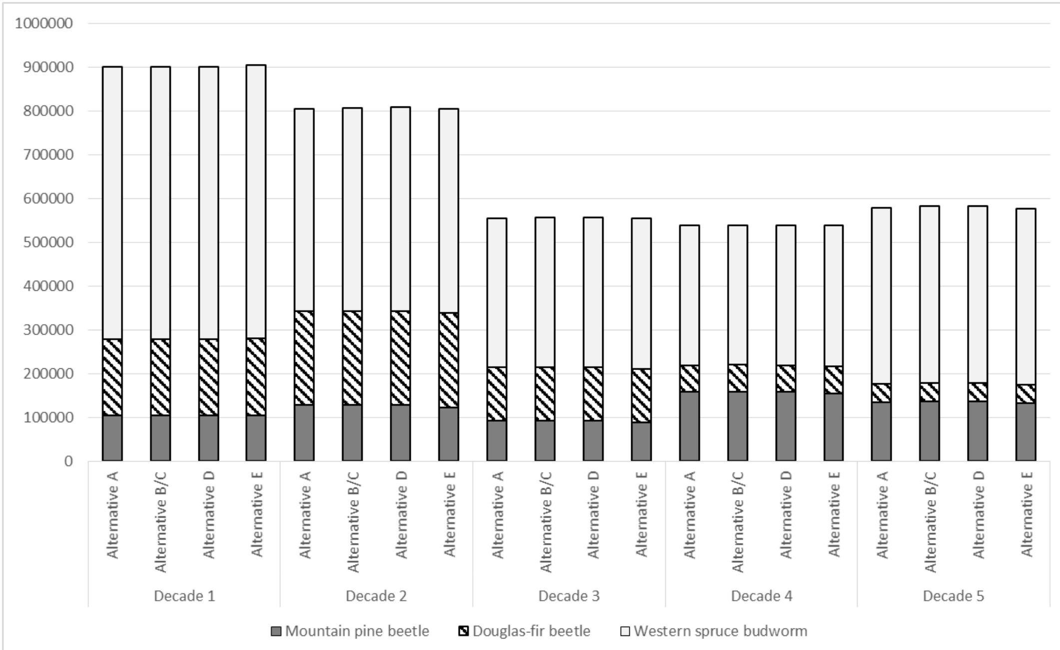


**Figure 40. Average acres per decade affected by mountain pine beetle, by alternative**

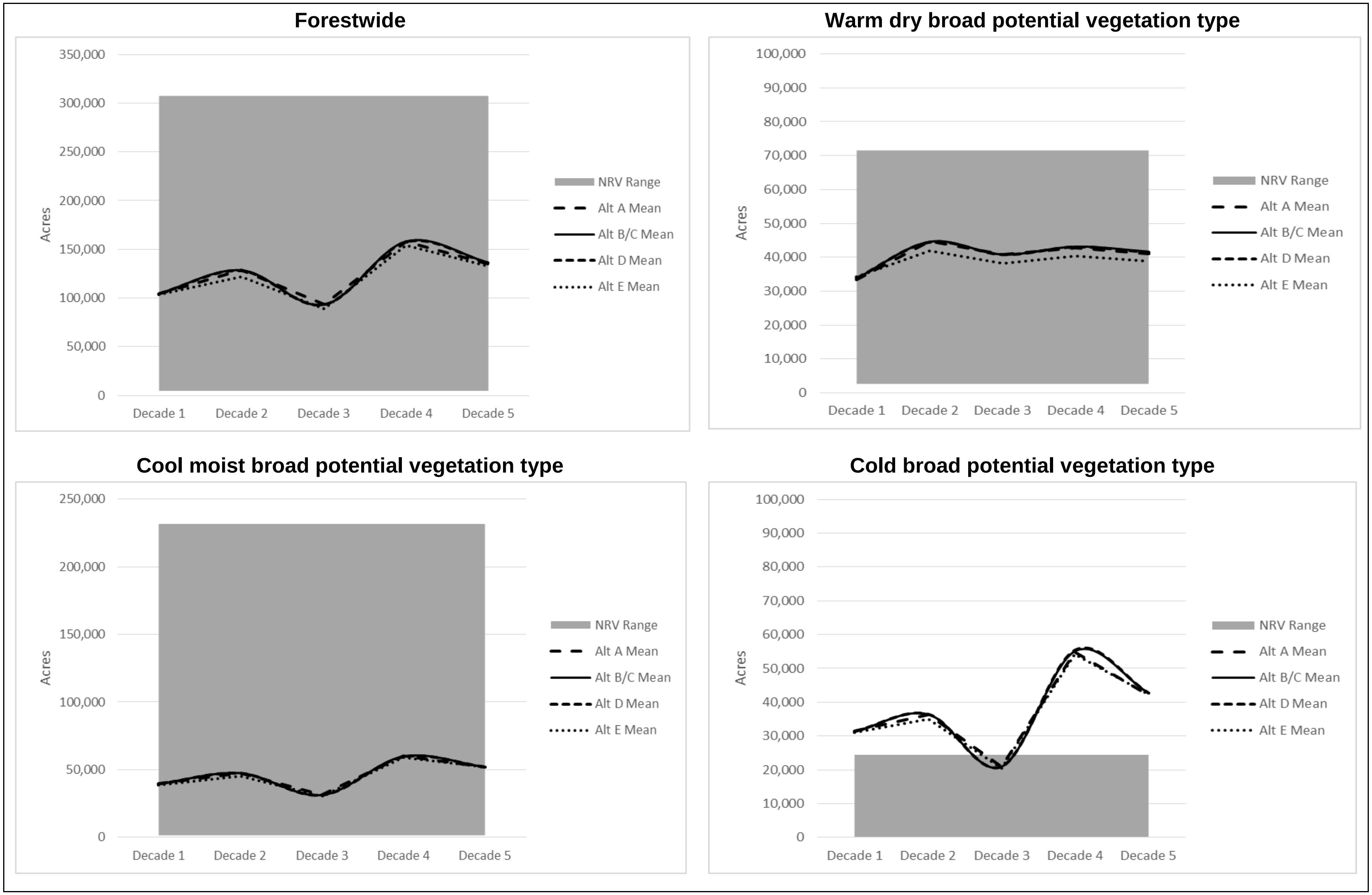


**Figure 41. Average acres per decade affected by Douglas-fir beetle, by alternative**

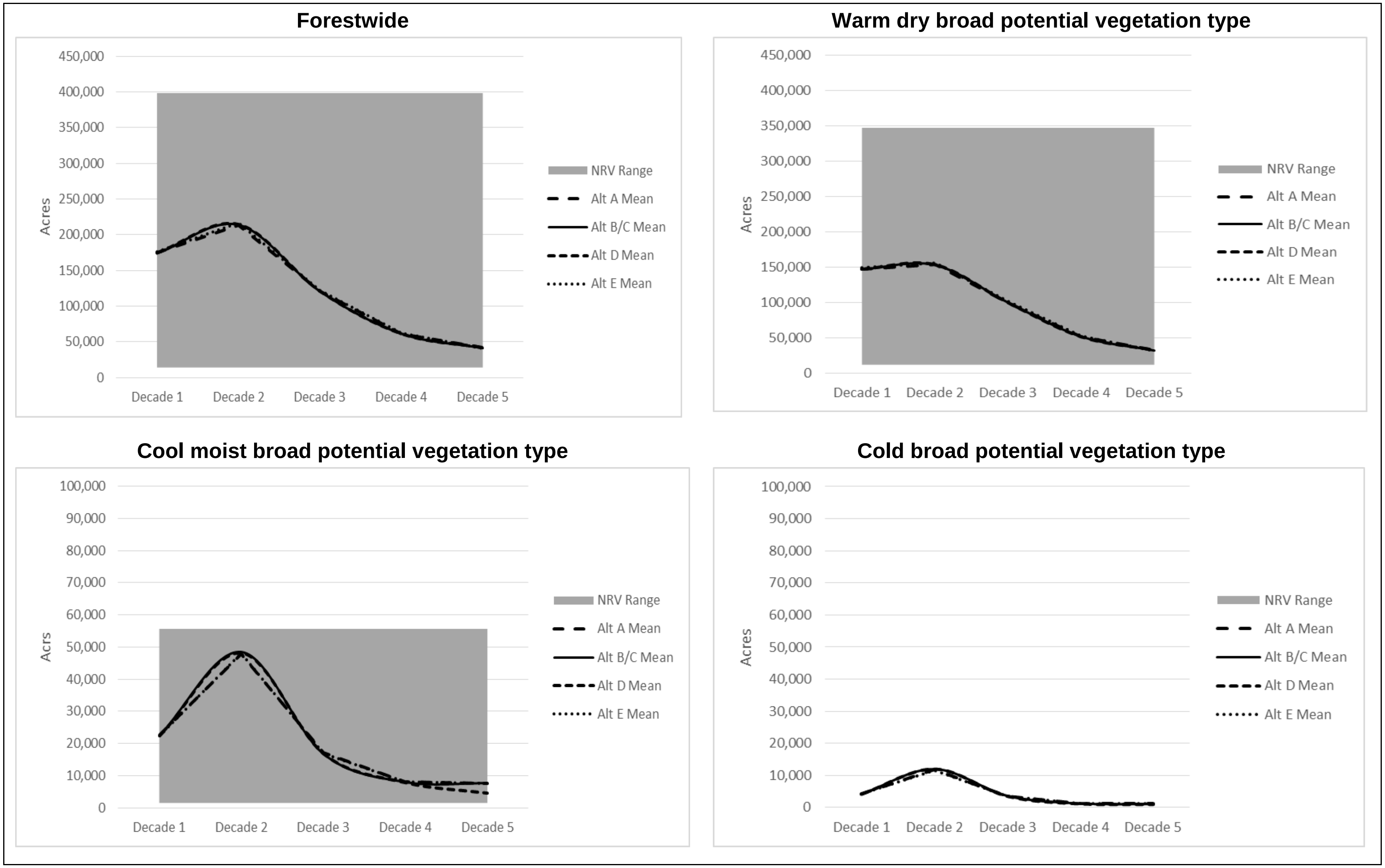


**Figure 42. Average acres per decade affected by western spruce budworm, by alternative**

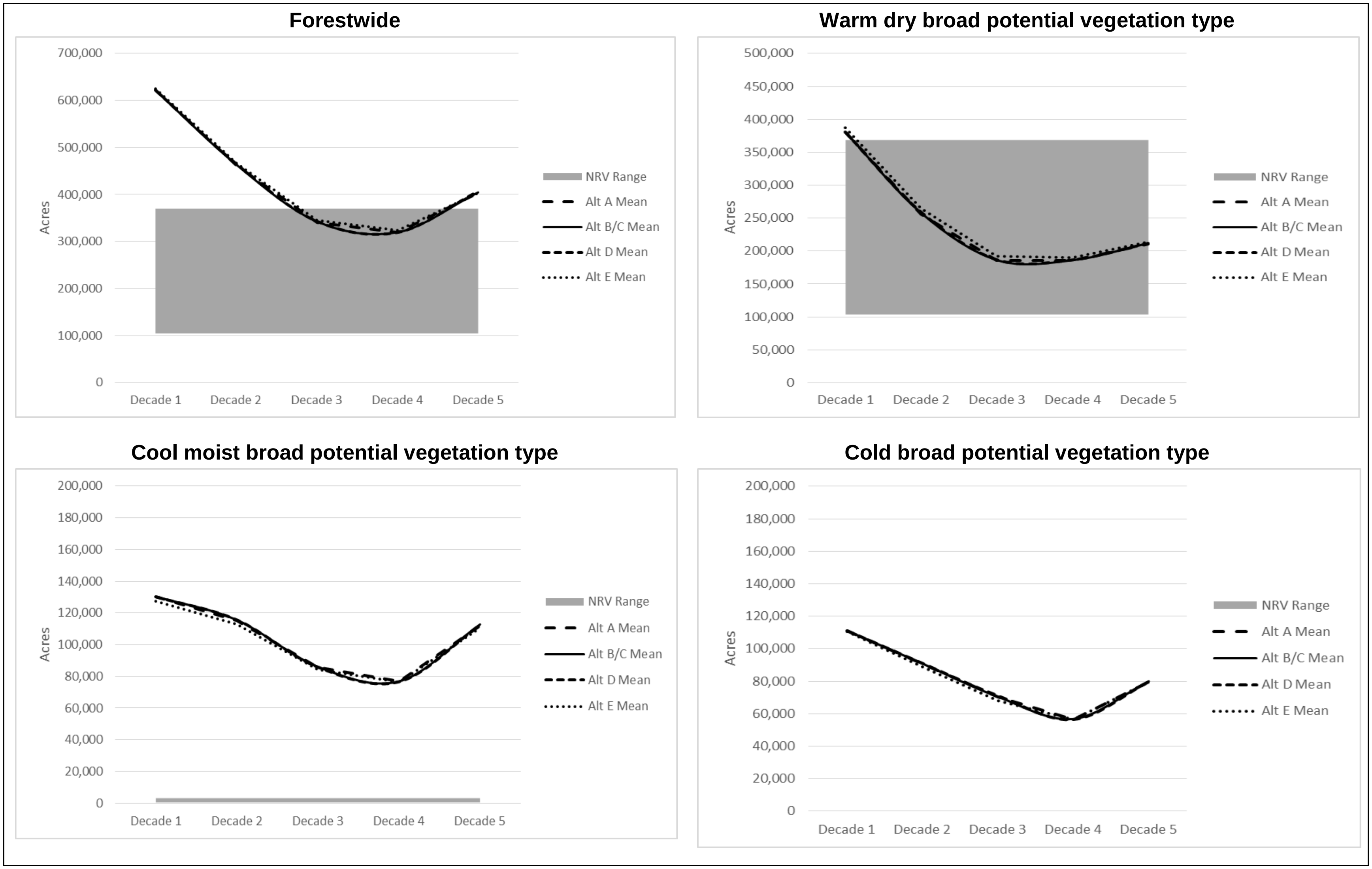
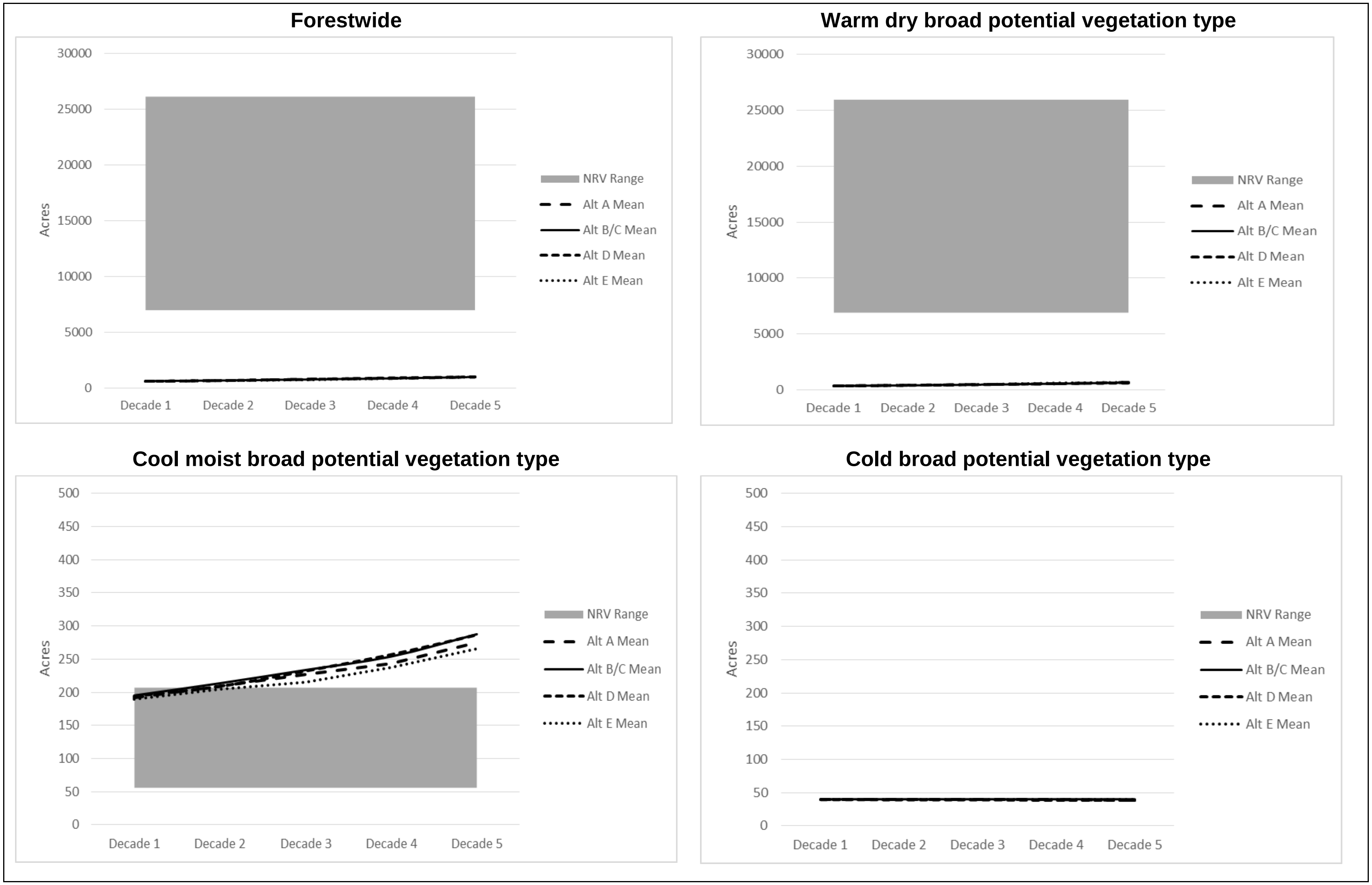


**Figure 43. Average acres per decade affected by root disease, by alternative**



### *Future terrestrial vegetation conditions*

The following sections show the future conditions for the key ecosystem characteristics identified for composition, structure, and function of terrestrial vegetation. The mean estimate of each condition depicted across 30 SIMPPLLE model runs, along with the existing condition and desired condition ranges. The existing conditions are based on FIA or FIA intensified grid plots. In some cases, this existing condition is not consistent with the starting condition of SIMPPLLE (based on VMap), due to the disparity in data sources. The expected trend is more crucial to the analysis than the overall endpoint.

#### Cover type

The modeled abundance of forested and nonforested cover types for the 50 year model period are shown in the figures below. Results are included for each R1 broad PVT (unless the cover type does not occur on a given PVT). Nonforested cover types (and size classes) are assigned to areas with less than 20 BA/ac or 100 TPA of trees. Most of these areas are grass or shrublands, but some are very open forest savannas or recently disturbed areas where reforestation has not yet occurred. Nonforested cover types are also displayed by GA, because there are desired conditions for this type at the GA scale. In addition, specific types are displayed for several GAs that have specific desired conditions developed that vary from the forestwide ranges: the Crazies, Elkhorns, Divide, Highwoods, Rocky Mountain Range, and Snowies.

**Figure 44. Cover types forestwide – desired range and mean at 50 years by alternative**

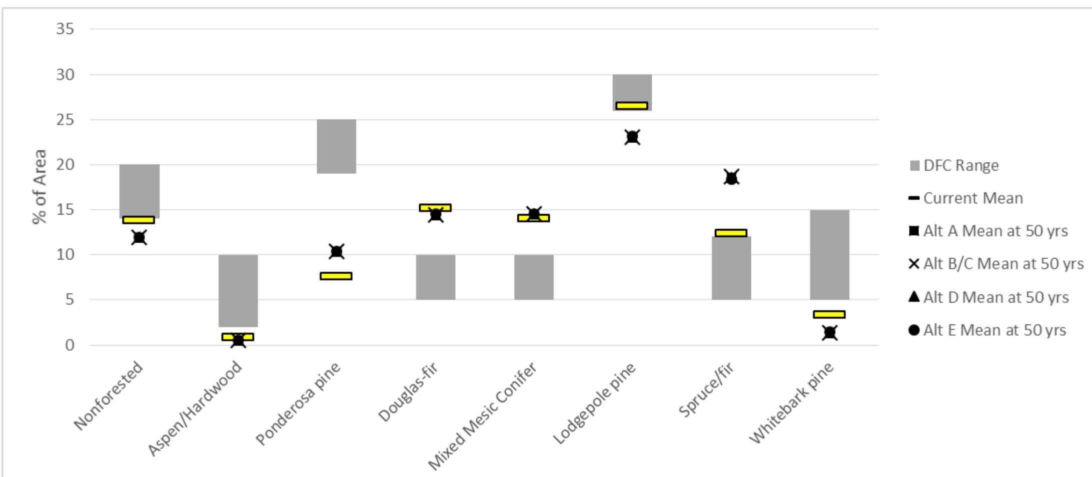



**Figure 45. Nonforest cover types by GA, desired range and mean at 50 years by alternative**

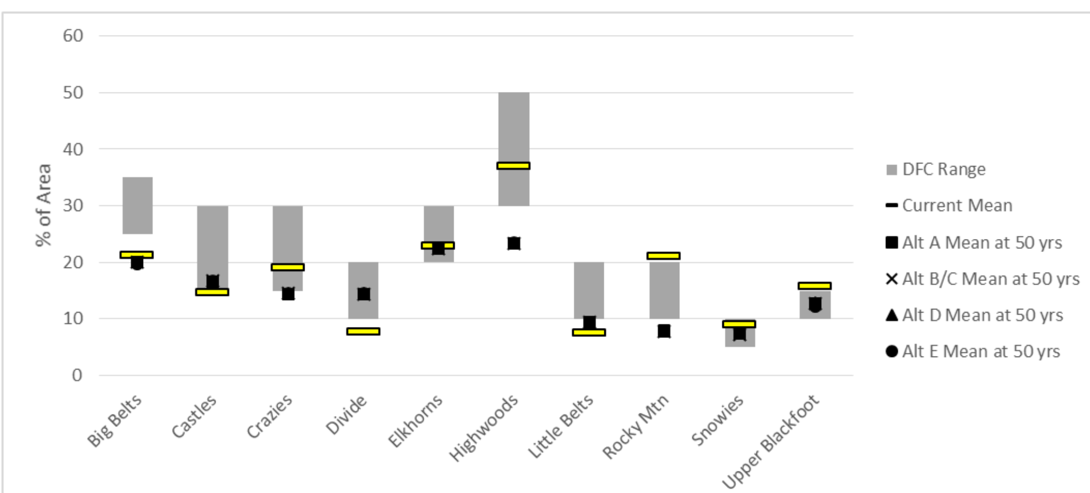


**Figure 46. Nonforest cover types over 5 decades**

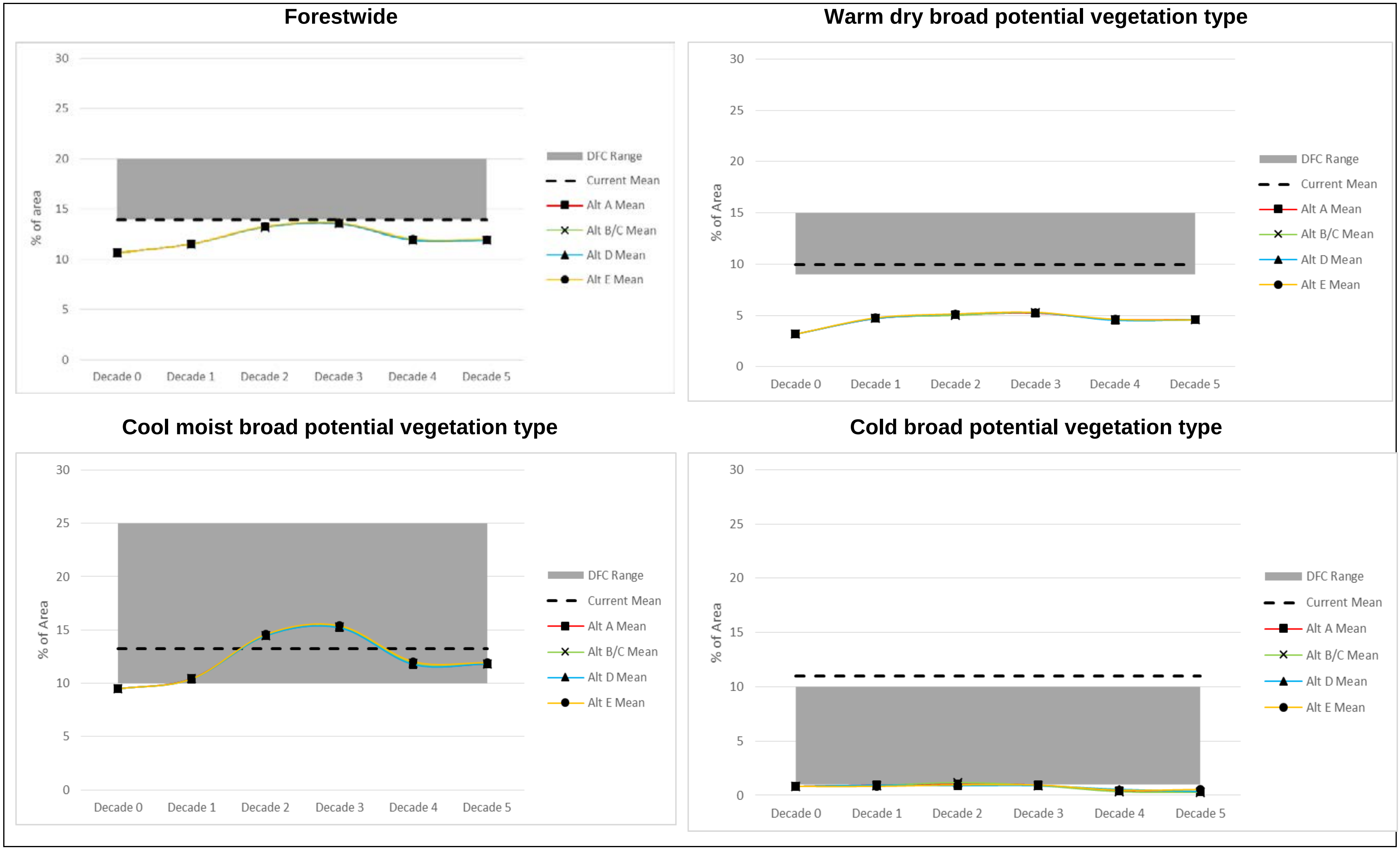


**Figure 47. Aspen/Hardwood cover type over 5 decades**

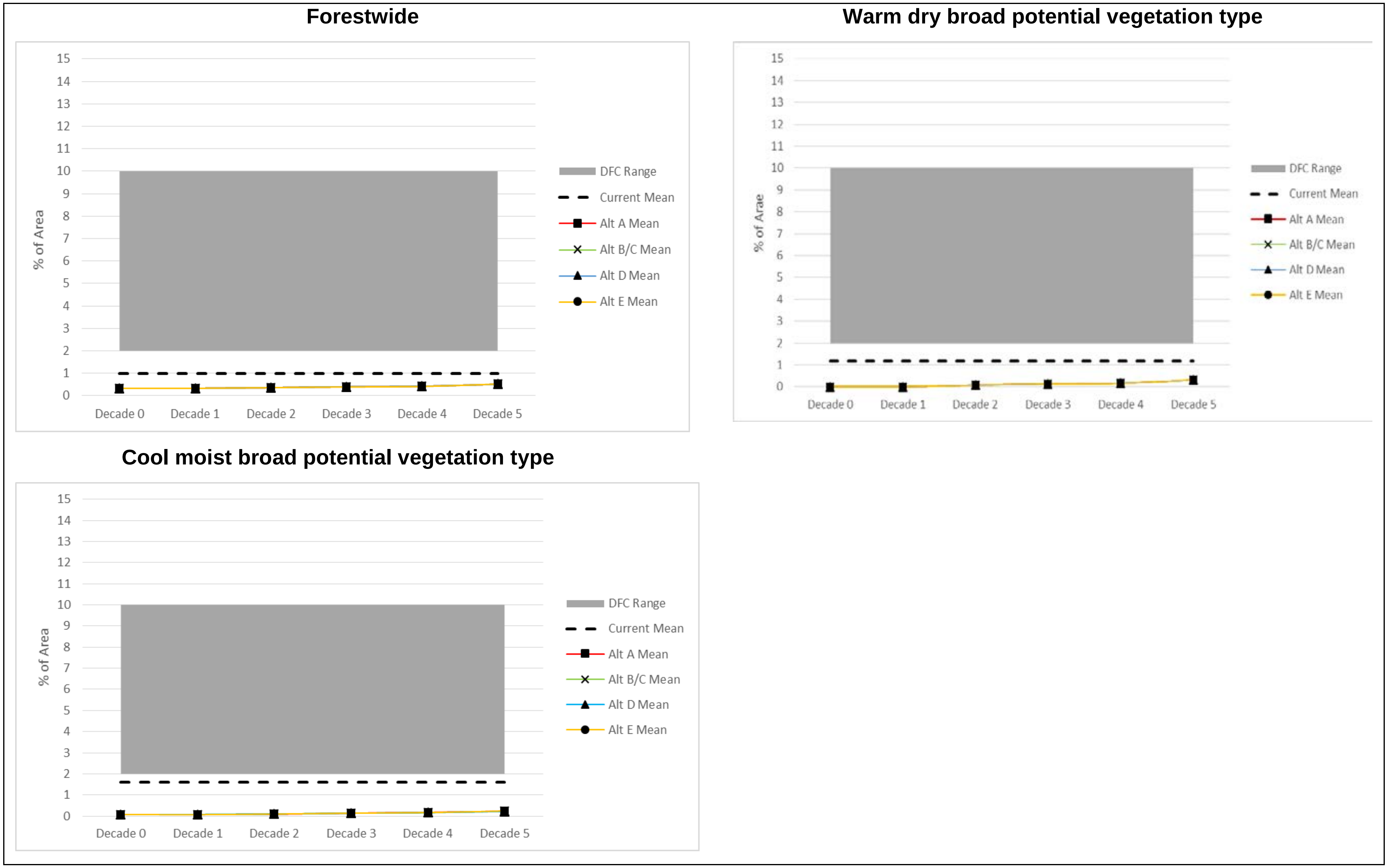


**Figure 48. Ponderosa pine cover type over 5 decades**

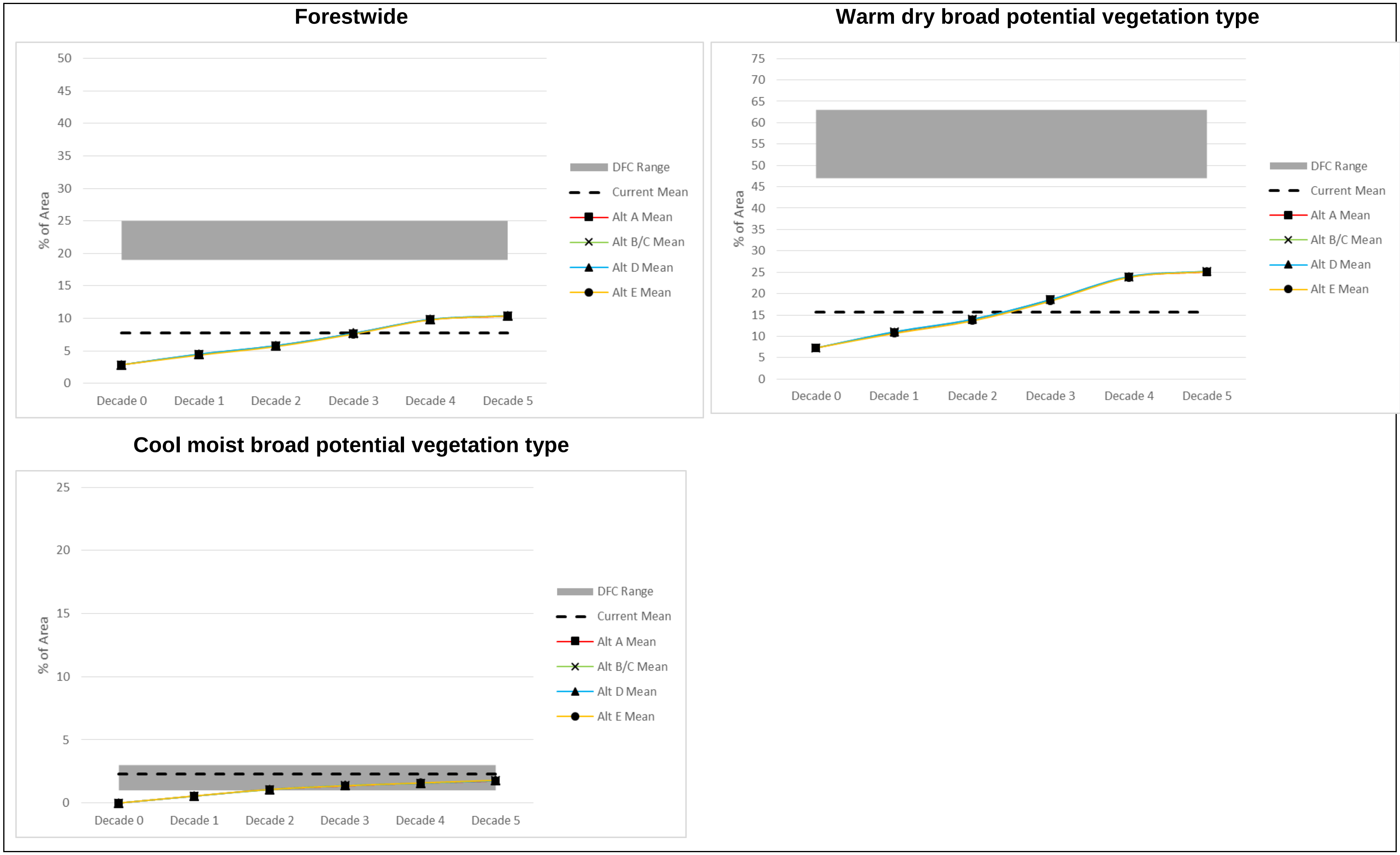


**Figure 49. Dry Douglas-fir cover type over 5 decades**

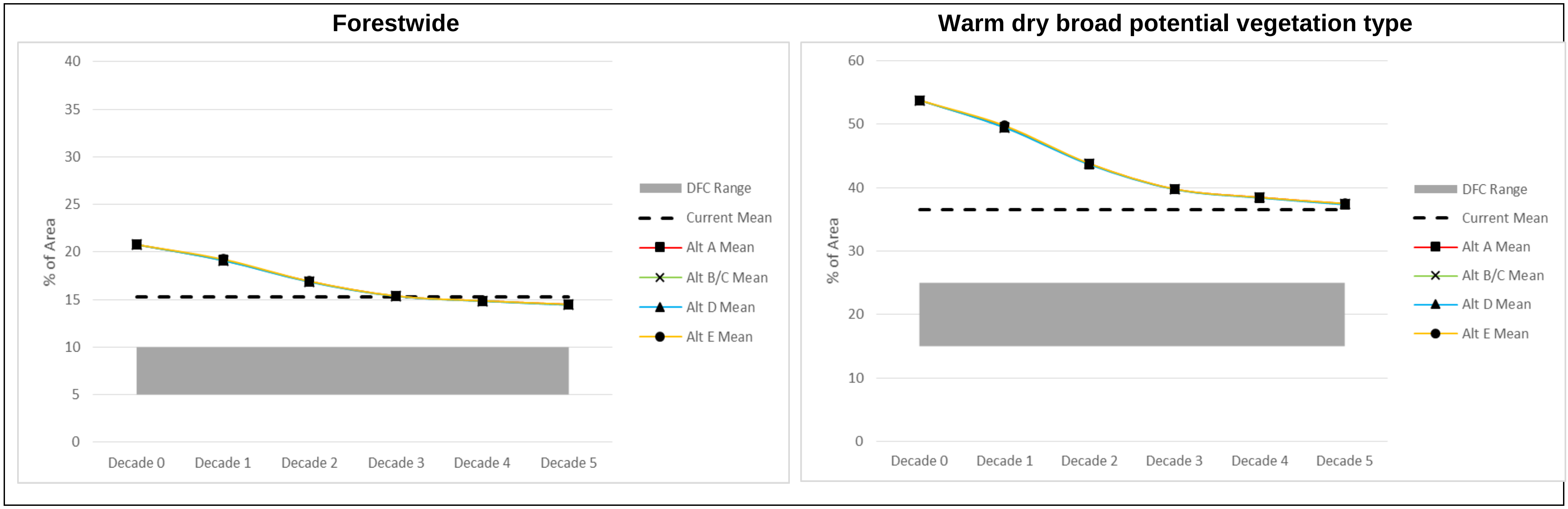


**Figure 50. Mixed Mesic Conifer cover type over 5 decades**

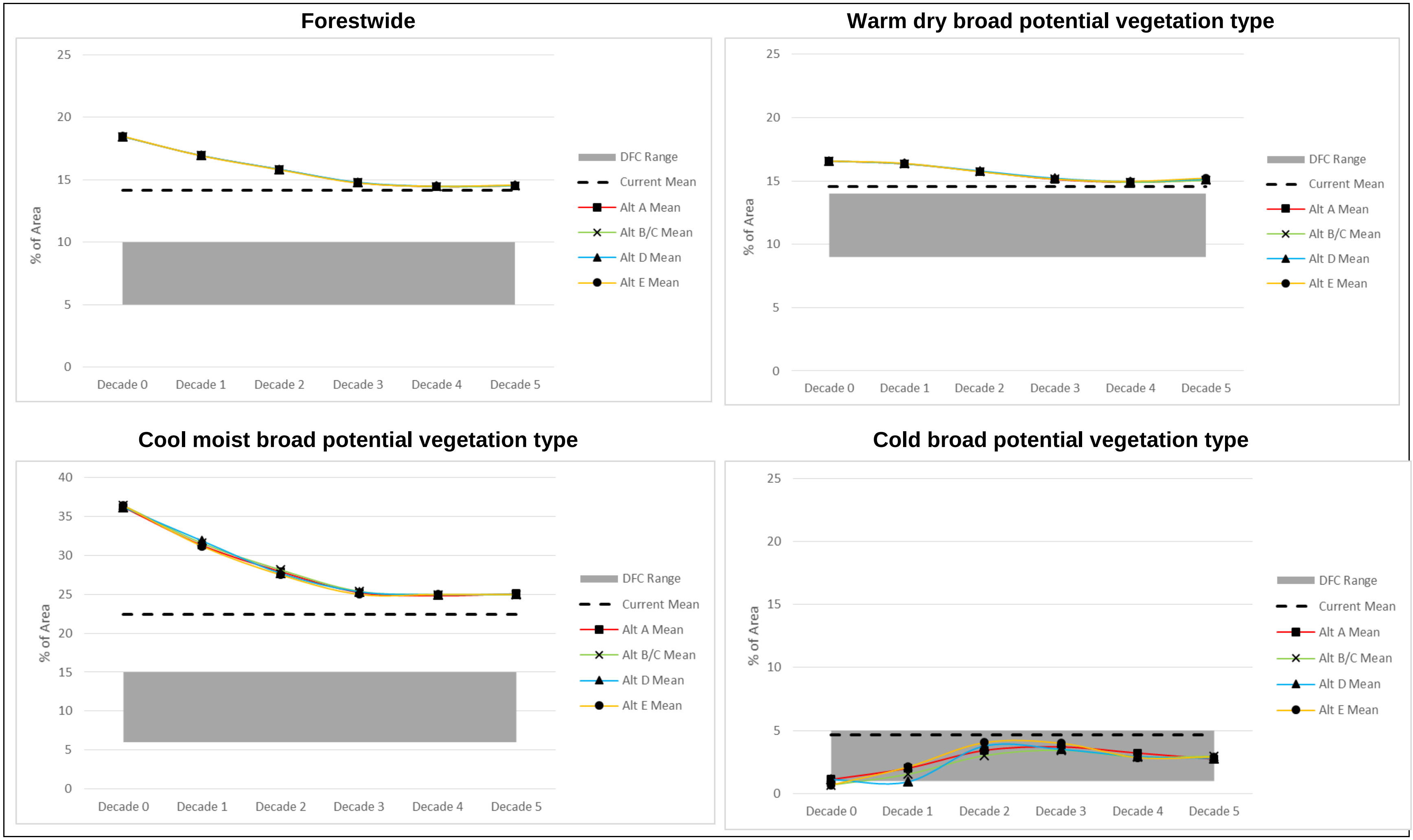


**Figure 51. Lodgepole pine cover type over 5 decades**

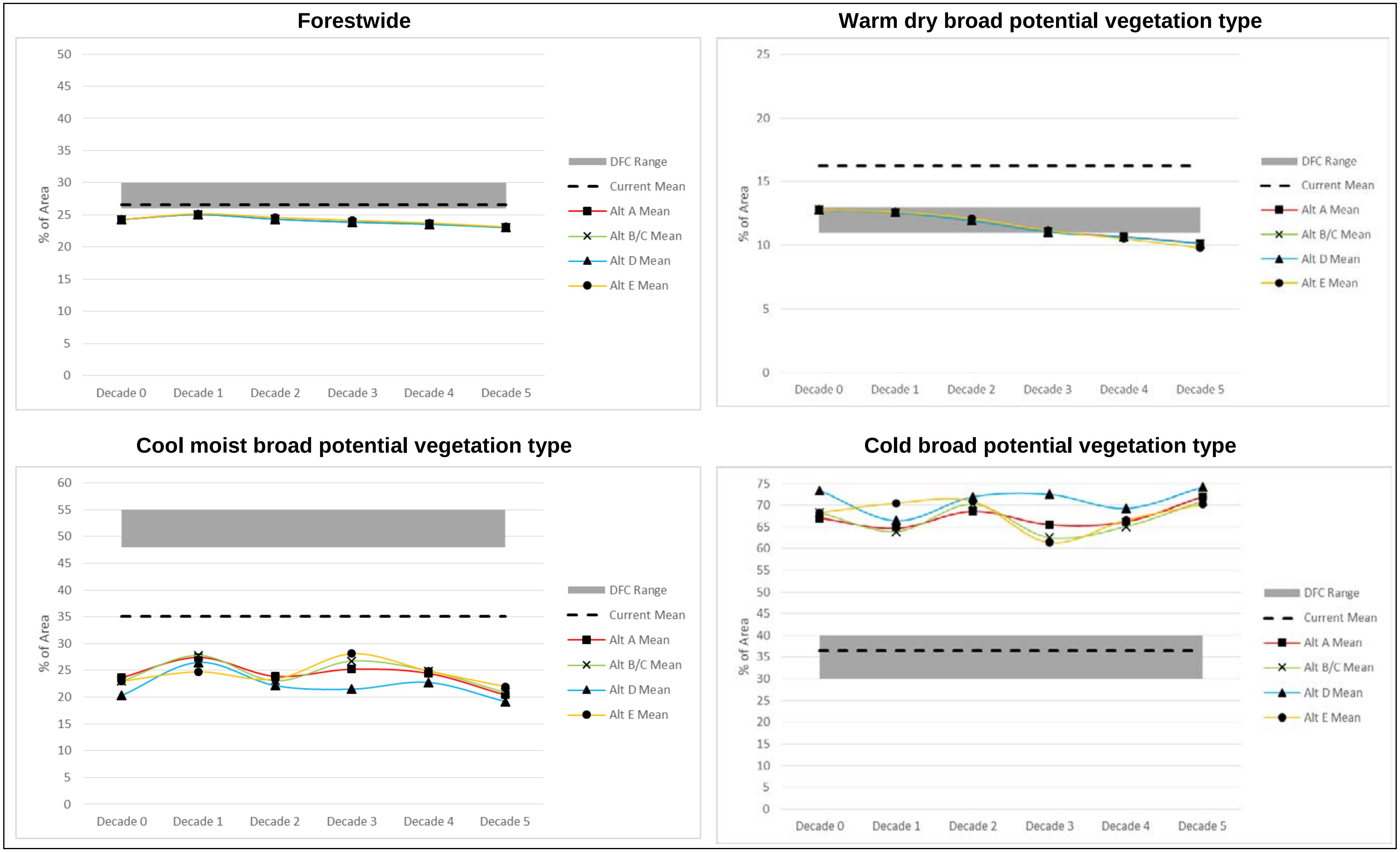


**Figure 52. Spruce/fir cover type over 5 decades**

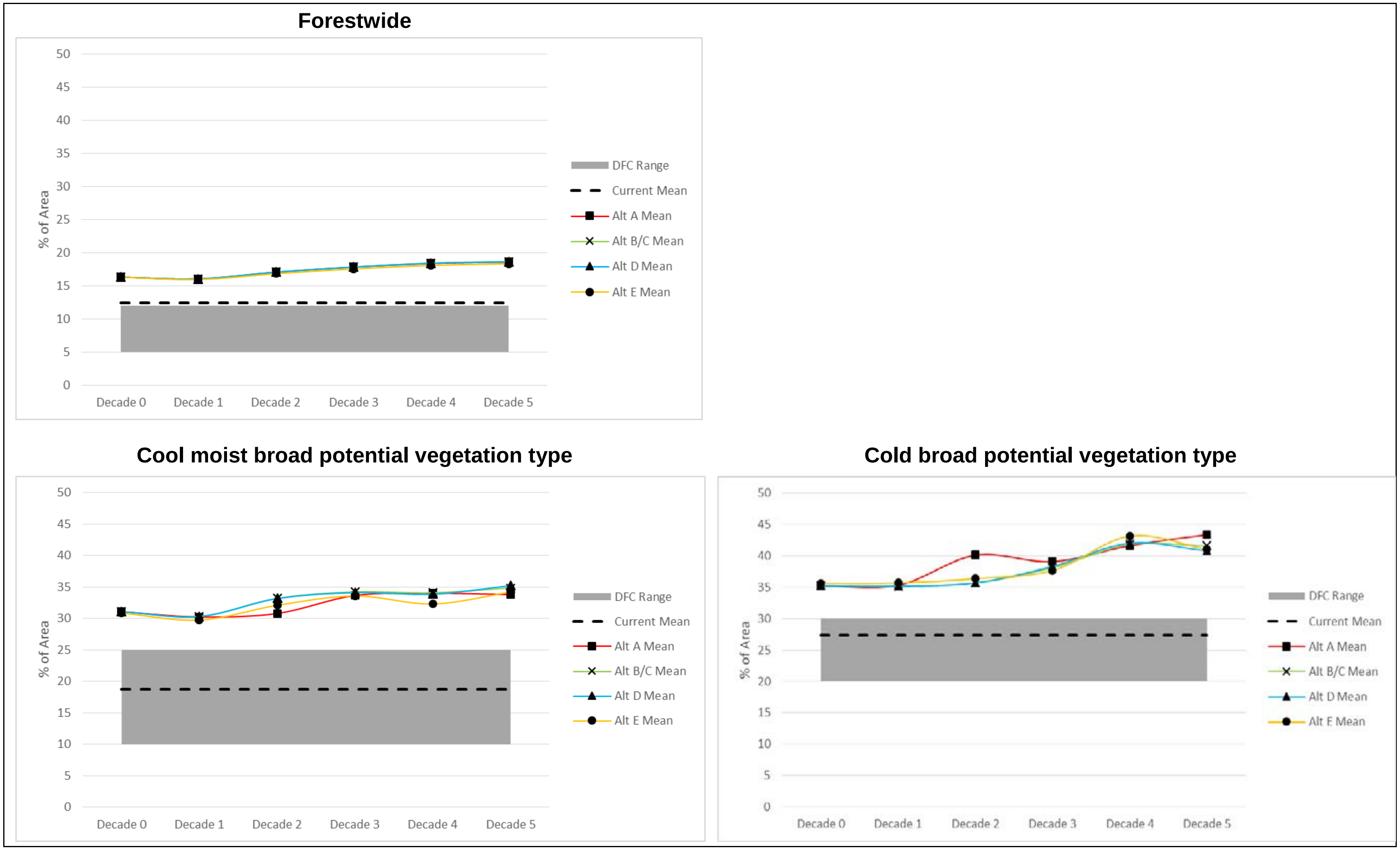
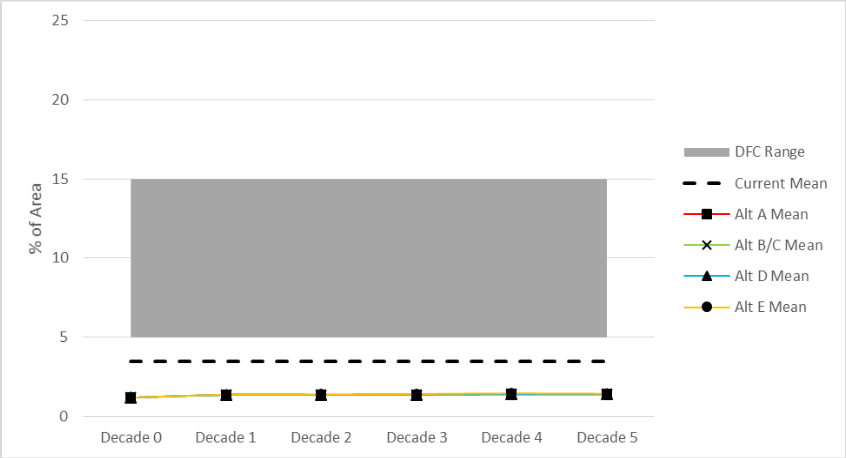
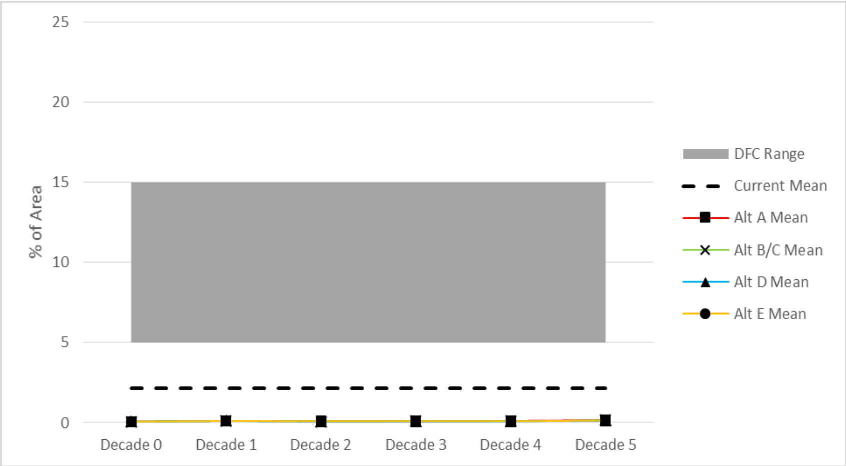


**Figure 53. Whitebark pine cover type over 5 decades**

**Forestwide**




**Cool moist broad potential vegetation type**




**Cold broad potential vegetation type**

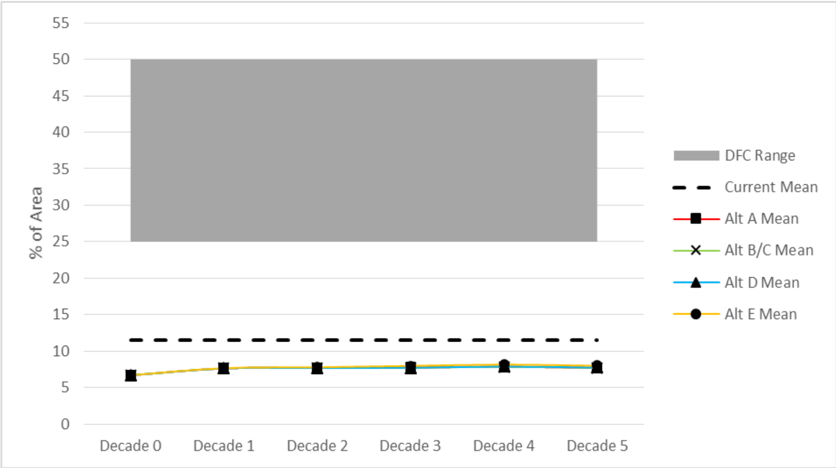


**Figure 54. GA-specific cover type results**

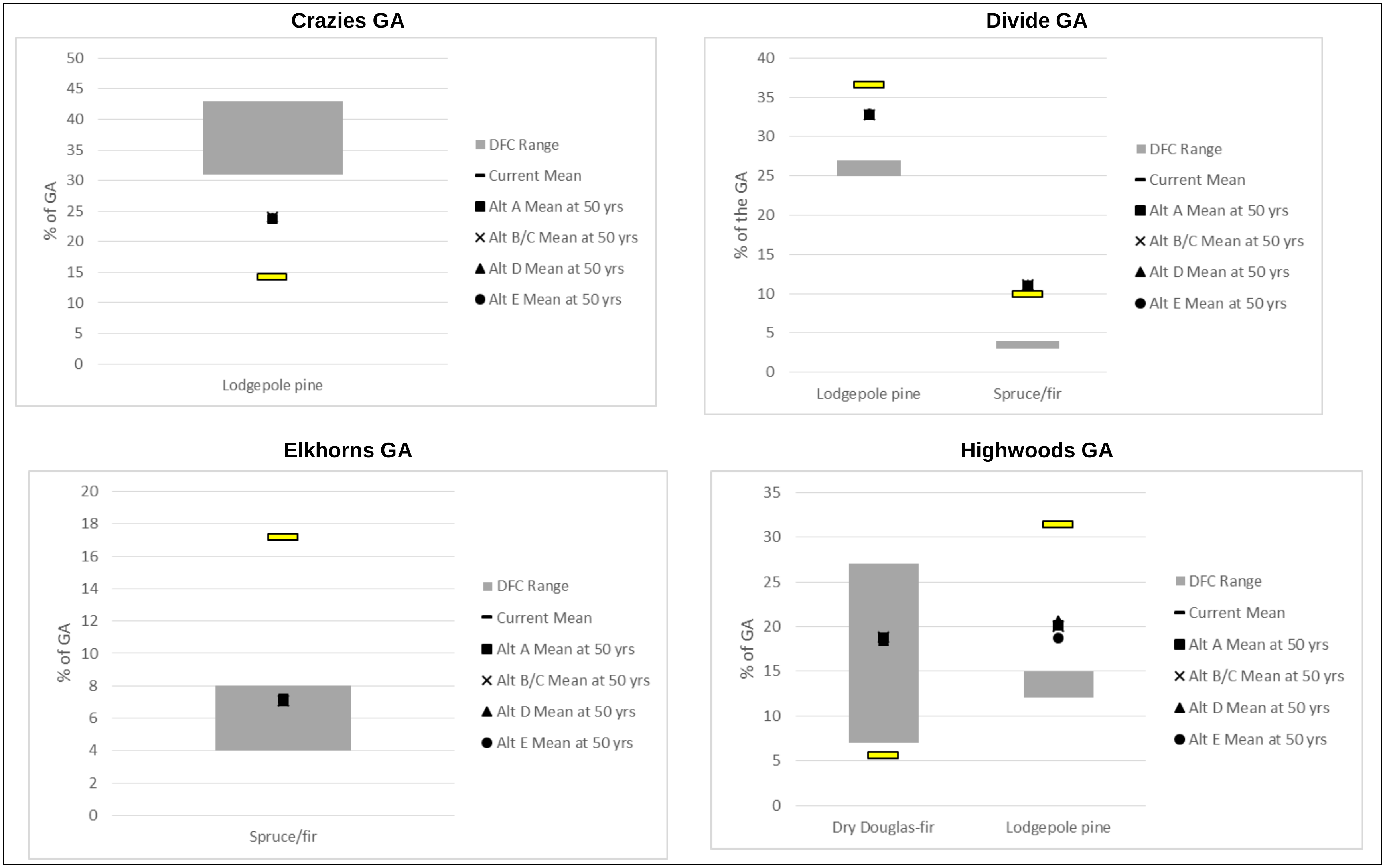
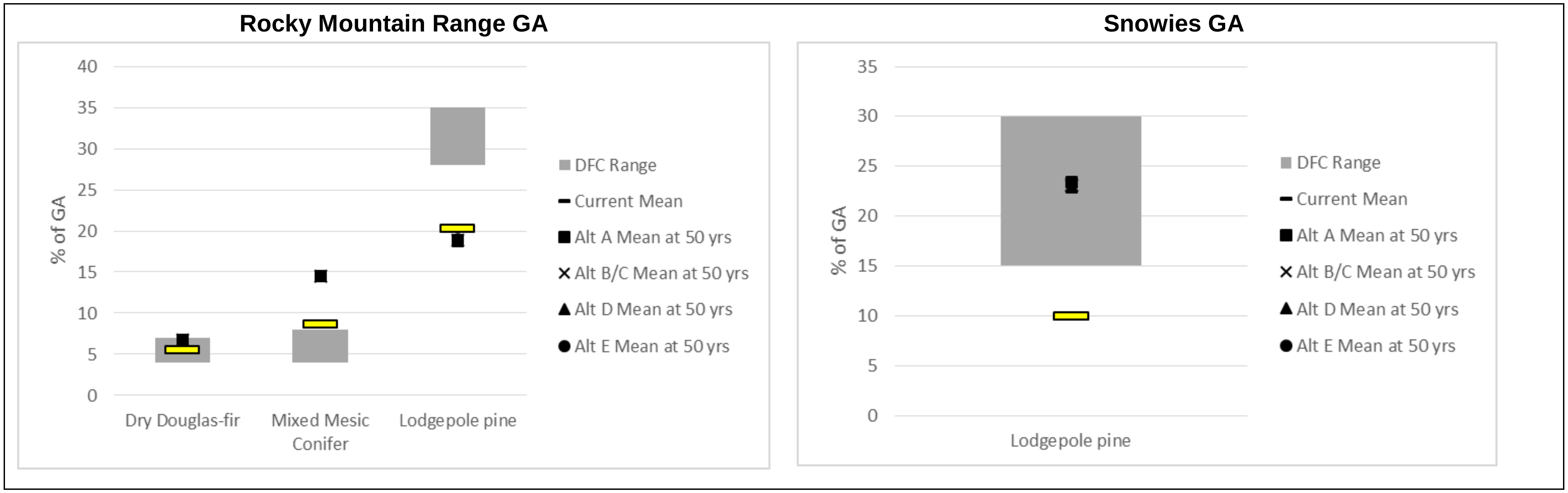


**Figure 55. GA-specific cover type results, continued**



### Tree Species Presence

The figures below shows the mean of tree species over 50 years, compared to the existing condition (FIA) and desired range. Results are shown at the forestwide, R1 broad PVT, and GA scales because desired conditions apply to all of these scales. Western larch is not shown because it is present only in low amounts in the Upper Blackfoot GA (1%). The SIMPPLLE model had a starting point below this amount, and did not predict any change over time under any alternative. Similarly, cottonwood is rare based on FIA plots (< 1% at all scales), and the SIMPPLLE model did not estimate its presence in the future.

**Figure 56. Tree species presence forestwide at 50 years, mean by alternative**

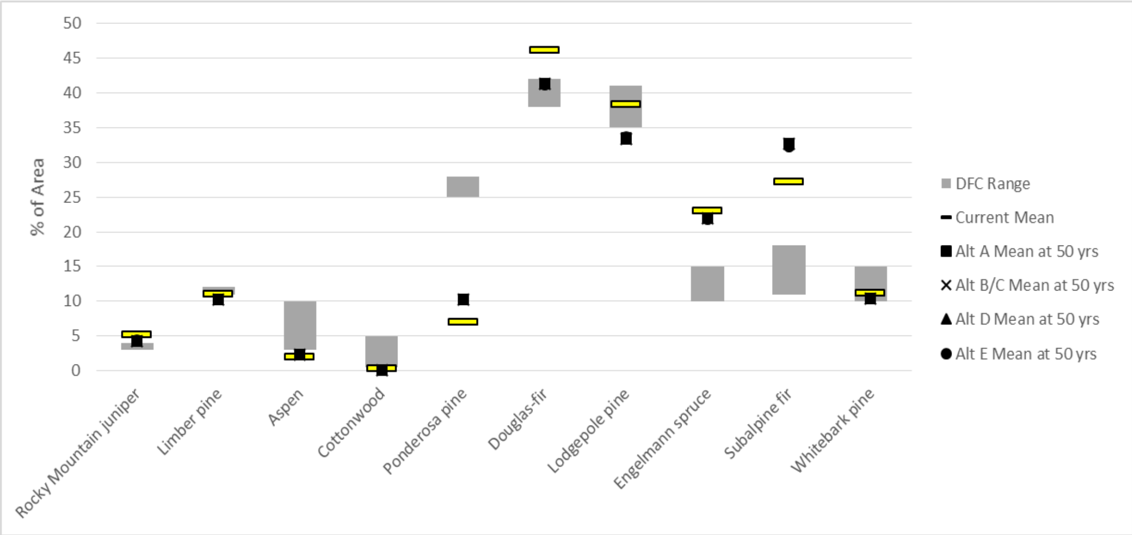



**Figure 57. Rocky mountain juniper presence forestwide over 5 decades by alternative**

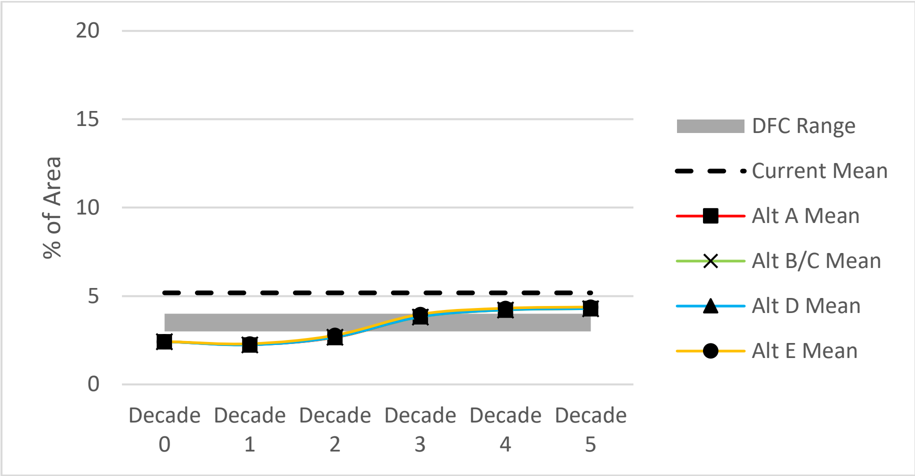


**Figure 58. Rocky mountain juniper presence by geographic area, mean at 50 years**

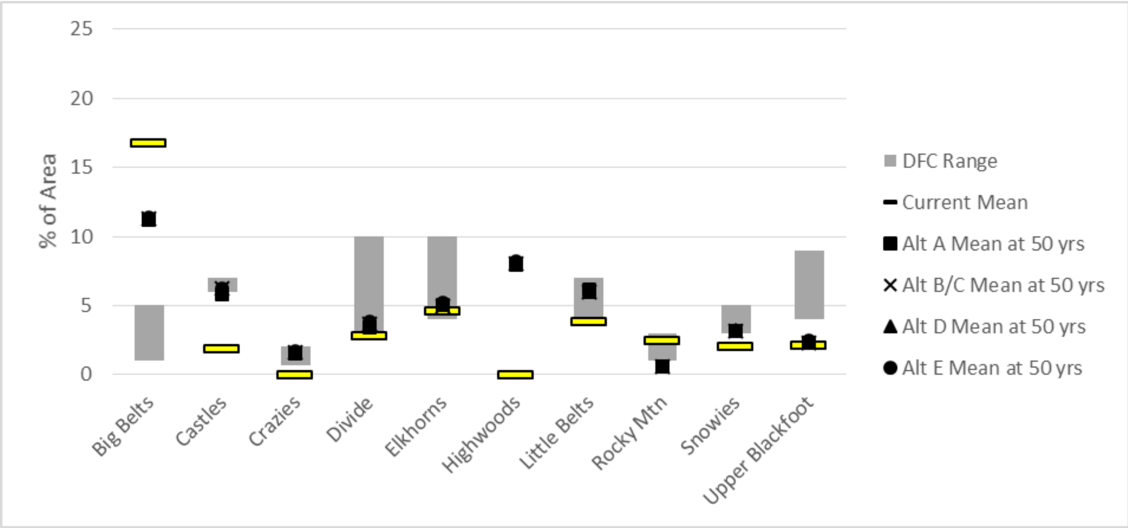



**Figure 59. Limber pine presence forestwide over 5 decades by alternative**

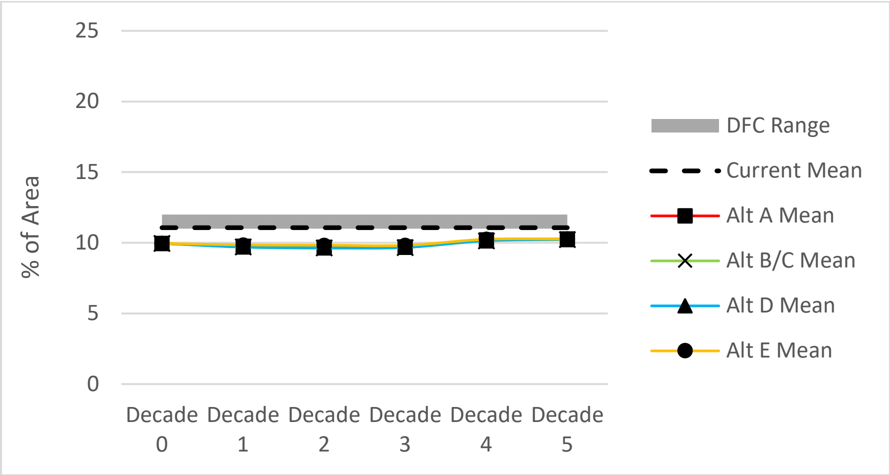



**Figure 60. Limber pine presence by geographic area, mean at 50 years**

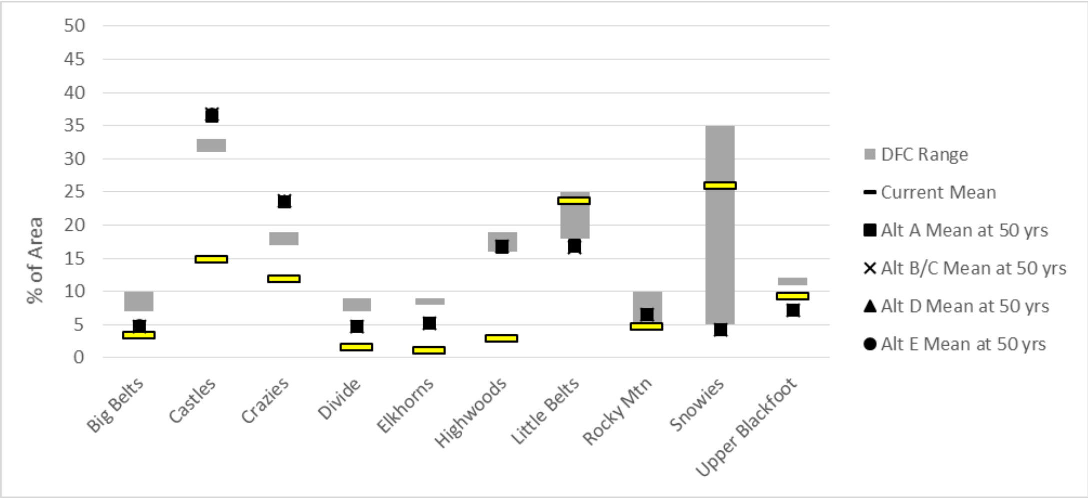


**Figure 61. Aspen presence forestwide over 5 decades by alternative**

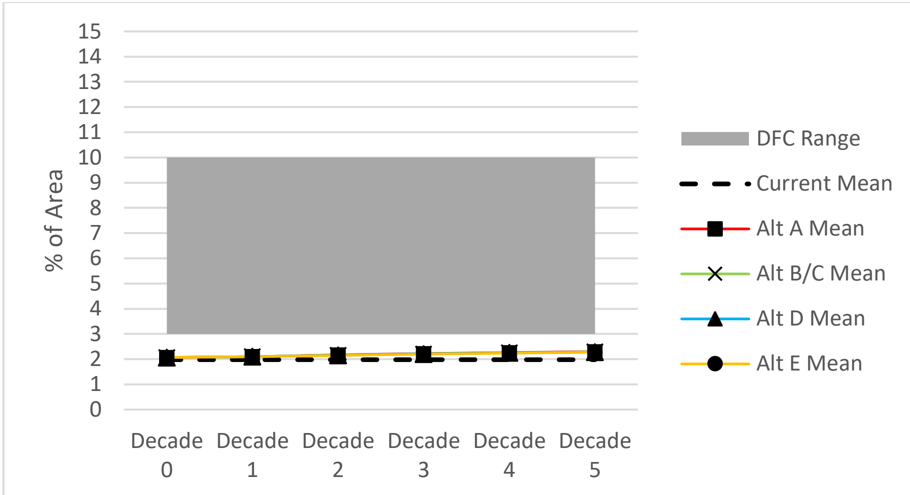



**Figure 62. Aspen presence by geographic area, mean at 50 years**

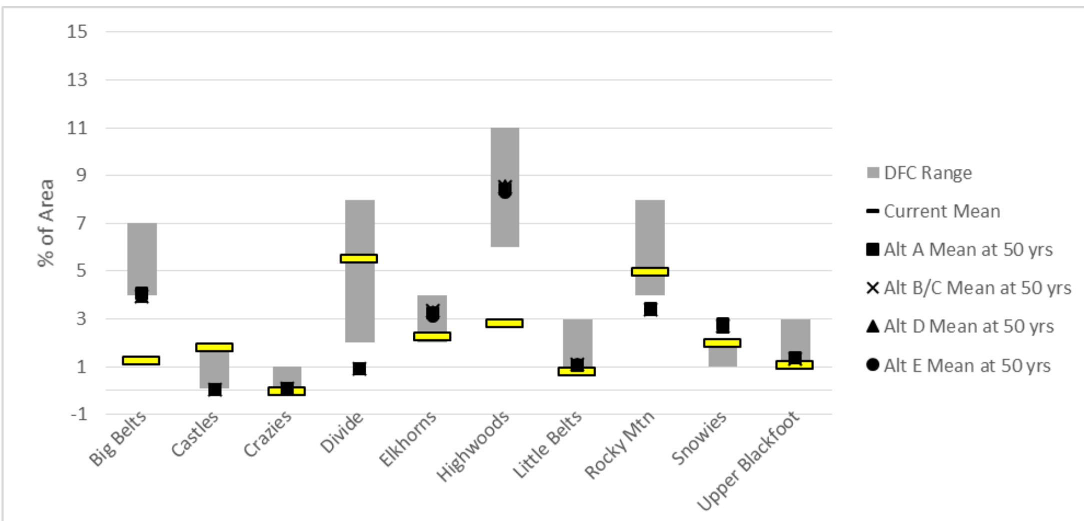



**Figure 63. Ponderosa pine presence forestwide over 5 decades by alternative**

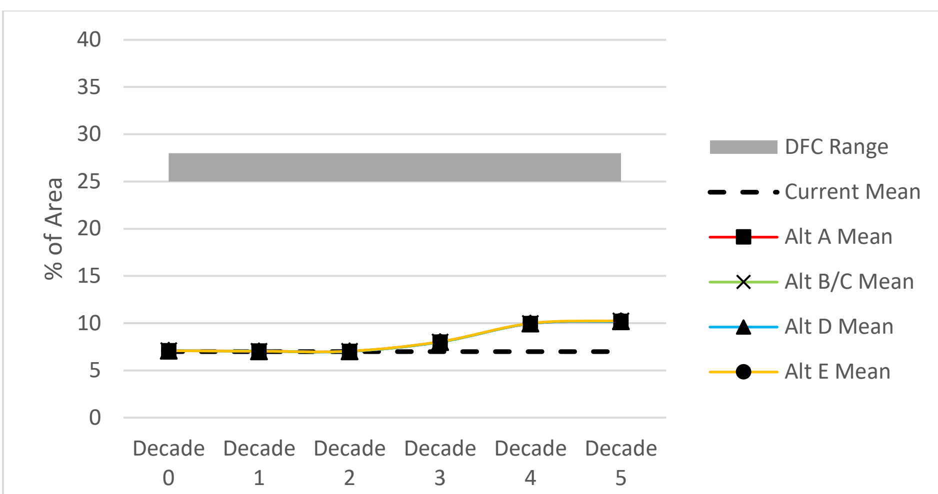


**Figure 64. Ponderosa pine presence by geographic area, mean at 50 years**

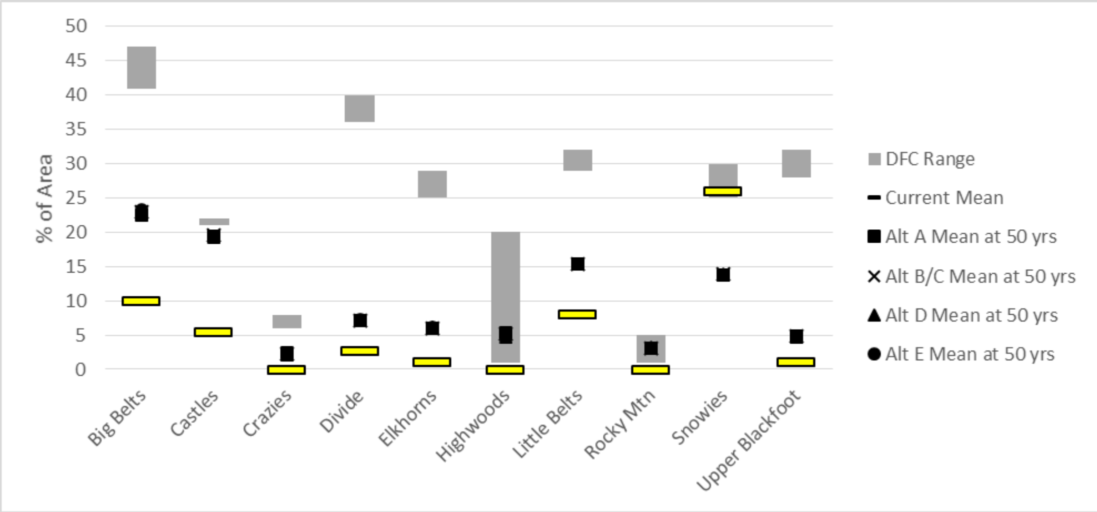



**Figure 65. Douglas-fir presence forestwide over 5 decades by alternative**

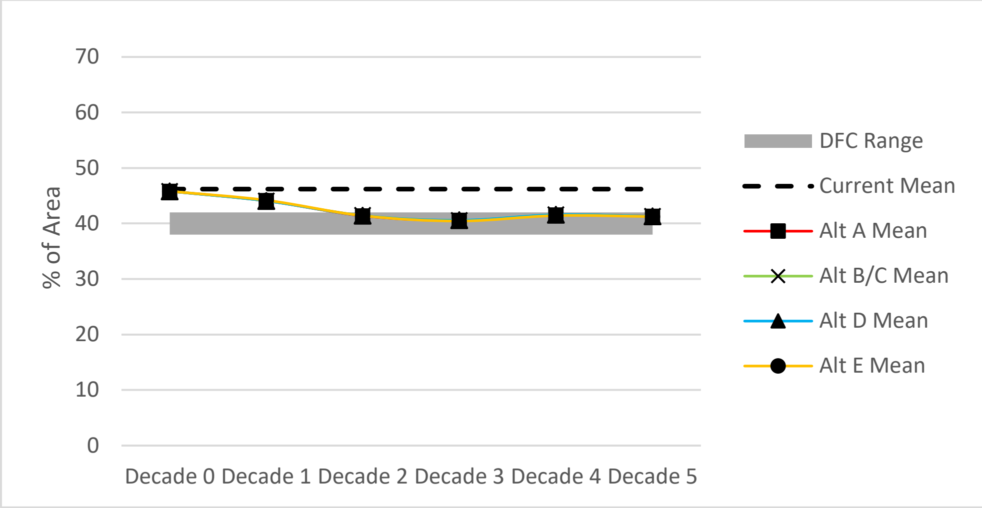



**Figure 66. Douglas-fir presence by geographic area, mean at 50 years**

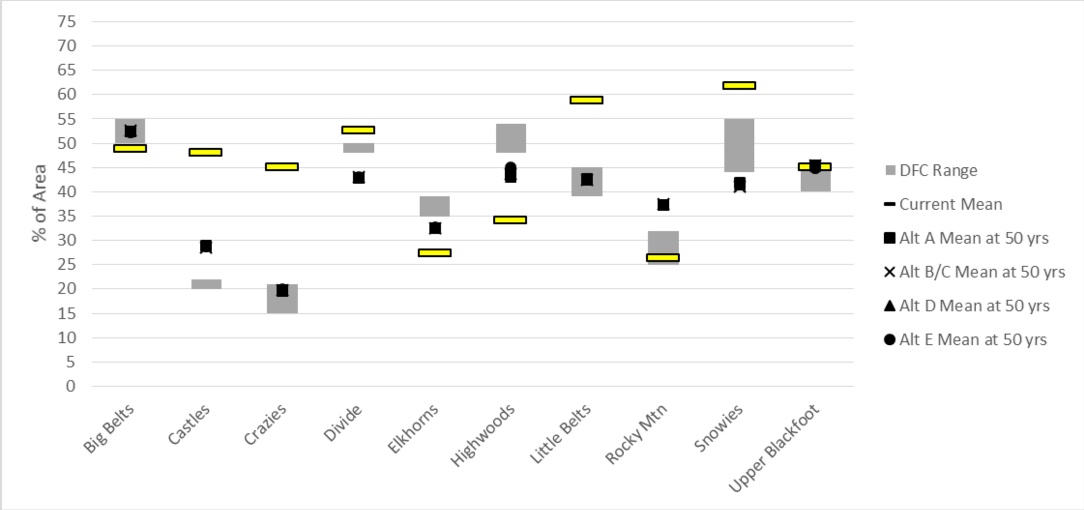


**Figure 67. Western larch presence in the Upper Blackfoot GA over 5 decades by alternative**

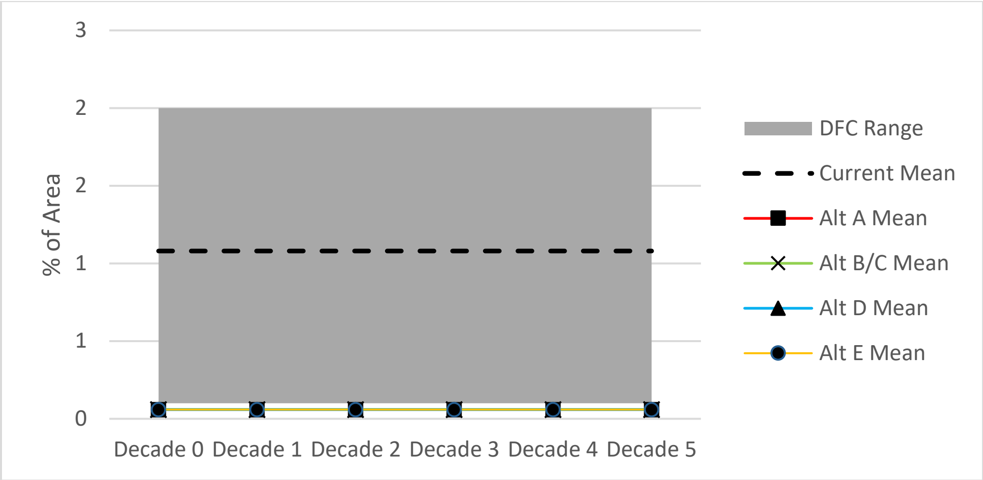



**Figure 68. Lodgepole pine presence forestwide over 5 decades by alternative**

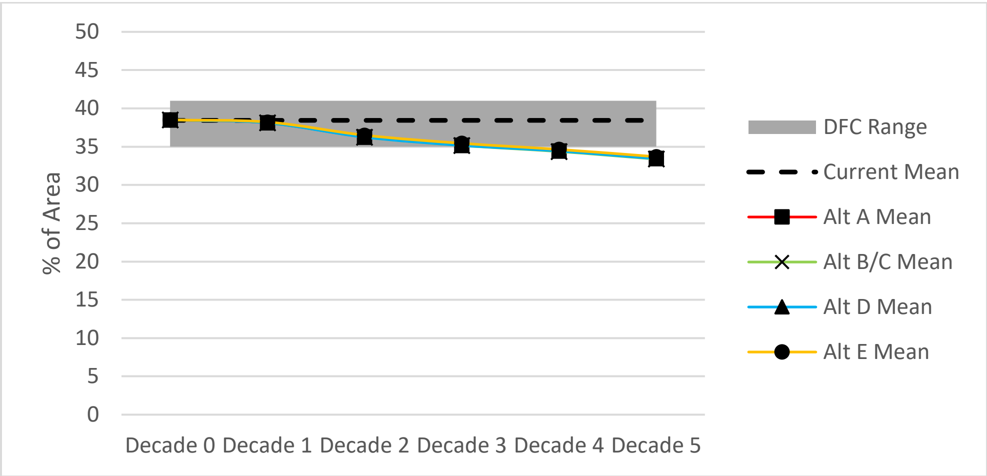



**Figure 69. Lodgepole pine presence by geographic area, mean at 50 years**

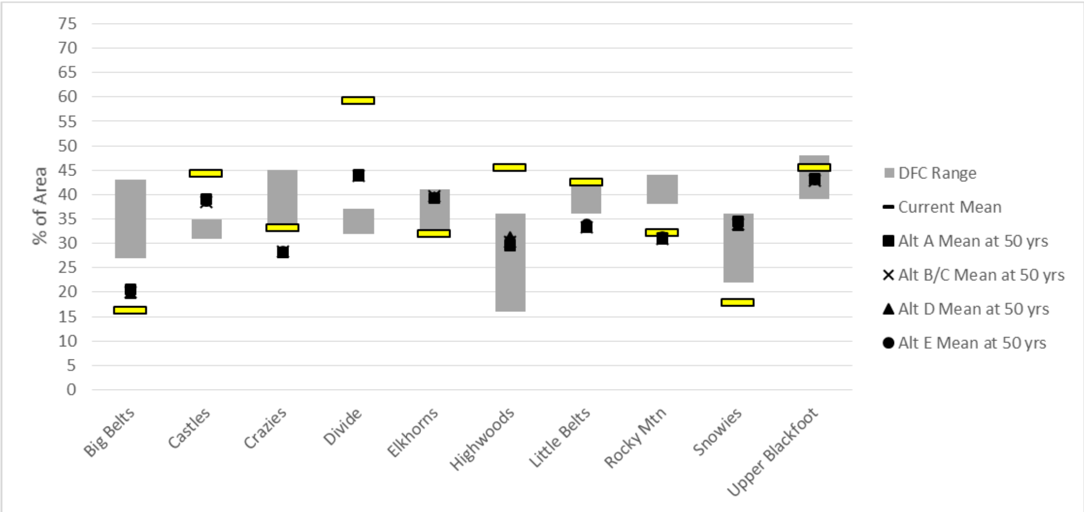


**Figure 70. Engelmann spruce presence forestwide over 5 decades by alternative**

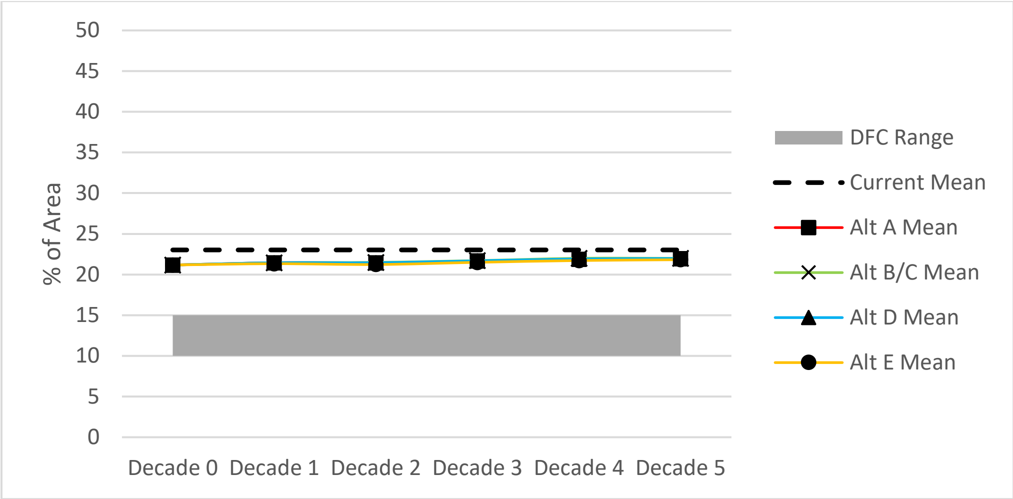



**Figure 71. Engelmann spruce presence by geographic area, mean at 50 years**

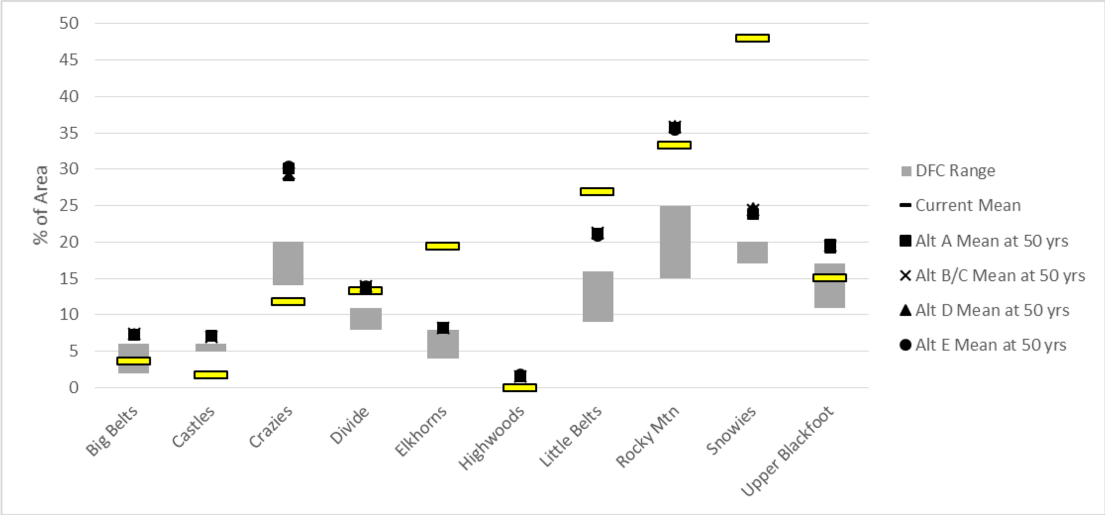



**Figure 72. Subalpine fir presence forestwide over 5 decades by alternative**

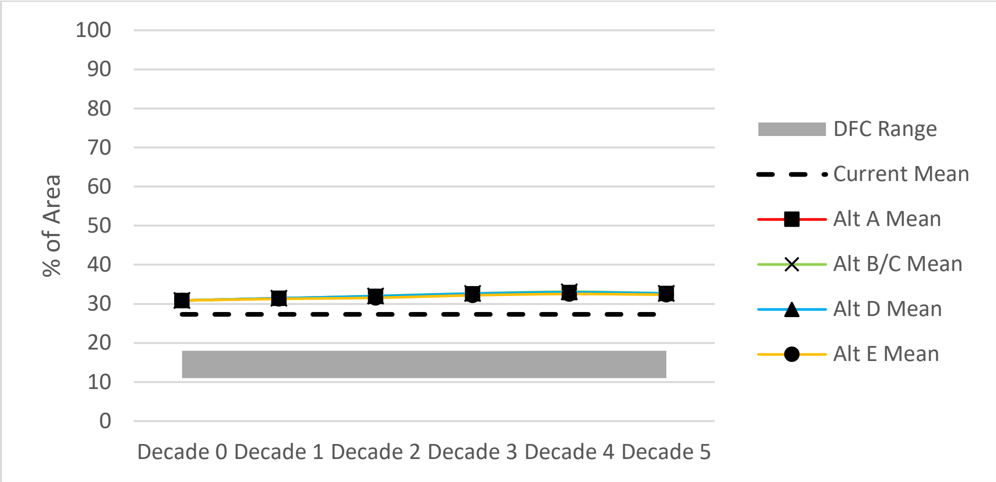


**Figure 73. Subalpine fir presence by geographic area, mean at 50 years**

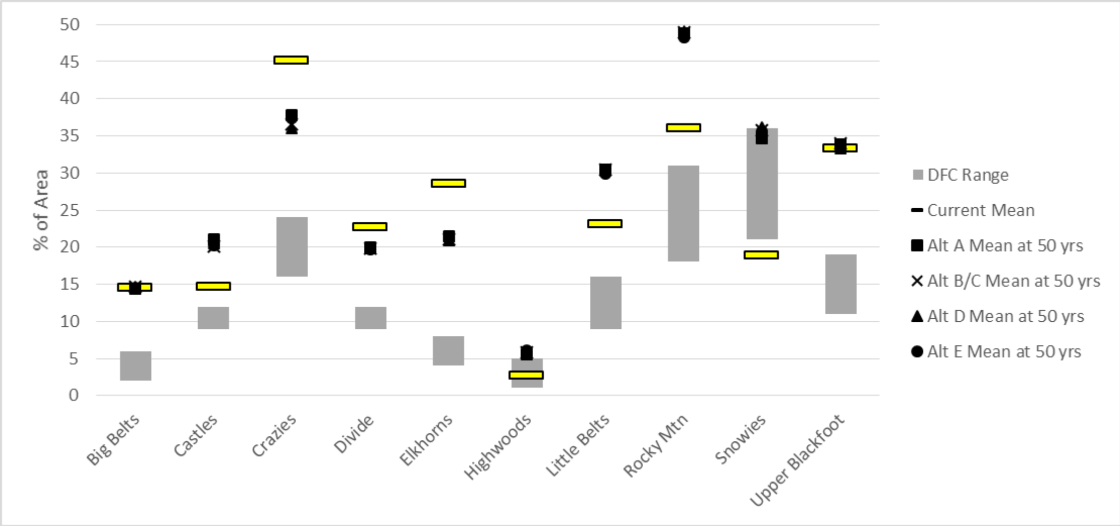



**Figure 74. Whitebark pine presence forestwide over 5 decades by alternative**

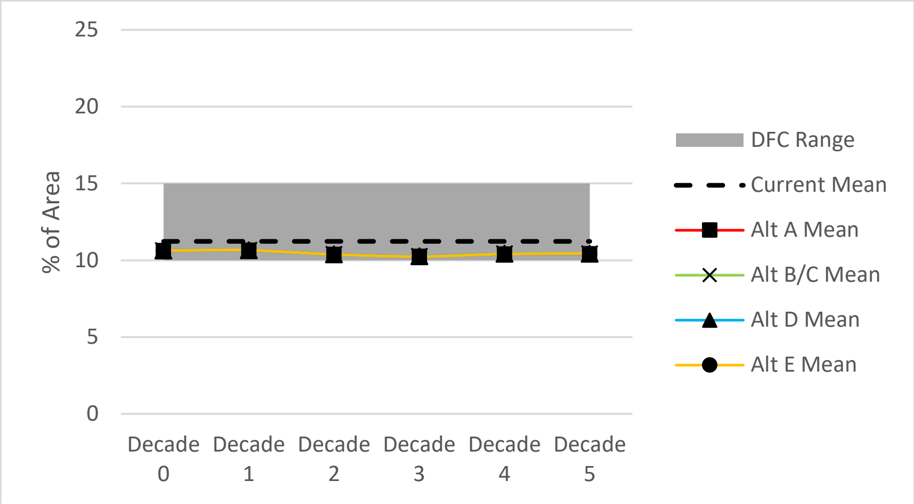



**Figure 75. Whitebark pine presence by geographic area, mean at 50 years**

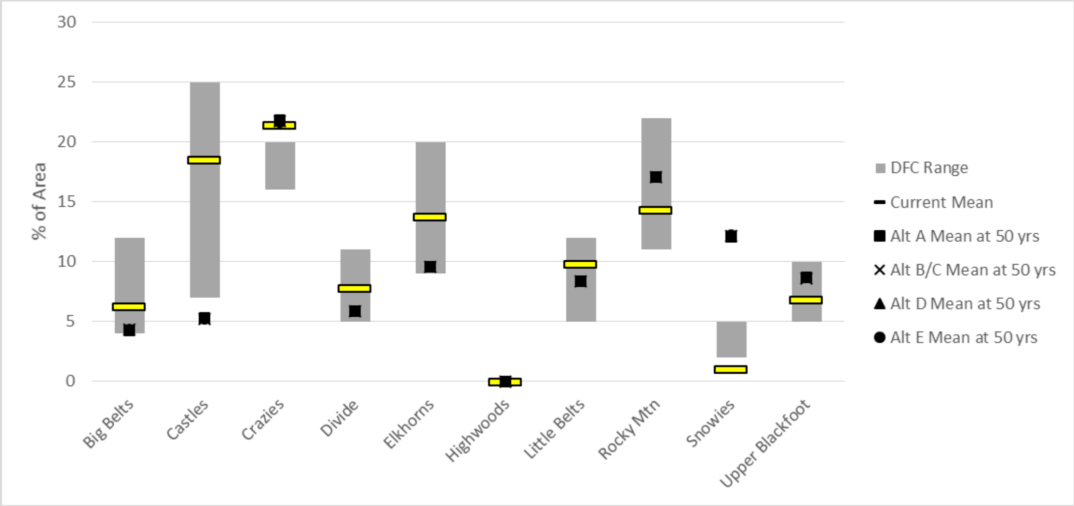


**Figure 76. Rocky mountain juniper presence over 5 decades**

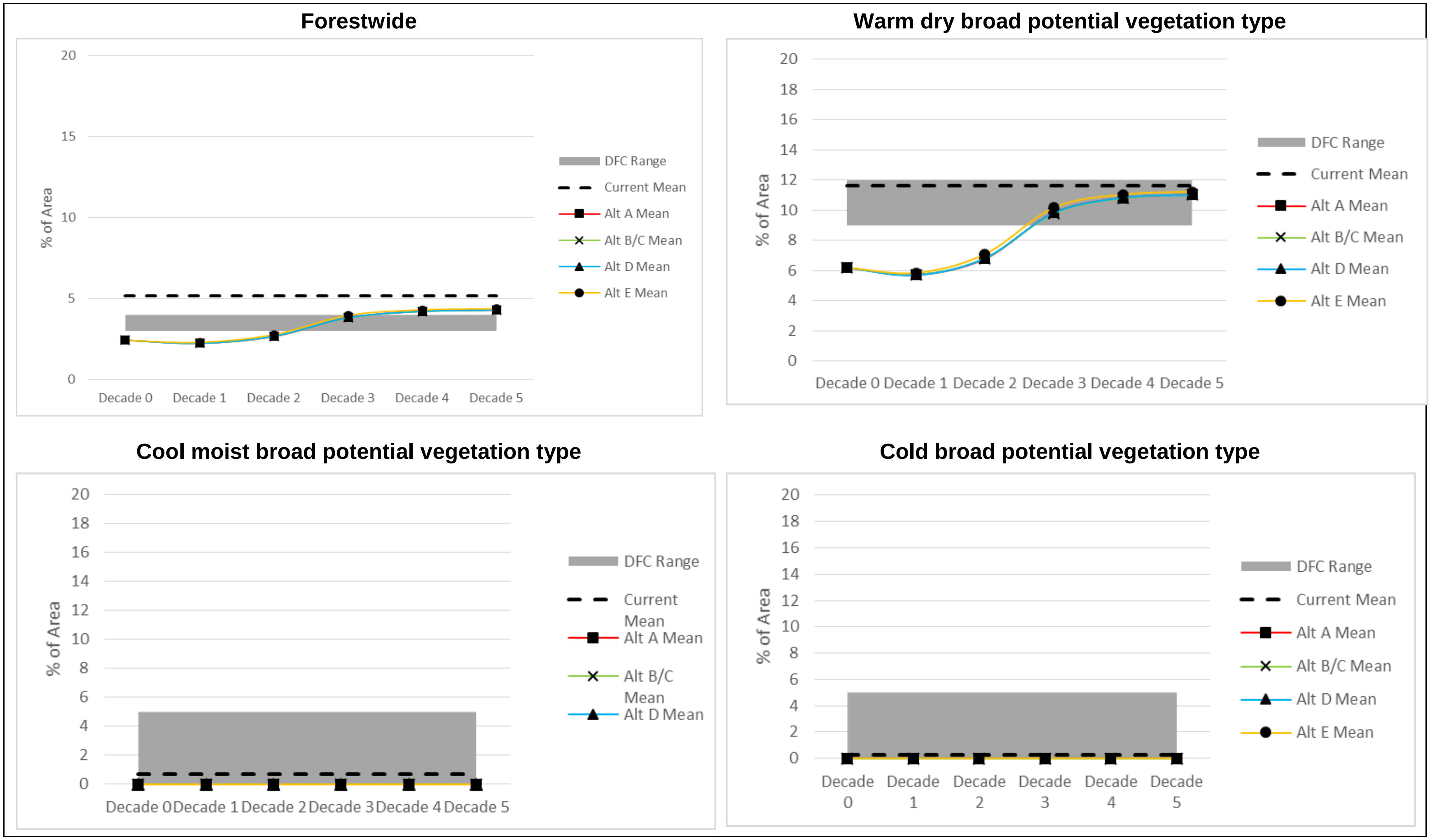


**Figure 77. Limber pine presence over 5 decades**

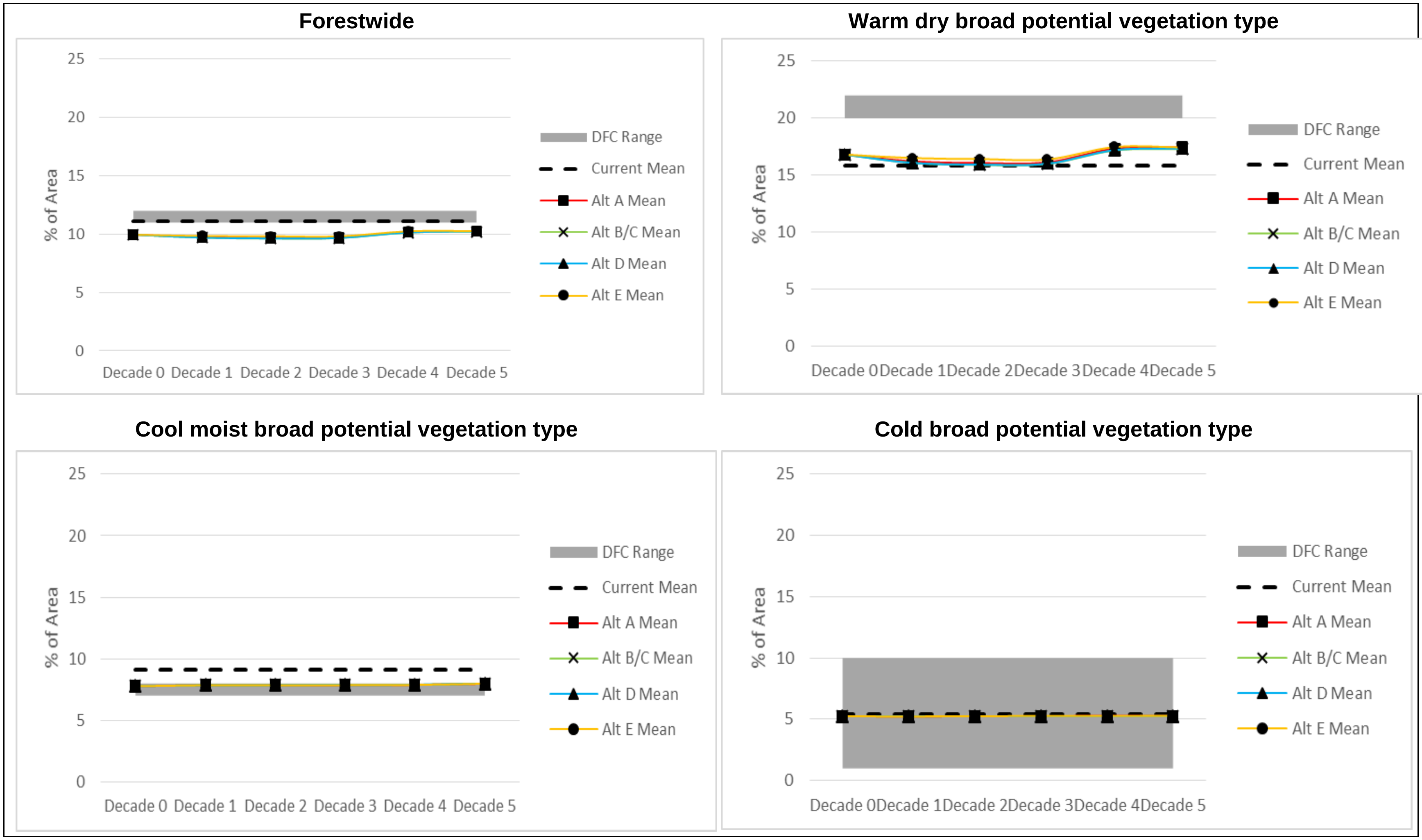


**Figure 78. Aspen presence over 5 decades**

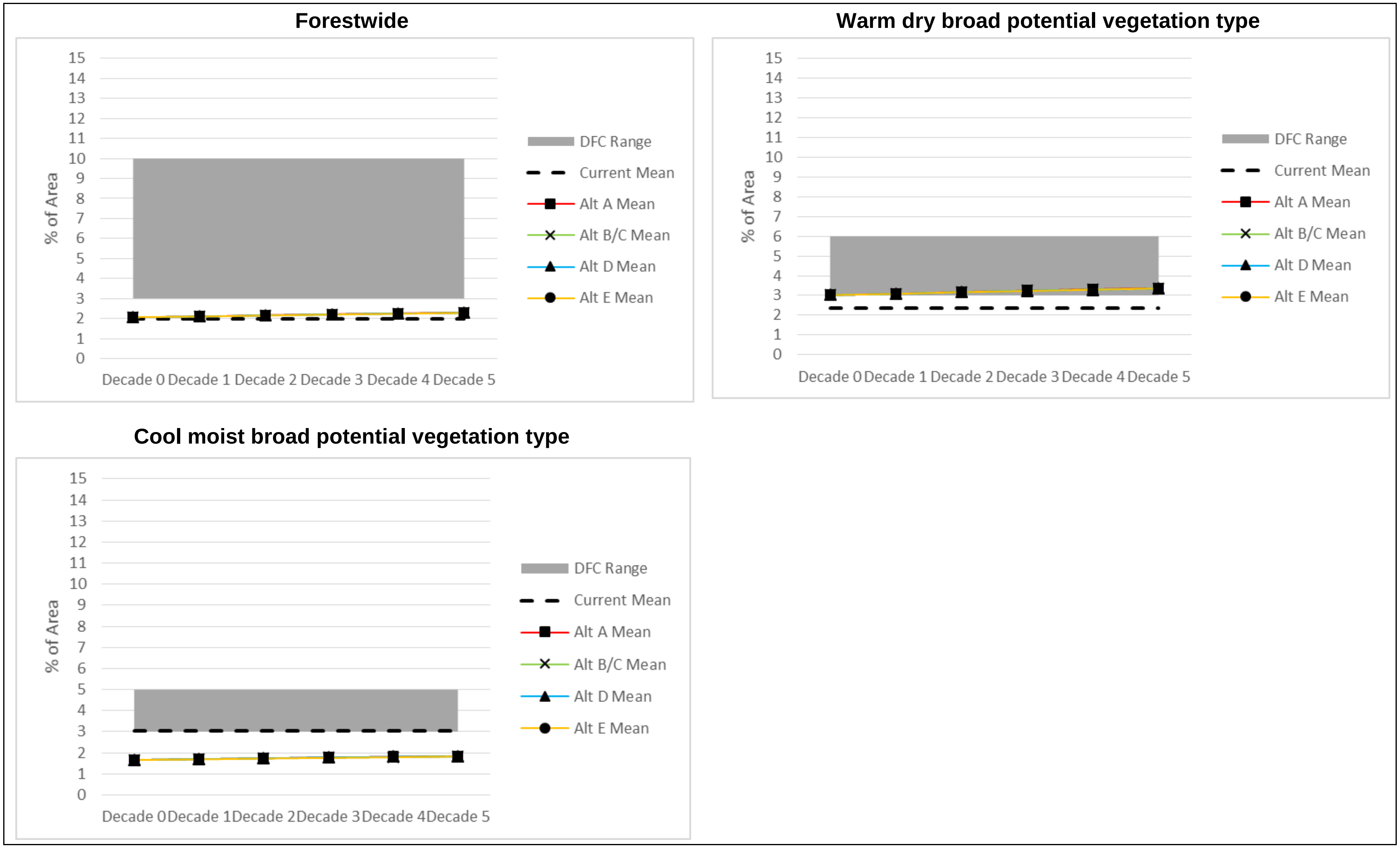


**Figure 79. Ponderosa pine presence over 5 decades**

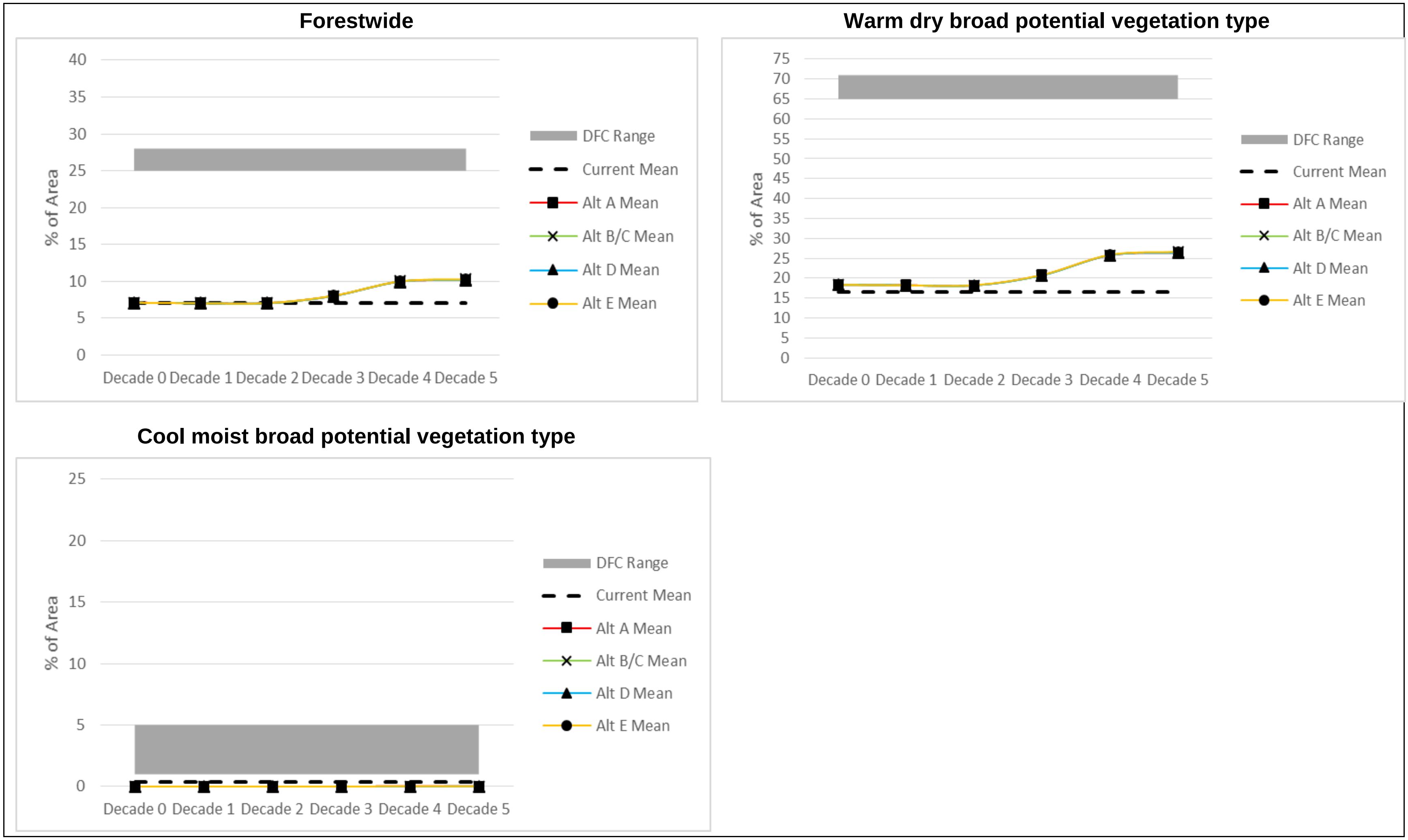


**Figure 80. Douglas-fir presence over 5 decades**

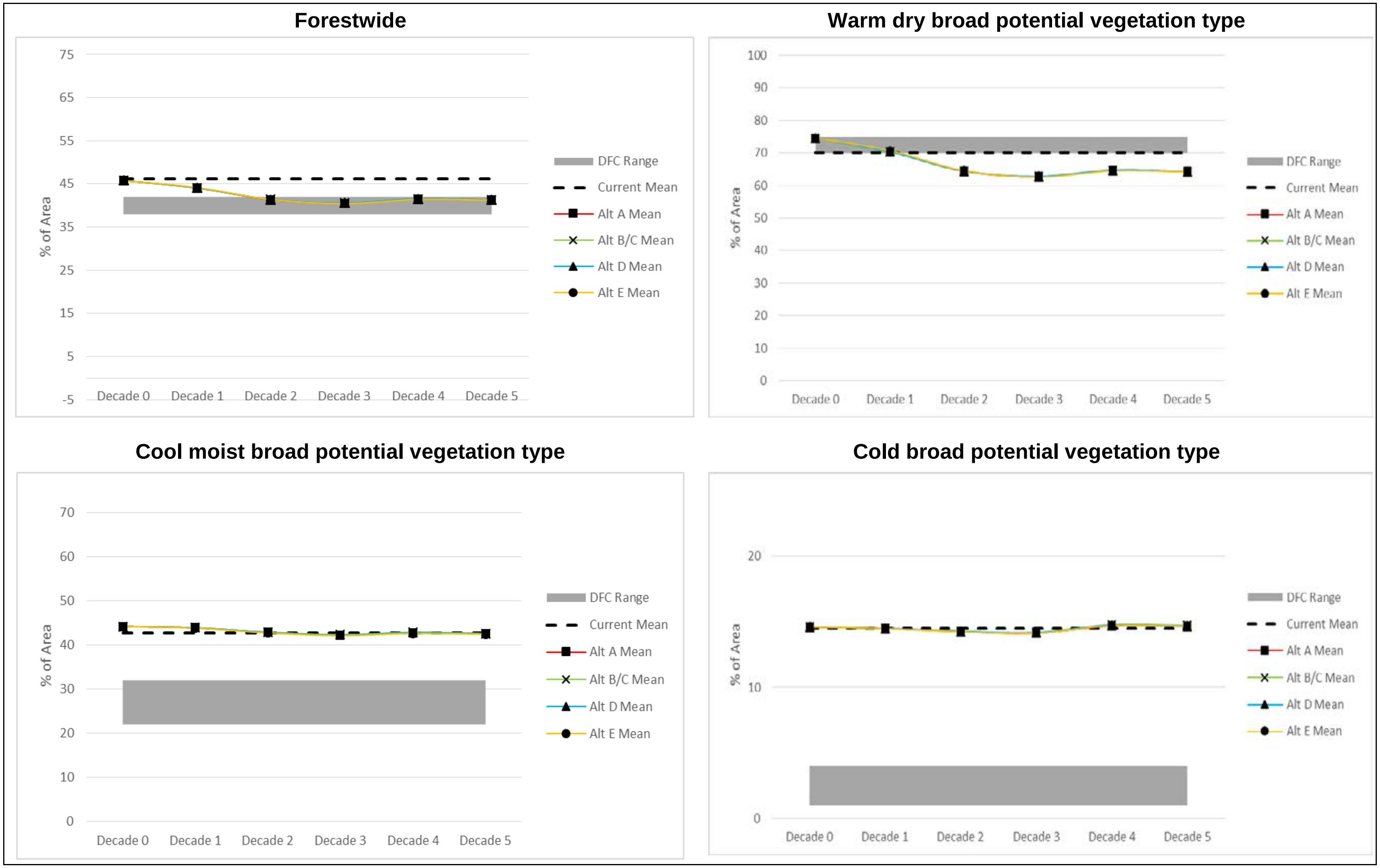


**Figure 81. Lodgepole pine presence over 5 decades**

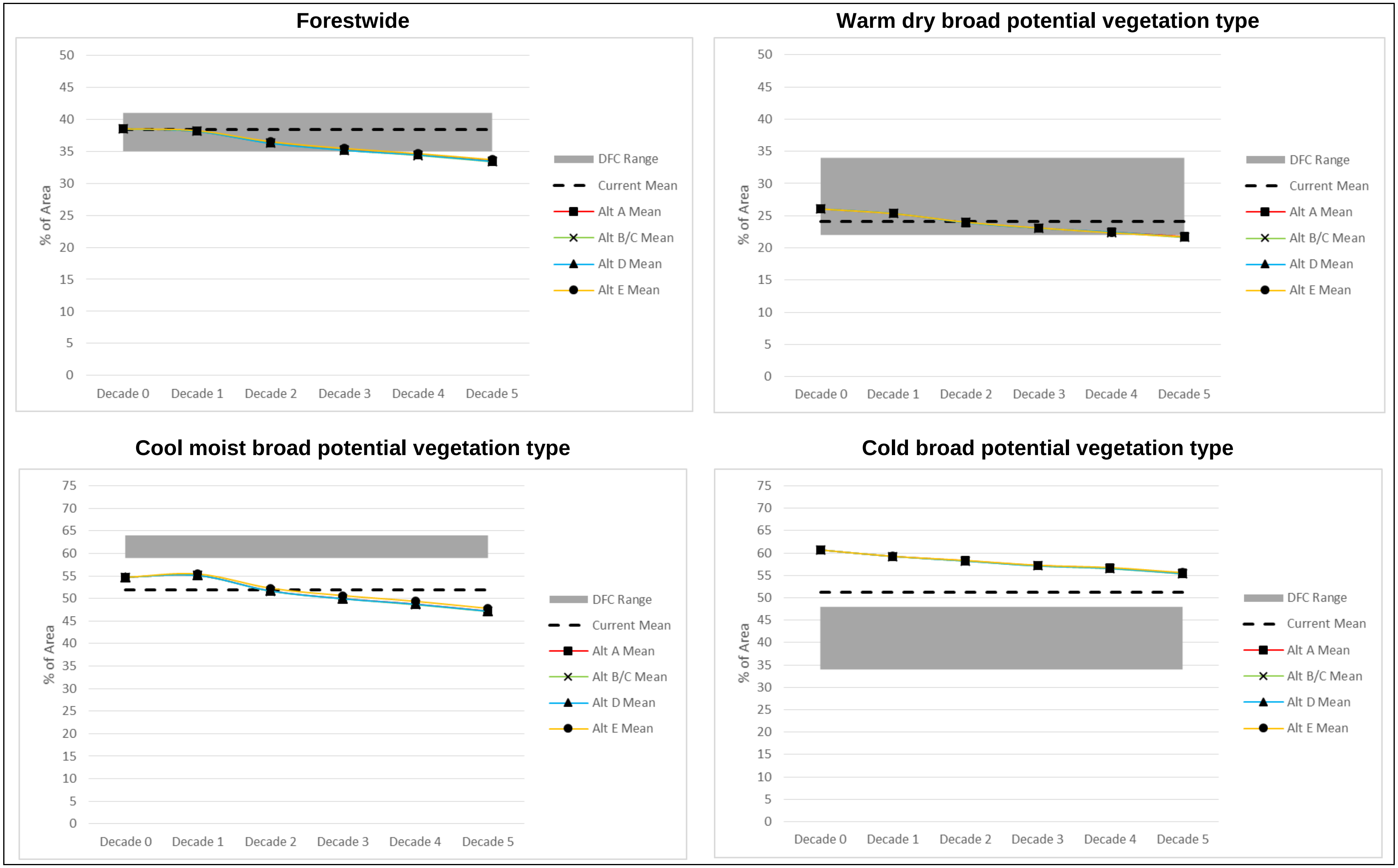


**Figure 82. Engelmann spruce presence over 5 decades**

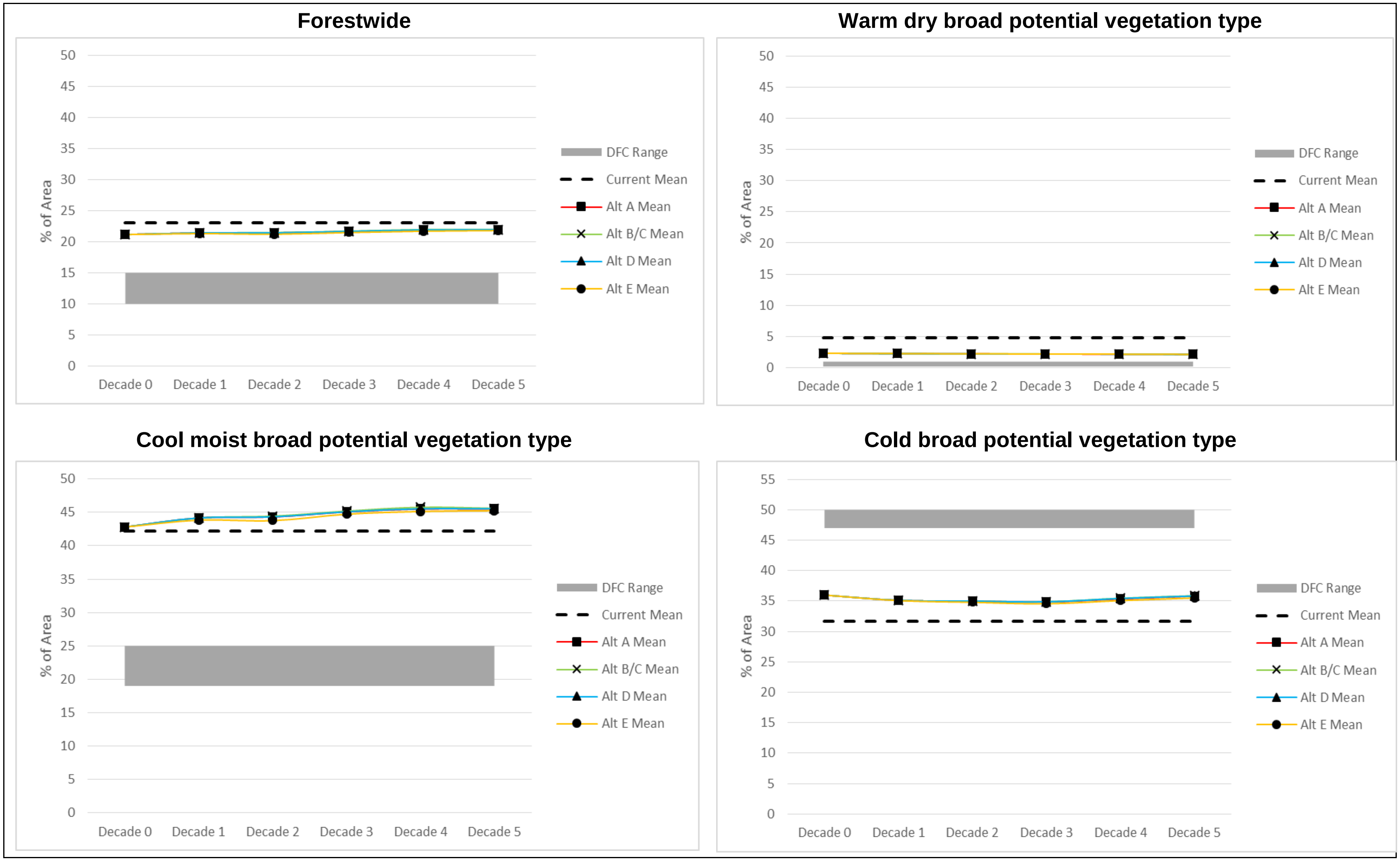


**Figure 83. Subalpine fir presence over 5 decades**

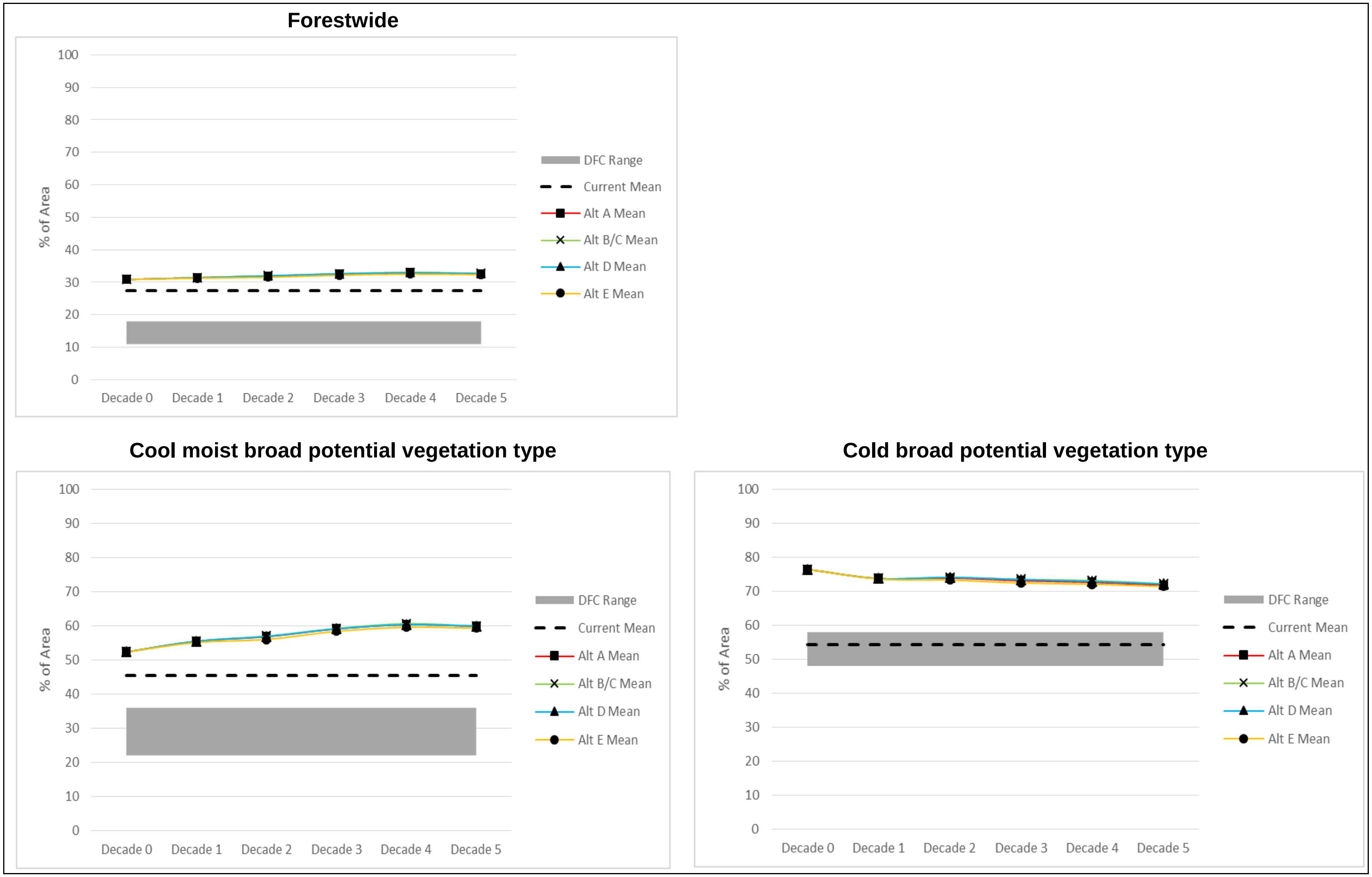
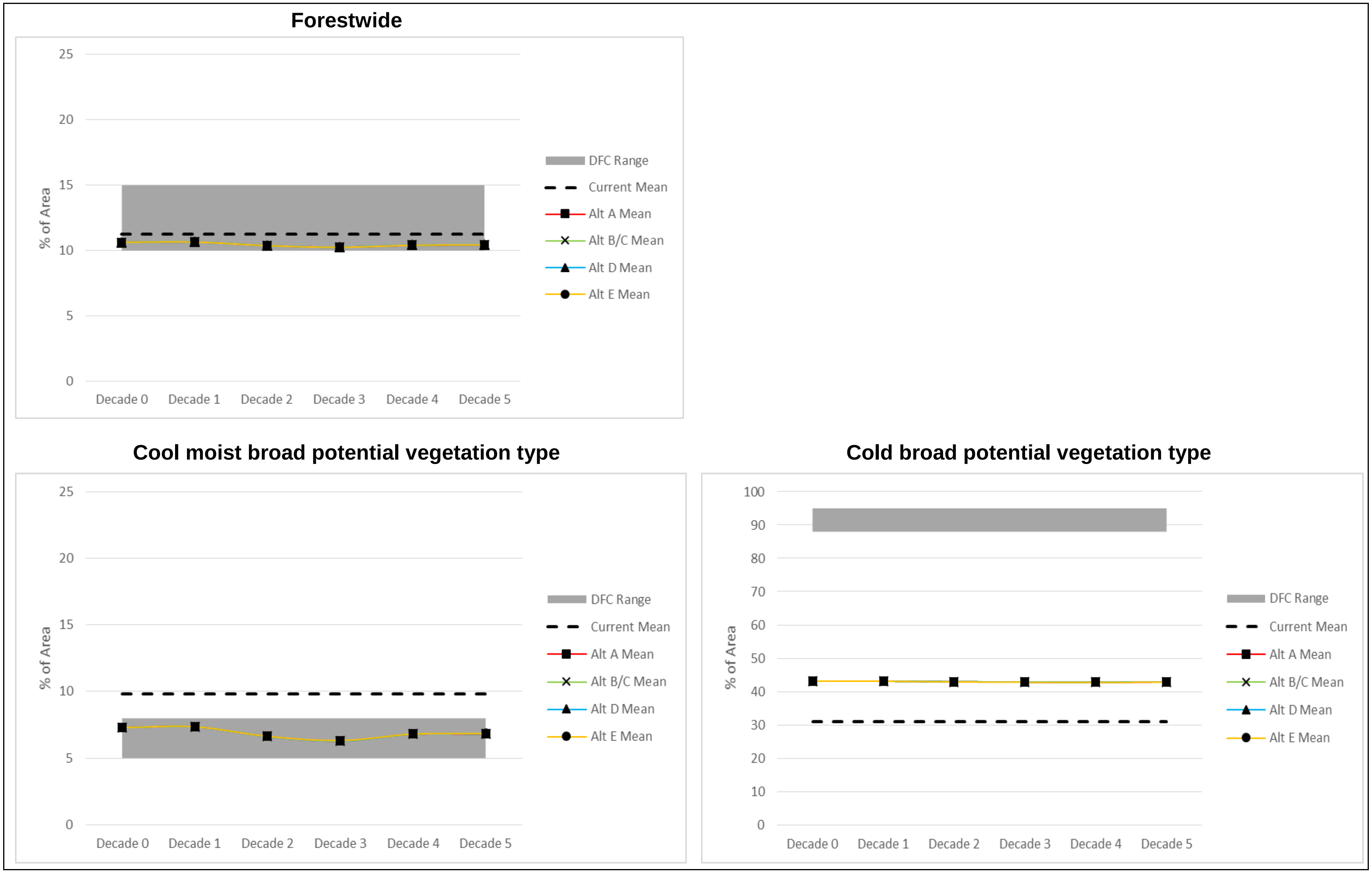


**Figure 84. Whitebark pine presence over 5 decades**



### Forest Size Class, and Large and Very Large Tree Concentrations

The modeled abundance of sizes classes for the 50 year model period are shown forestwide and by broad PVT. In addition, specific results are displayed for several GAs that have desired conditions that vary from the forestwide ranges: the Castles, Crazies, and Highwoods. Areas without size class assigned are excluded; refer to the discussion under nonforested cover types and density classes

The outputs from SIMPPLLE are adjusted proportionately to show outputs that are similar to the classification of size class applied to plot data per the R1 Classification System. This adjustment is done in the same manner as the NRV analysis to develop the desired conditions. The adjustments include increasing the modeled range for seedling/sapling by 5%; increasing small tree by 25%; increasing medium tree by 40%; decreasing large tree by 40%; and decreasing very large tree by 30%. The large and very large size classes projected in SIMPPLLE are analogous to the large and very large tree concentrations as defined in appendix D of the Draft Plan.

**Figure 85. Forest size class, forestwide, average conditions at 50 years**

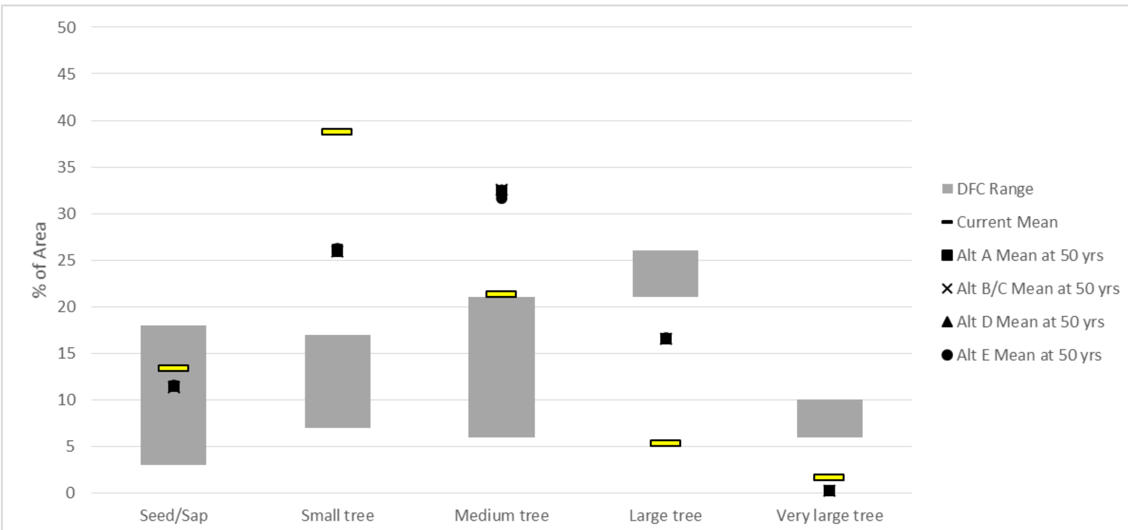



**Figure 86. Large and very large tree concentrations, forestwide, average conditions at 50 years**

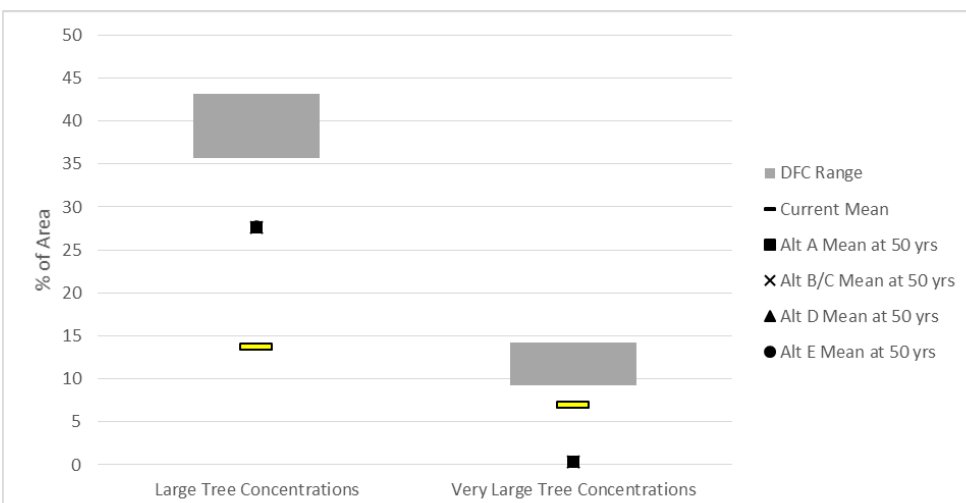


**Figure 87. Seedling/sapling size class over 5 decades**

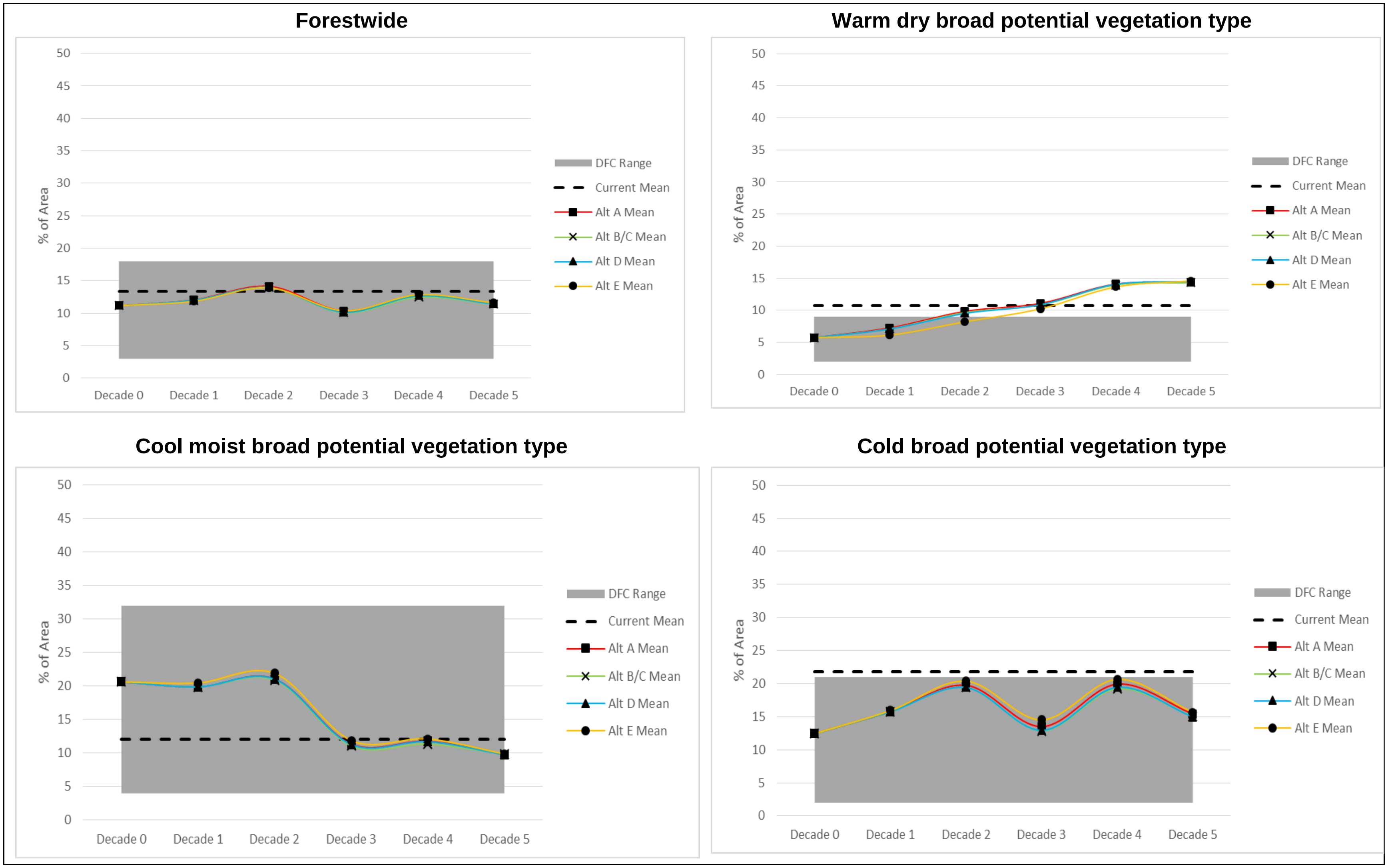


**Figure 88. Small tree size class over 5 decades**

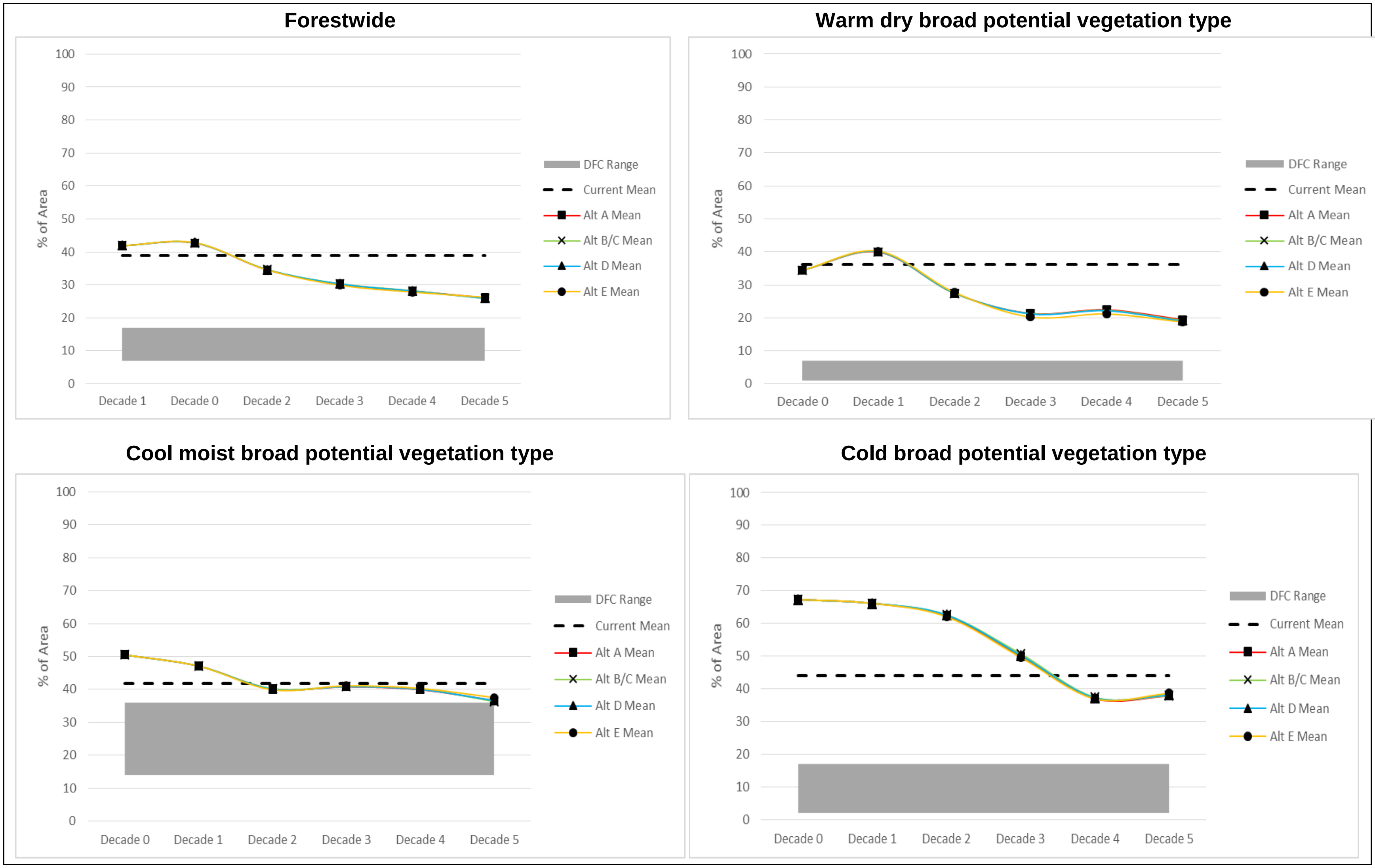


**Figure 89. Medium tree size class over 5 decades**

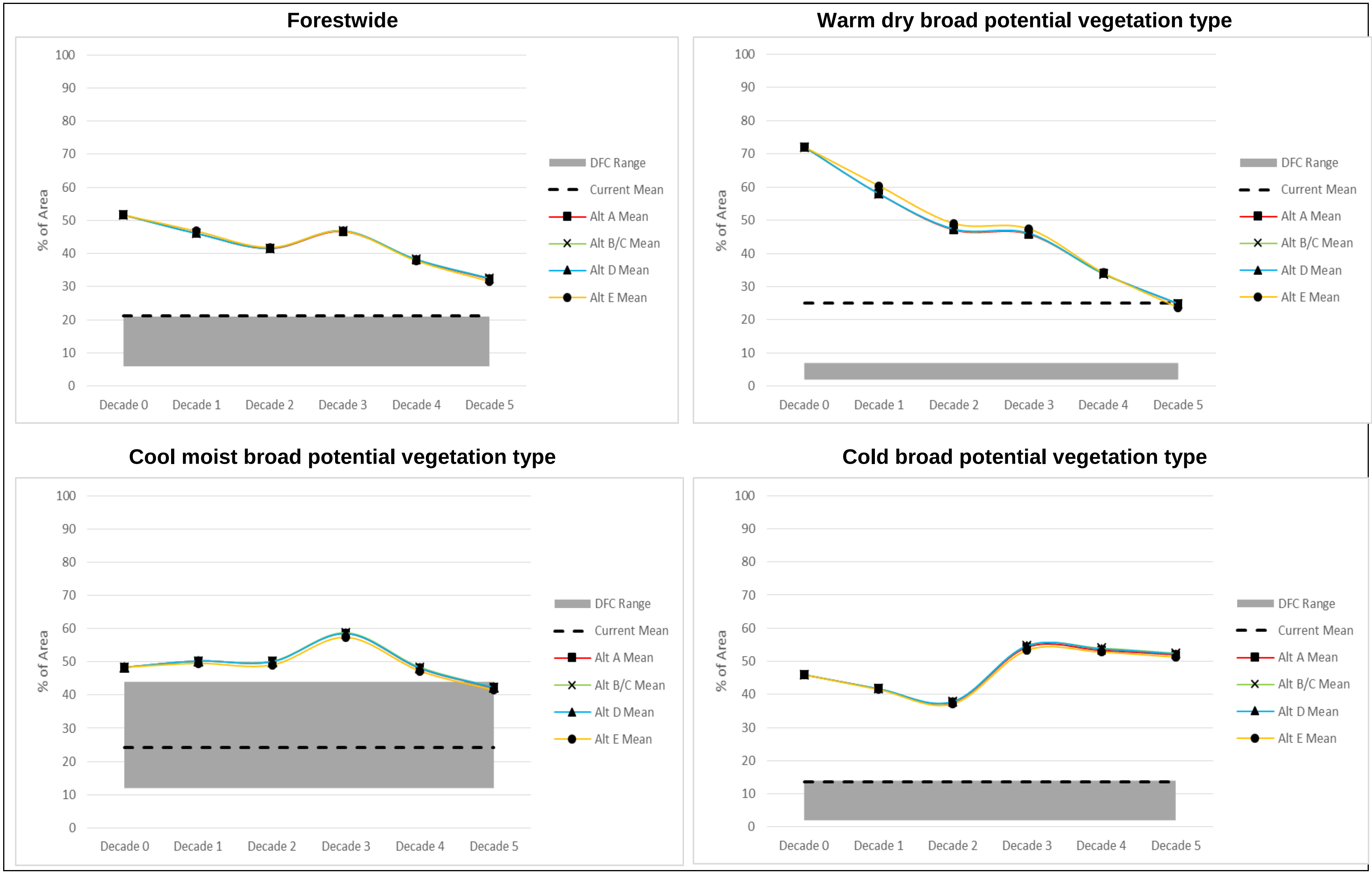


**Figure 90. Large tree size class over 5 decades**

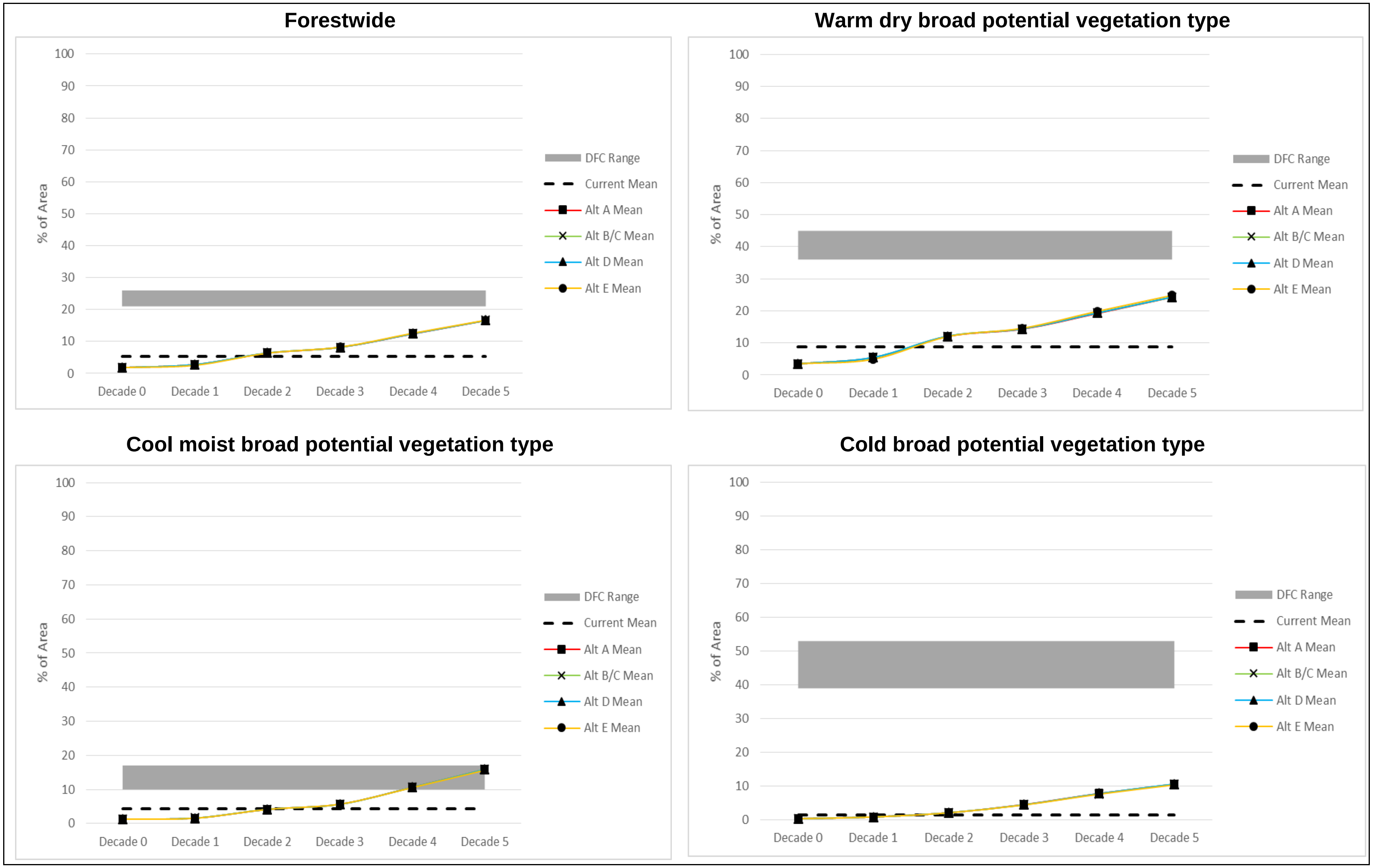


**Figure 91. Very large tree size class over 5 decades**

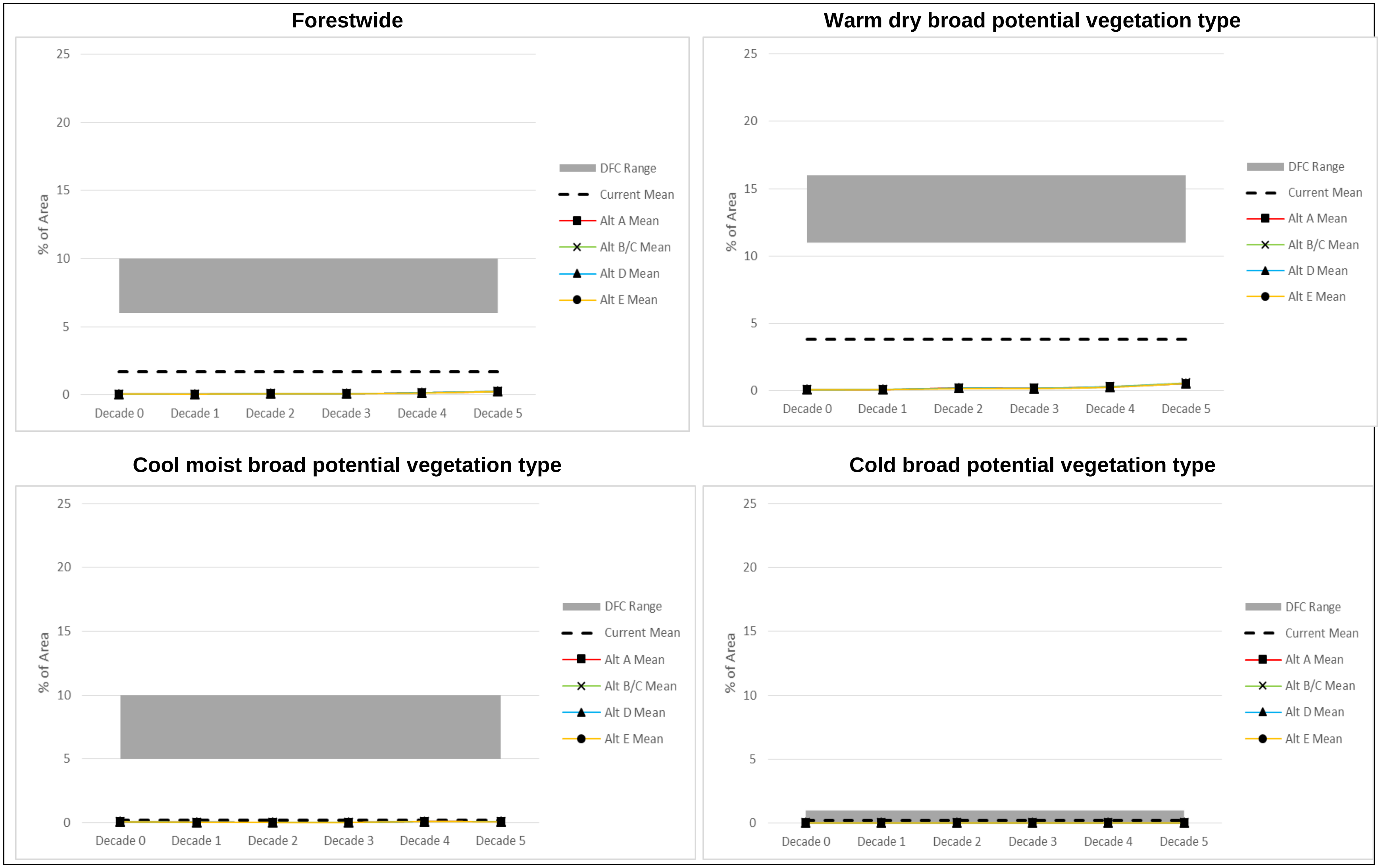


**Figure 92. GA-specific size class results**

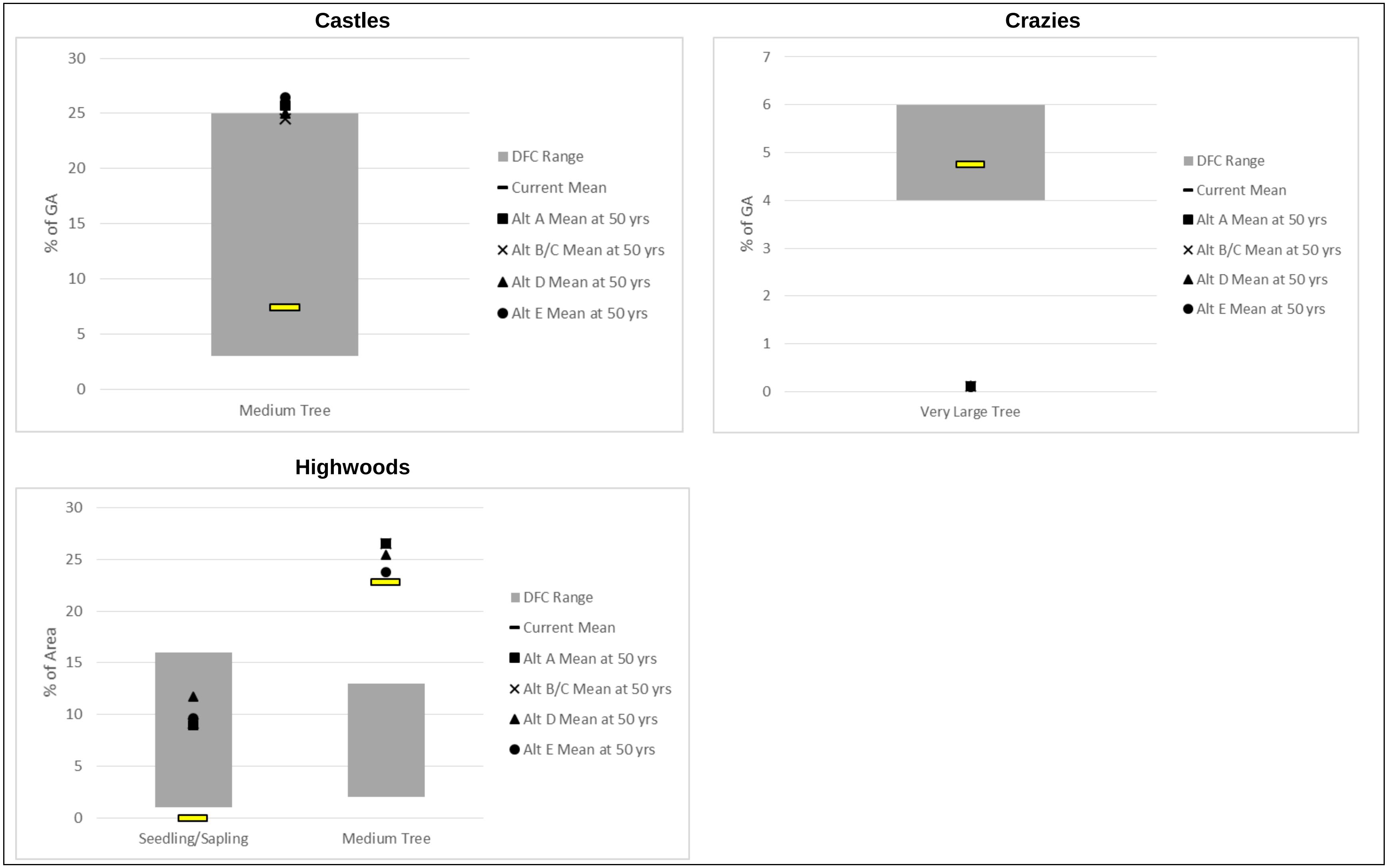


**Figure 93. Large tree concentrations over 5 decades**

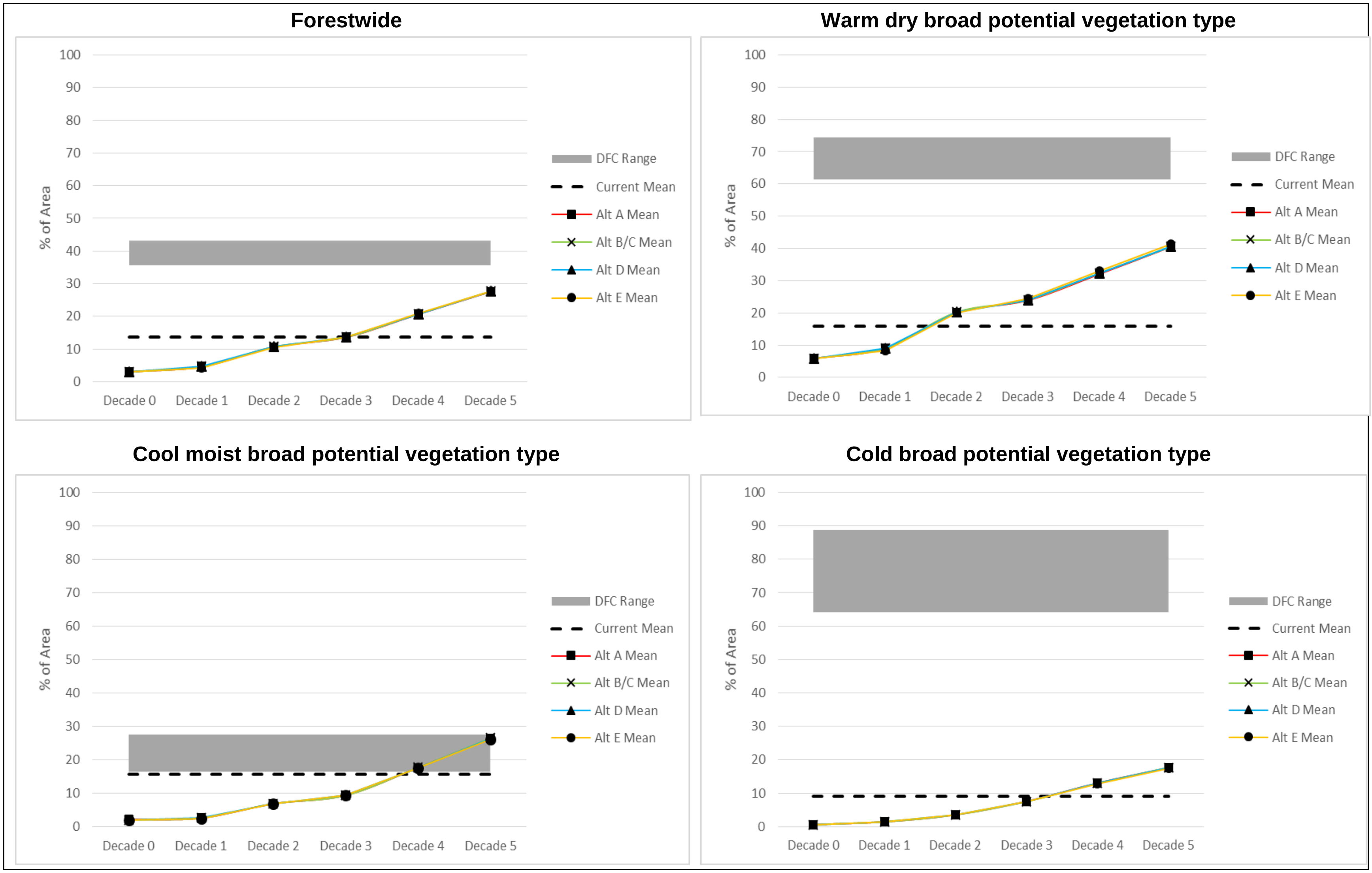
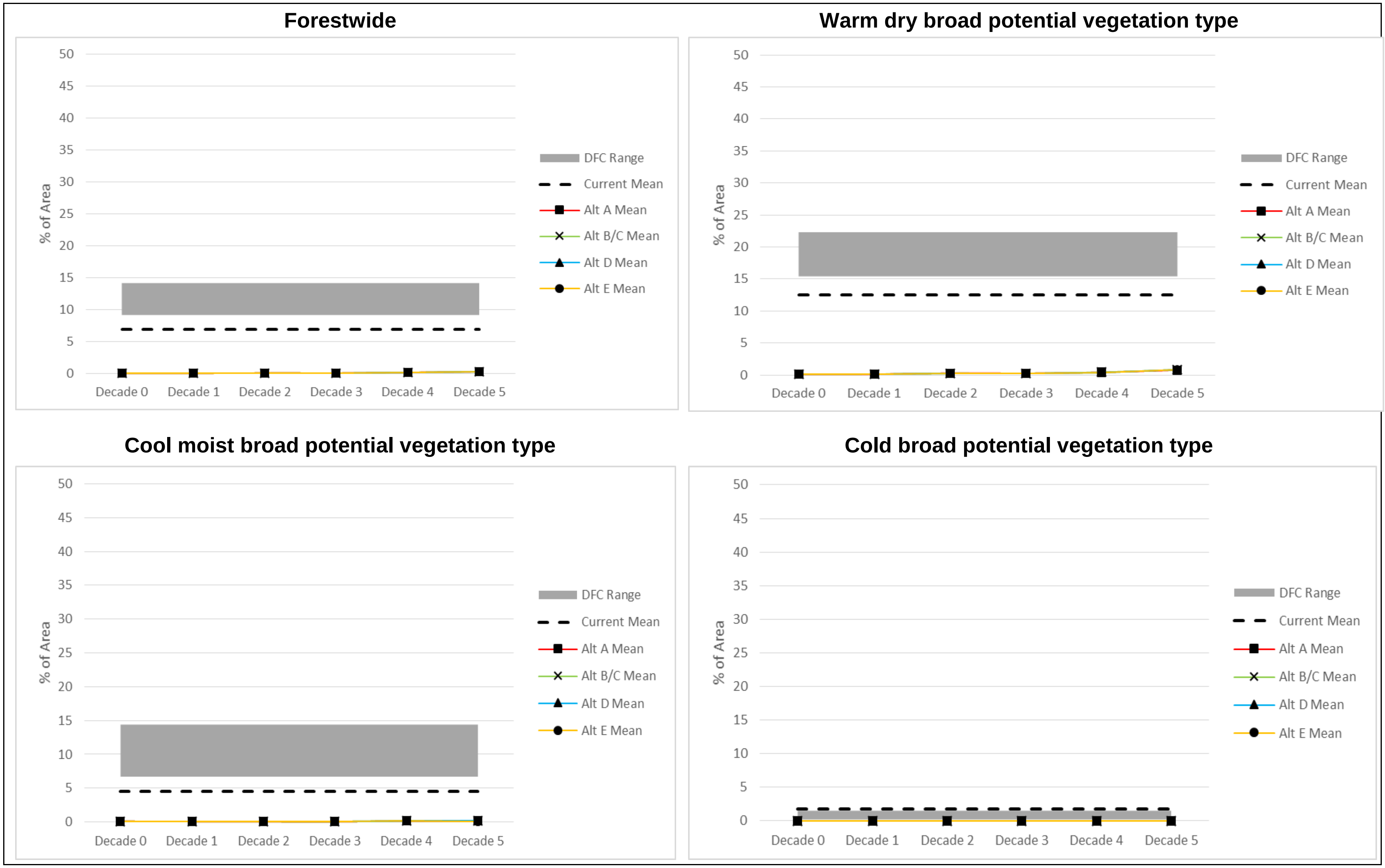


**Figure 94. Very large tree concentrations over 5 decades**



### Forest Density Class

The modeled abundance of density classes for the 50 year model period are shown below. Results are shown forestwide and by broad PVT. There were no specific results for GAs with desired conditions that vary from the forestwide ranges.

Areas are considered non-forested or do not have a density class assigned when there is less than 10% canopy cover of trees present. This includes true grass and shrublands with 0-5% canopy cover, open forest savannas with 5-10% canopy cover, and recently disturbed areas where reforestation has not yet occurred. Refer to the nonforested cover type summaries; note that there are more areas considered non-forested for the purposes of 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 forest savannas with very open spacing of trees. The existing abundance of nonforested cover types is approximately 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.

**Figure 95. Summary of forest density class, forestwide, average conditions at 50 years**

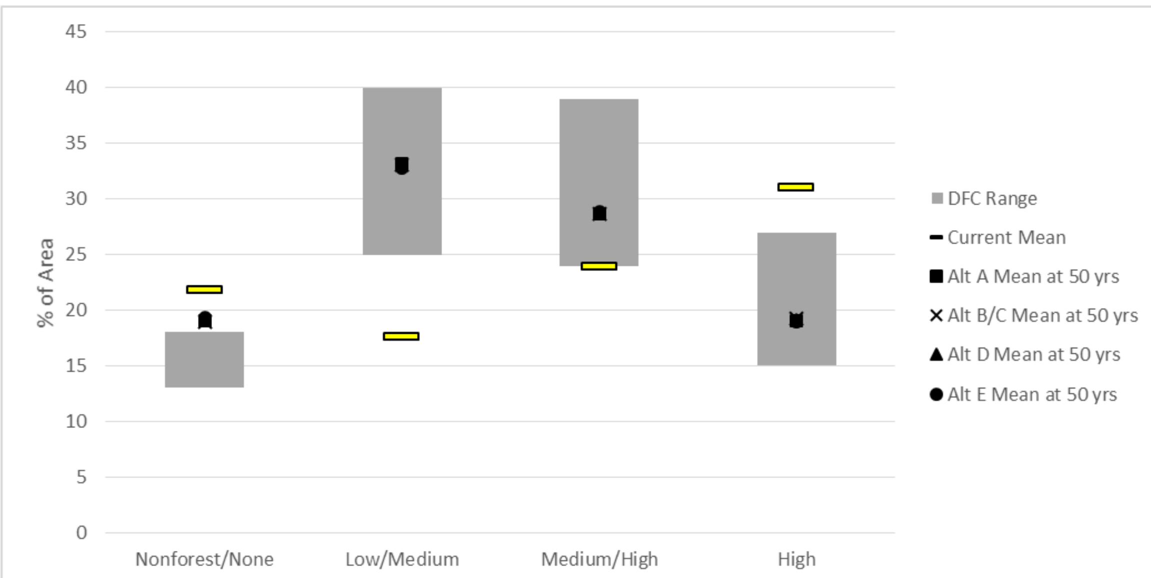


**Figure 96. Nonforest/None forest density class over 5 decades**

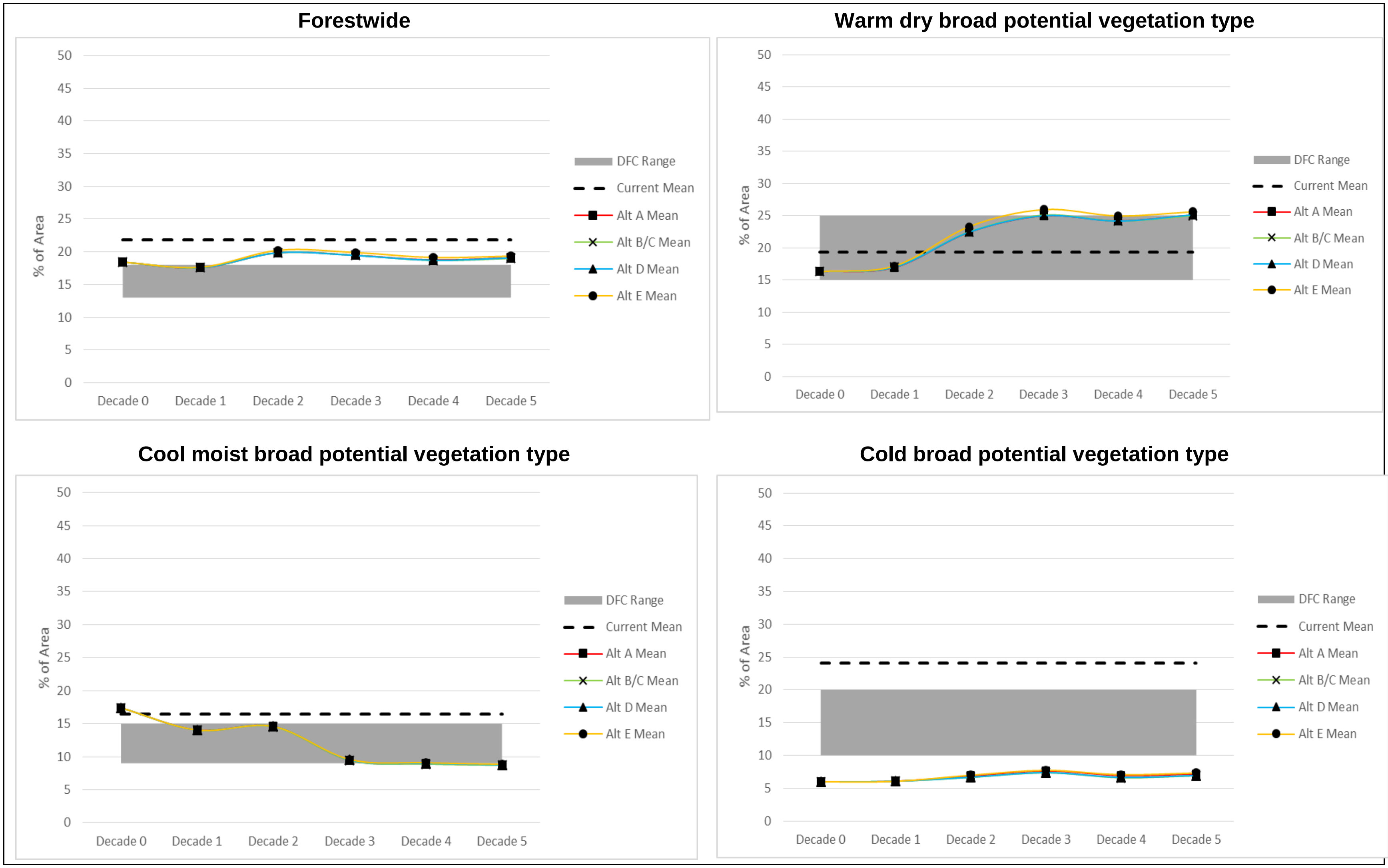


**Figure 97. Low/Medium forest density class over 5 decades**

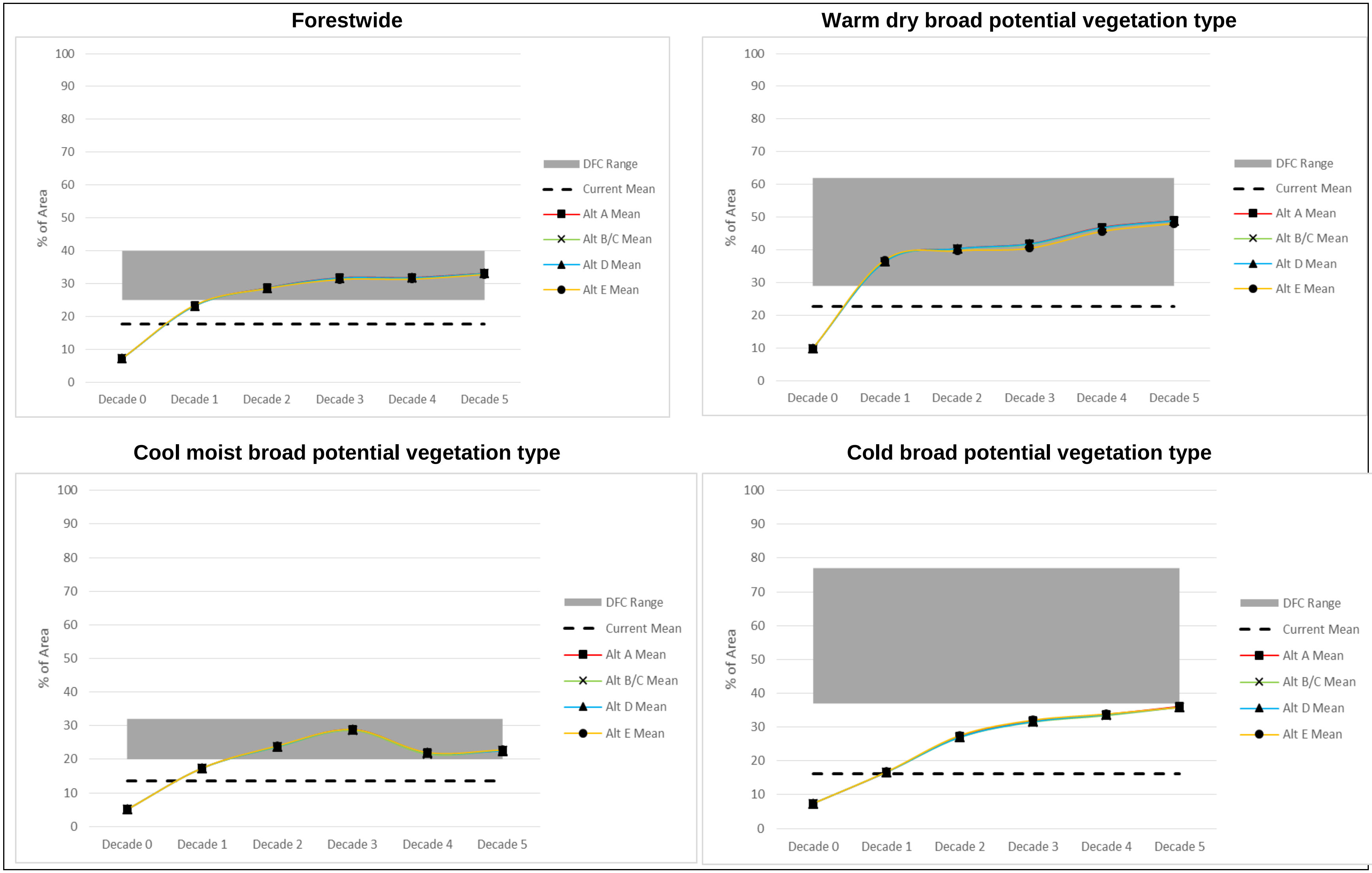


**Figure 98. Medium/High forest density class over 5 decades**

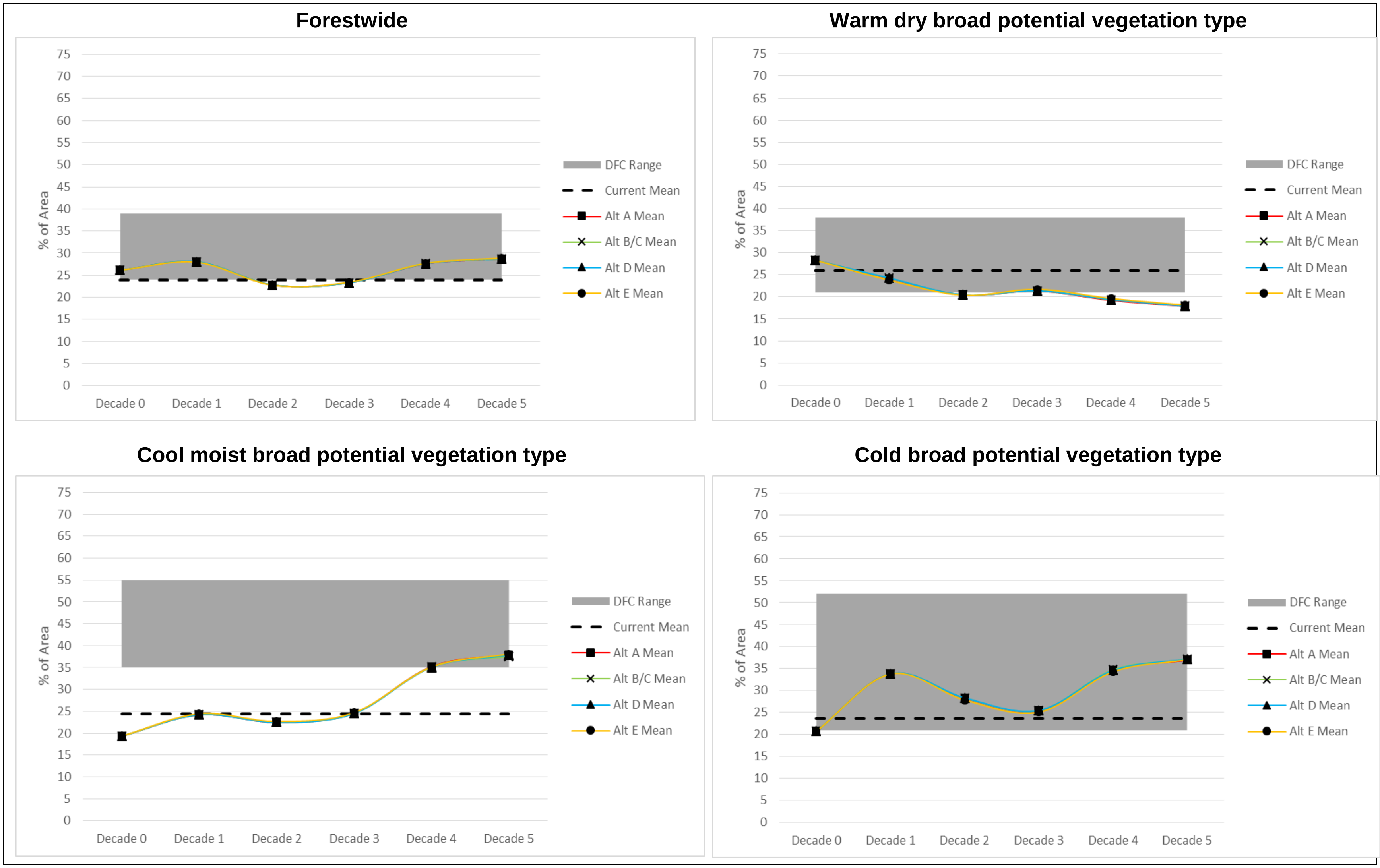
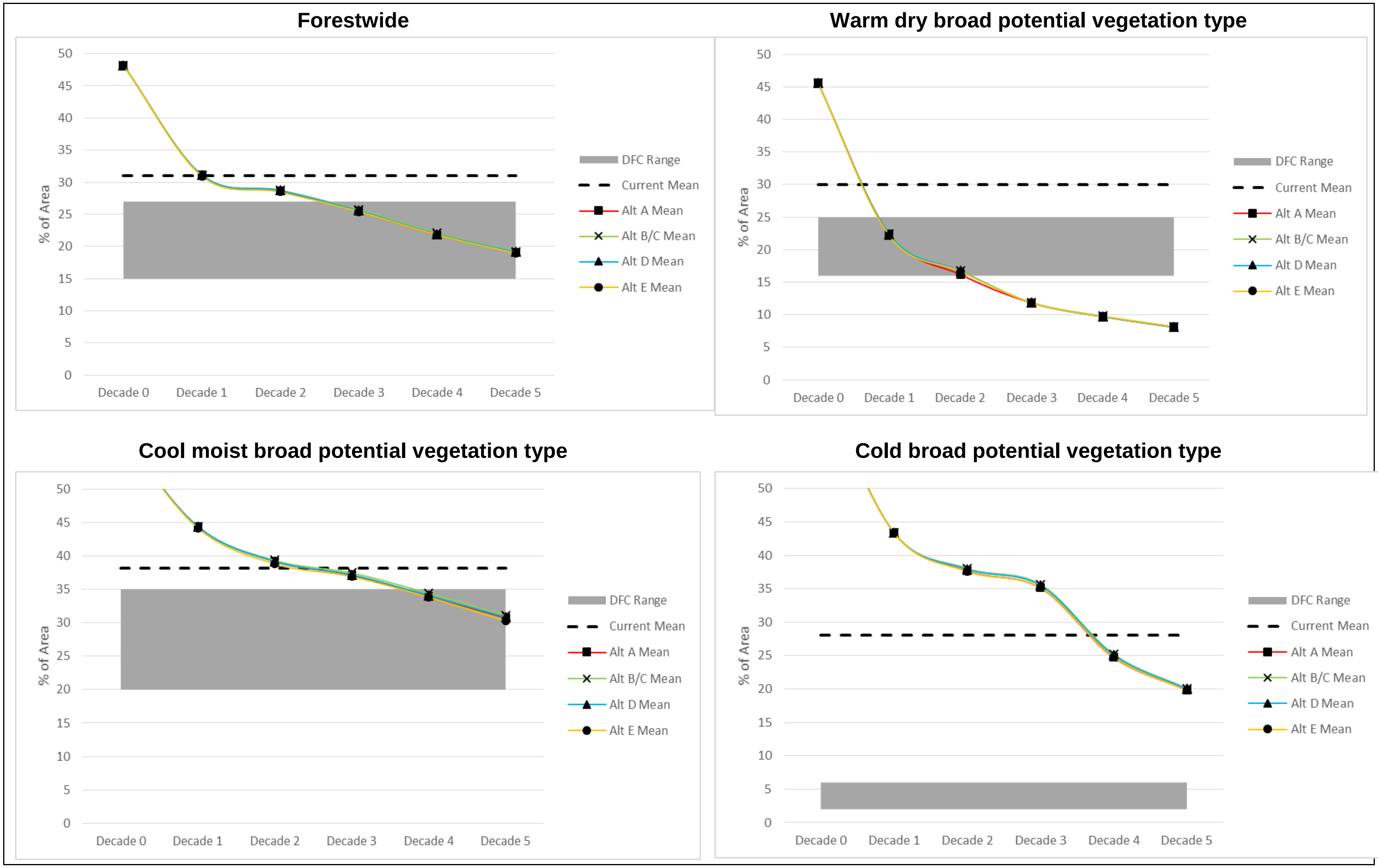


**Figure 99. High forest density class over 5 decades**



### Forest Vertical Structure Class

No quantitative desired conditions are associated with forest vertical structure class because they are inherently provided by the natural ranges of composition and size classes; however they are included for analysis purposes to fully describe the suite of vegetation conditions on the landscape. Nonforested areas are not shown. Seedling/sapling forests from the NRV modeling are combined with the single-storied class, as young regenerating forests are predominantly in this condition. Areas without a forest vertical structure (nonforested or no data) are not shown; refer to the cover type and density class discussions to represent trends for nonforested vegetation.

**Figure 100. Summary of vertical structure class, forestwide, average conditions at 50 years**

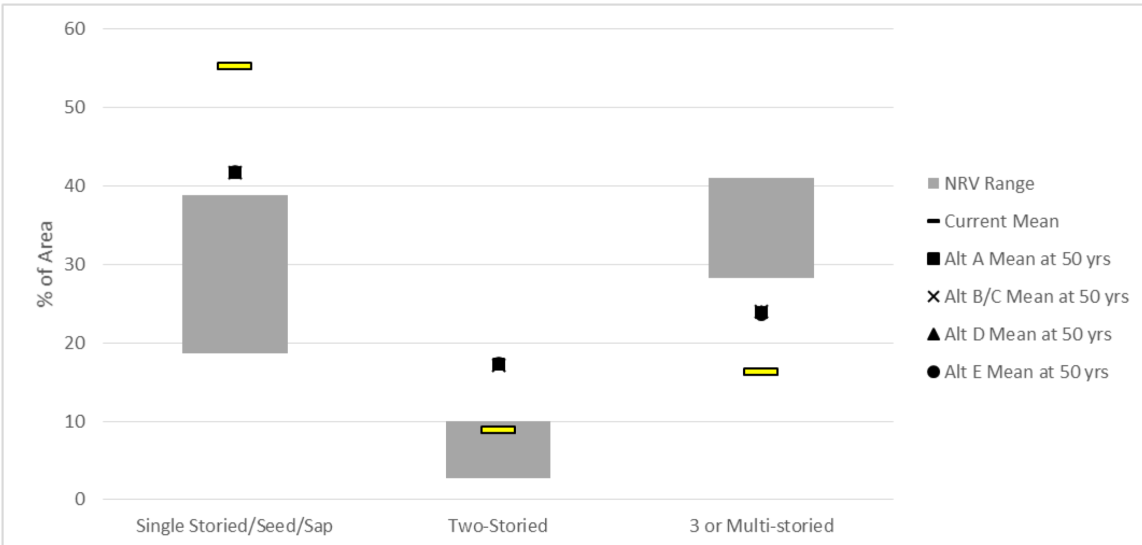


**Figure 101. Single-storied vertical structure class over 5 decades**

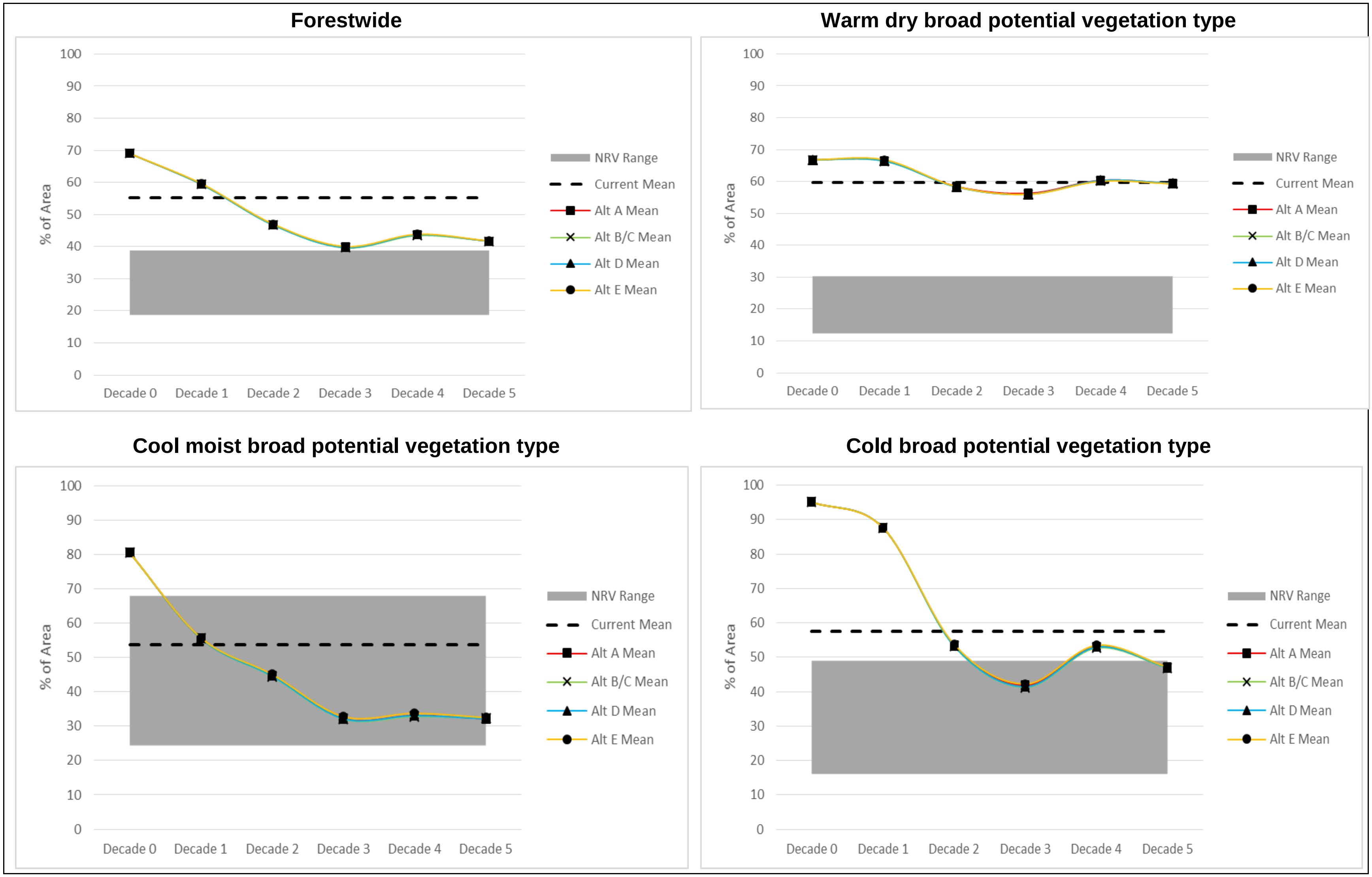


**Figure 102. Two-storied vertical structure class over 5 decades**

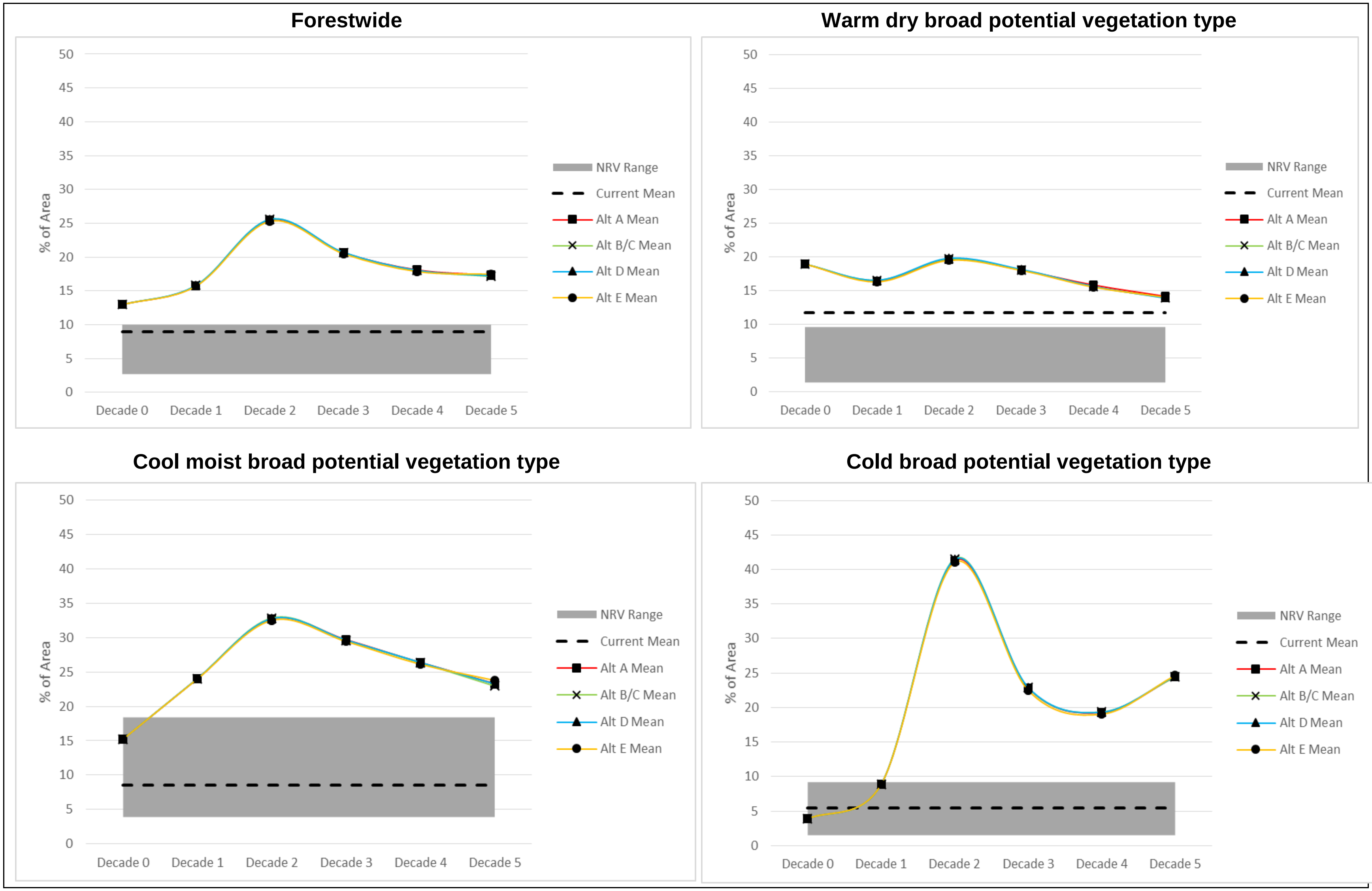
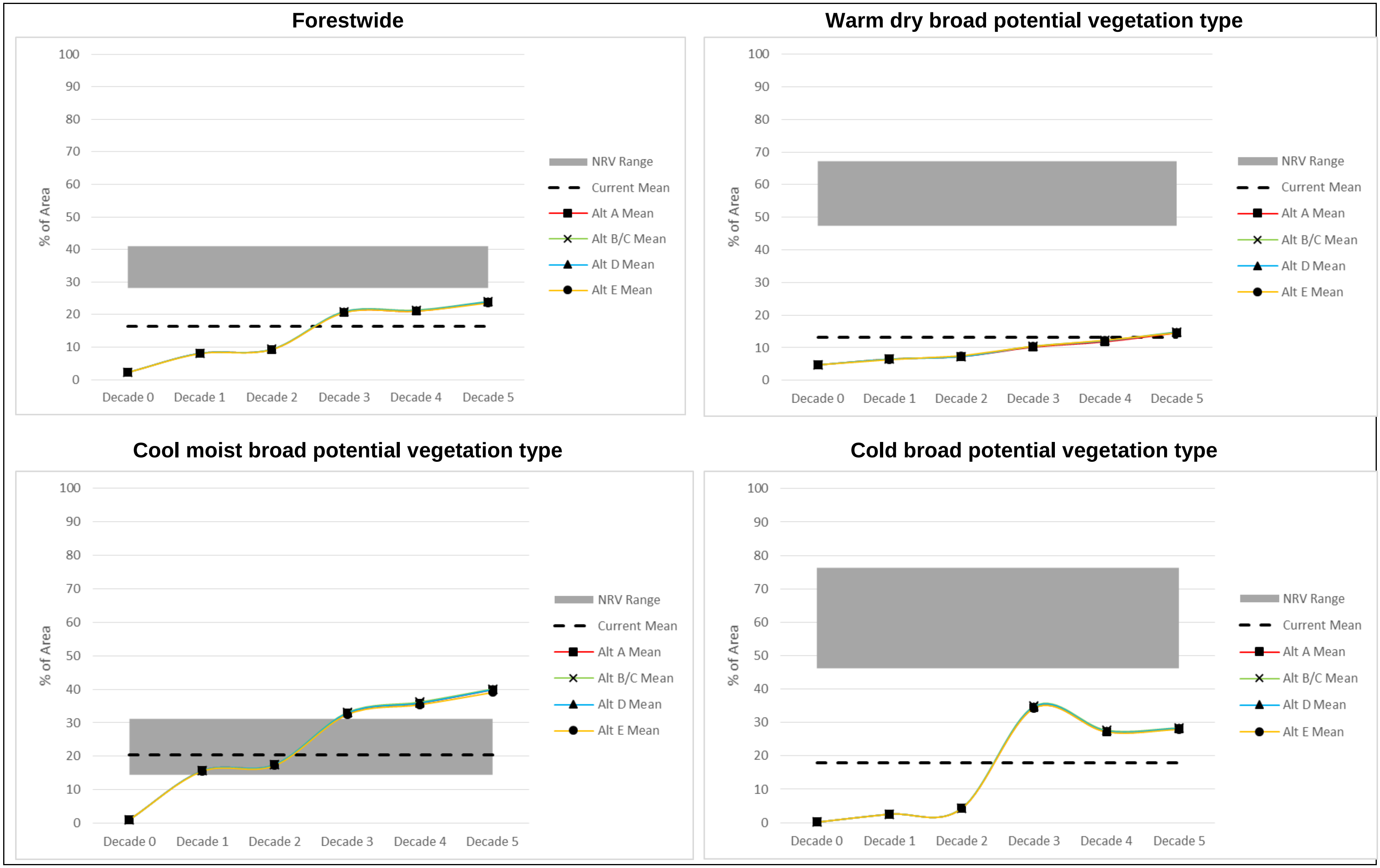


**Figure 103. Three or multi-storied vertical structure class over 5 decades**



#### Patch size of early successional forests

Early successional forests were defined as those in the seedling/sapling size class, as well as grass/shrub states found on forested potential vegetation types. The minimum patch size considered was 10 acres based on the pixel sizes of the data layer used for modeling. Two attributes of patch size were analyzed:

- *Average patch size*, which is a simple arithmetic mean; and
- *Area weighted mean patch size*, in which the mean is weighted based on the size of the patch. This metric reflects the largest average patches that would occur.

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. This information was used only for developing forest plan components and is not relevant to the effects analysis.

All alternatives displayed similar trends over time. The desired condition ranges match the NRV patch size analysis. Stratifying the landscape by broad PVT may artificially reduce the average patch sizes. For example, a large fire patch that crosses multiple PVTs may essentially create one large patch, but be calculated as several smaller patches based on the delineation of PVTs.

**Table 7. Existing and NRV of early successional forest patch size[2] (acres)**

| Attribute | Forestwide | Warm Dry | Cool Moist | Cold |
|---|---|---|---|---|
| NRV Mean Patch Size of patches | 81<br>(35-139) | 29<br>(21-57) | 95<br>(37-164) | 33<br>(17-68) |
| NRV Area Weighted Mean Patch Size[1] | 10,213<br>(223-72,288) | 174<br>(47-4,210) | 7,833<br>(195-45,694) | 142<br>(24-868) |
| NRV Mean Patch Size of patches, limited to 1 decade duration[3] | 117<br>(13-394) | 32<br>(11-251) | 128<br>(0-376) | 24<br>(0-102) |
| Existing Condition Avg. Patch Size | 113 | 49 | 76 | 39 |
| Existing Condition Area Weighted Mean of patches | 25,507 | 1,615 | 7,296 | 2,033 |

1 Weighted mean patch size provides an indication of the maximum or largest patch size
2 Patches had a minimum size threshold of 10 acres. Source for all data: SIMPPLLE modeling.
3 This analysis was used to inform the maximum opening size standard for Timber plan components.

**Figure 104. Average patch size of early successional forests over 5 decades**

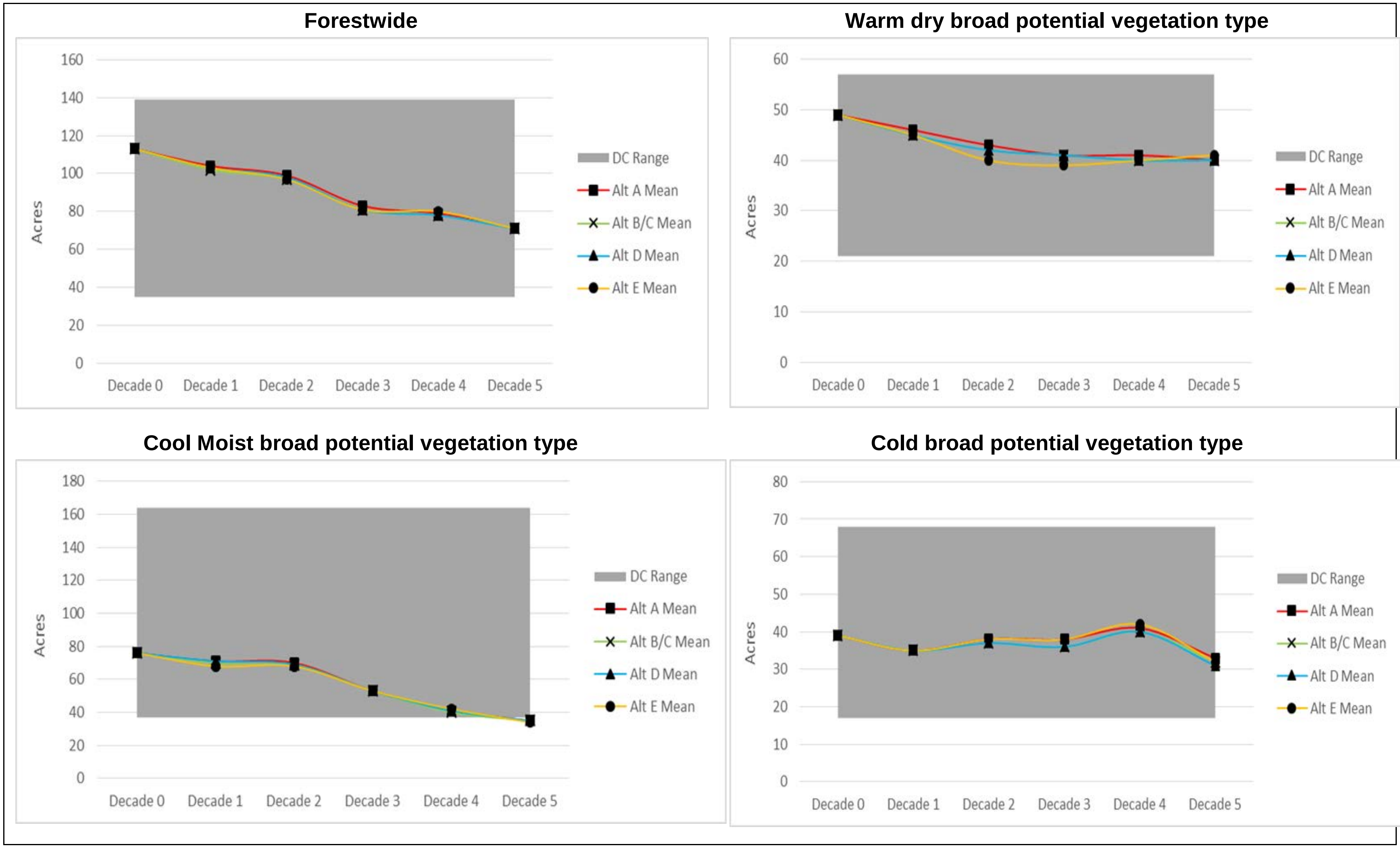
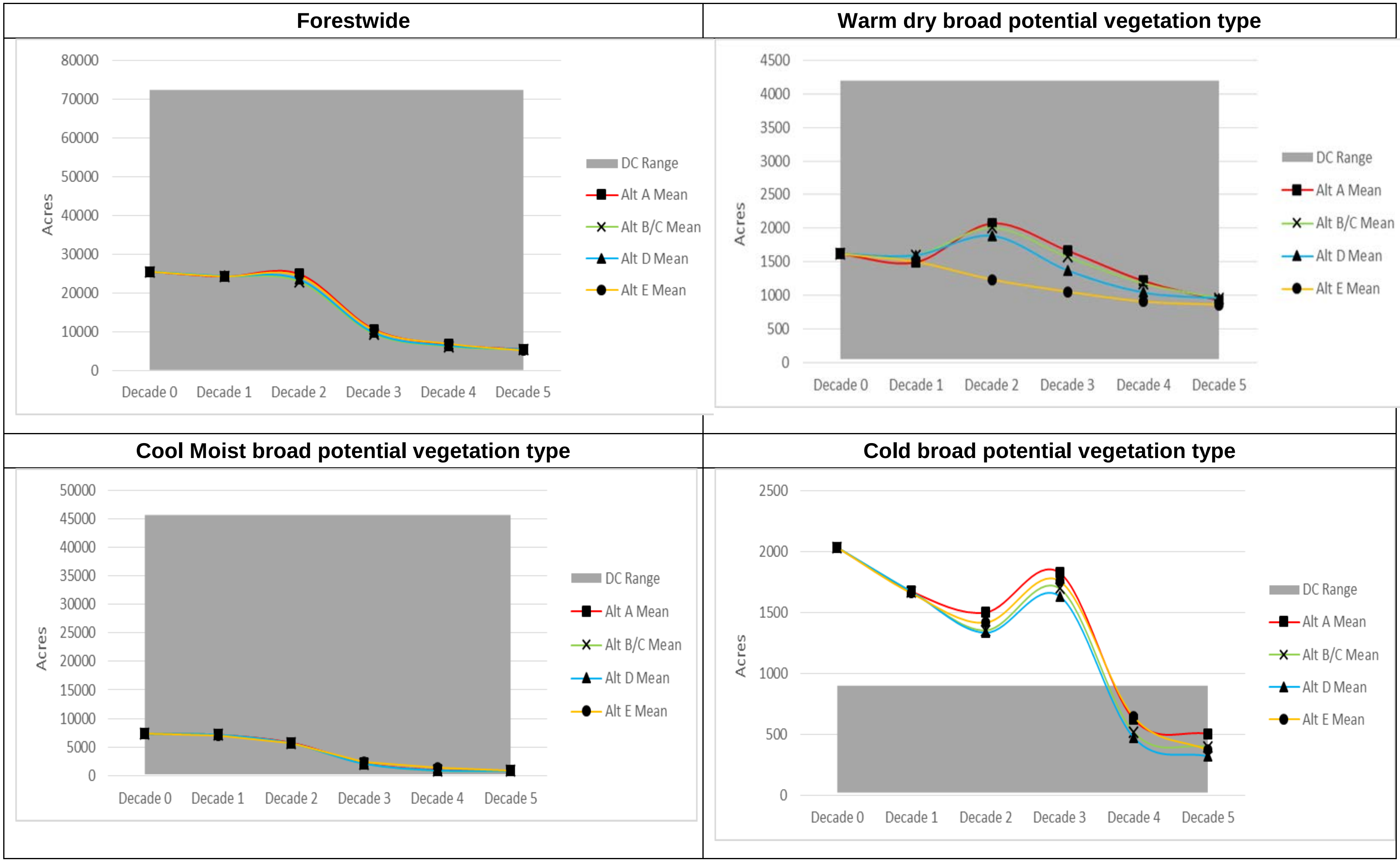


**Figure 105. Area weighted mean patch size of early successional forests over 5 decades**



# Old Growth

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. Geographic area (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 revised forest plan (alternatives B, C, D, and E) applies forestwide and by each broad PVT, and indicates that old growth should be distributed across these areas. There is no data available to inform the appropriate scale at which old growth should be distributed. Small scales, such as individual watersheds or drainages, or even the smallest GAs, would not necessarily be appropriate to encompass the large 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.

FIA field procedures collect tree diameter and measure age so this data can be used to assess old growth, and thus provides a statistically sound estimate of the amount of old growth across the forest. Confidence intervals around estimates vary based on the size of the sample and the variability of vegetation. Two datasets are used to estimate old growth condition. The first, “Hybrid 2011”, is used for forestwide and broad potential vegetation group estimates because it statistically represents all NFS lands across the plan area. The second, “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 future with the available models. However, several indicators that are available provide context to the old growth analysis. The large and very large size classes that are modeled with SIMPPLLE may have some correlation to old growth in that they represent large and very large tree concentrations as defined in appendix D of the Draft Plan. In addition, “old forests” were tracked with the Spectrum model, as shown in the Spectrum results subsection under the Timber section of this appendix; a subset of these areas may be old growth and therefore the trend may be similar.

## Old growth desired conditions

Because old growth definitions are based in part on the presence of large trees, a partial correlation can be drawn with the presence of large and very large tree concentrations. The definitions of large/very large tree concentrations are consistent with minimum large tree criteria found in old growth definitions (Green et al., 1992). This concept is also similar to how large and very large size classes are modeled in SIMPPLLE. These areas are the most likely to contain sufficient large trees to be old growth.

The NRV analysis estimated a mean of about 40% (range 35 to 43%) of the landscape had large tree concentrations, and 11% (range 9 to 14%) had very large tree concentrations. Not all of these areas would actually have been old growth, because factors such as tree age and density are not reflected. To estimate a possible proportion, the current relationship between large and very large tree concentrations and old growth can be explored. About 44% of the FIA plots that currently have large/very large tree concentrations on the HLC NF plan area also classify as old growth. If this proportion were applied to the natural range of variation estimates for areas with large/very large tree concentrations, then it can be postulated that a natural range of old growth forestwide may have been 20-25%. This range would indicate that past amounts of old growth were likely higher than the existing condition. This conclusion is supported by the finding that the existing abundance of large and very large tree concentrations and size classes are lower than the NRV, especially in the warm dry broad PVT.

The use of exact values as desired conditions is unadvisable given the wide span of assumptions used. However, this evidence indicates qualitatively that old growth was likely more abundant in the past.

Old growth conditions vary depending on the site capabilities and on other factors unique to the site, such as disturbance history. Brief descriptions of desired composition and structure of old growth found on the HLC NF are shown in Table 8, based on the old growth types and criteria from Green et al (1992). The crosswalk between the habitat type groups used for old growth and the R1 broad PVTs is imperfect, but the most predominant relationship is shown.

**Table 8. Desired old growth[1] stand conditions on the HLC NF**

| Old Growth Type | Habitat type group | Minimum age of large trees | Minimum number TPA/ DBH | Minimum basal area ($ft^2$/ac) | R1 Broad PVT[2] | Description |
|---|---|---|---|---|---|---|
| 1 -DF | A | 200 | 4 ≥ 17” | 60 | Warm Dry | Typically contain large diameter, old Douglas-fir and/or ponderosa pine; rare types have lodgepole or subalpine fir. A relatively open overstory canopy exists, but Douglas-fir can be dense in the mid and understory canopy layers with lack of disturbance. When this occurs, the large trees become more susceptible to bark beetle-caused mortality. |
| 2 –DF | B, C | 200 | 5 ≥ 19” | 60 | | |
| 4 –PP | A, B, C | 180 | 4 ≥ 17” | 40 | | |
| 5 –PF | A, B | 120 | 6 ≥ 9” | 50 | | |
| 6 -LP | A, B, C | 150 | 12 ≥ 10” | 50 | | |
| 7 –SAF | C | 160 | 12 ≥ 17” | 80 | | |
| 2 –DF | D, E, F, H | 200 | 5 ≥ 19” | 60 | Cool Moist | Douglas-fir, Engelmann spruce, subalpine fir, and/or lodgepole pine are the dominant large, old trees; rare sites may have whitebark pine. Lodgepole pine may be single-storied, or support a developing understory of spruce and fir. Spruce and fir old growth is typically dense, with multi-canopy layers, with subalpine fir and spruce the most common mid and understory tree species |
| 3 –DF | G | 180 | 10 ≥ 17” | 80 | | |
| 6 -LP | D, E, F, G, H | 150 | 12 ≥ 10” | 50 | | |
| 8 –SAF | D, E | 160 | 7 ≥ 17” | 80 | | |
| 9 –SAF | F, G, H | 160 | 10 ≥ 13” | 60 | | |
| 11 –WBP | D, E, F, G, H | 150 | 11 ≥ 13” | 60 | | |
| 6 -LP | I | 150 | 12 ≥ 10” | 50 | Cold | Engelmann spruce, subalpine fir, and whitebark pine are the most common large, old overstory trees. Because of the harsh conditions, tree growth is slower and old trees are smaller than in old growth at lower elevations. There are typically multi-canopy layers, though tree density may be low. Subalpine fir and spruce dominate the mid and lower canopy. |
| 9 –SAF | I | 160 | 10 ≥ 13” | 60 | | |
| 10 –SAF | J | 135 | 8 ≥ 13” | 40 | | |
| 11 –WBP | I | 150 | 11 ≥ 13” | 60 | | |
| 12 -WBP | J | 135 | 7 ≥ 13” | 40 | | |

1 The old growth types, groups, and descriptions are based on the minimum criteria found in Green et al (1992).
2 This crosswalk shows the most dominant relationship between old growth habitat type group and R1 broad PVT; specific habitat types may vary.

## SIMPPLLE model results for old growth

SIMPPLLE was used to estimate the abundance of large and very large forest size classes. These values are generally consistent with the classification of large and very large tree concentrations. The combined proportion of large and very large tree concentrations show correlation to areas that are most likely to be old growth. The figures below show the anticipated trend of large and very large size classes over time, forestwide, and by broad PVT as a proxy indicator for the potential expected trend of old growth.

**Figure 106. Projected abundance of large and very large tree concentrations by alternative**

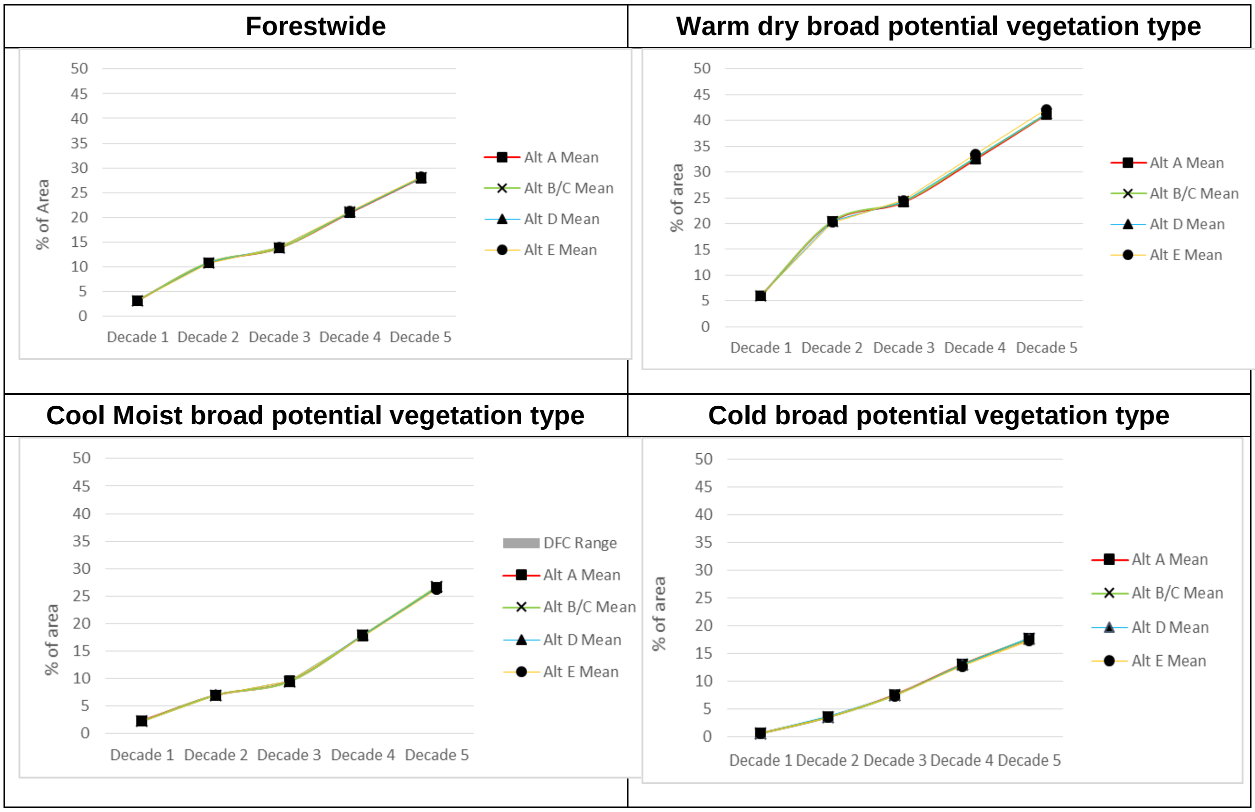
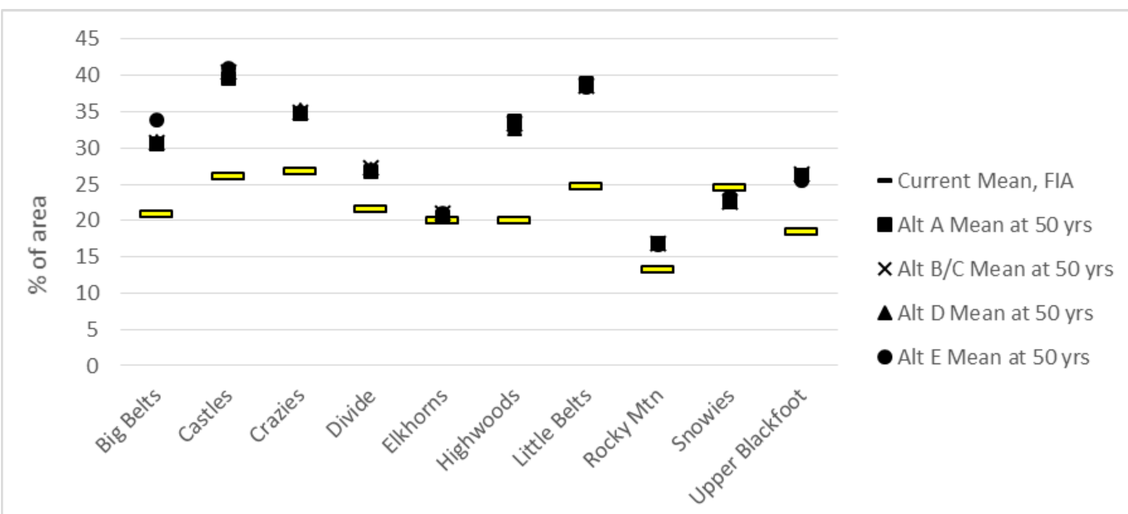



**Figure 107. Projected abundance of large and very large tree concentrations by GA**



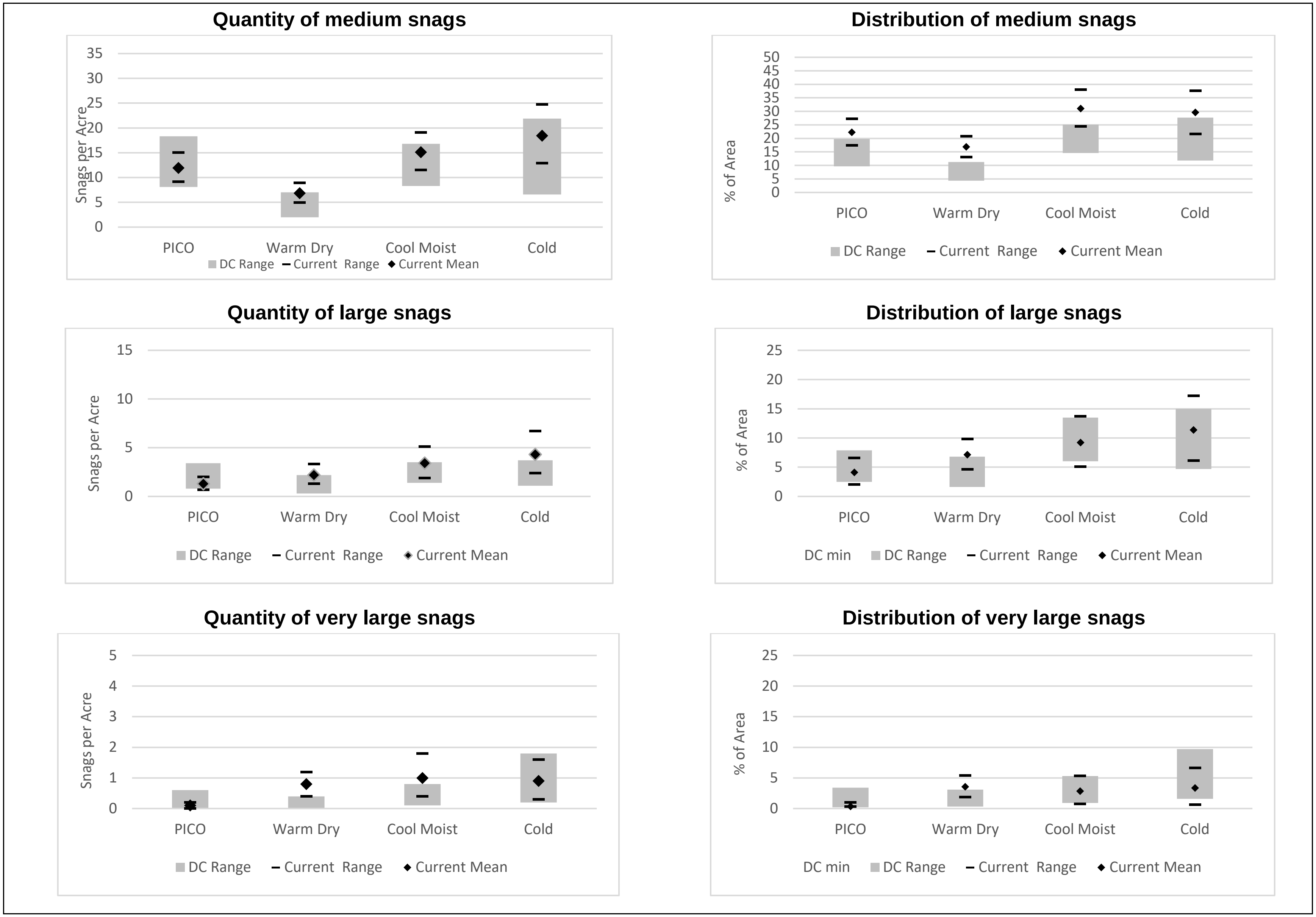

# Snags and Downed Wood

The analysis area for snags is Forestwide by snag analysis group. Snag analysis groups are consistent with R1 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 potential vegetation groups to be consistent with the best available information to inform the desired condition.

## Snag desired conditions

Desired conditions for snags (by snag analysis groups) are shown in the figure below, and are designed to reflect the conditions that would be expected to occur under natural disturbance regimes. The desired snags per acre are 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 prior to the mountain beetle outbreak and reported by Bollenbacher and others (2008). The existing condition is based on the Hybrid 2011 FIA dataset. The desired distribution reflects the proportion of the snag analysis group that contains one or more snags in the indicated size class.

**Figure 108. Forestwide existing and desired quantity of snags, by snag analysis group and size class**



## Coarse woody debris desired conditions

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.

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 potential vegetation types and 10 to 30 tons per acre for other types. The amount and distribution of coarse woody debris in roadless and wilderness areas (as measured on FIA plots) 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) because the data for this type includes open savannas, where grass and shrubs dominate and trees are widespread. Therefore, the lower end of the range described by Brown and others (2003) is adjusted downward to account for the unique (drier) conditions found on the HLC NF.

**Table 9. Existing condition and desired range of downed wood 3” diameter and greater**

| Broad PVT | Desired[1] tons/acre | Existing[2] tons/acre | Desired Trend and Distribution |
|---|---|---|---|
| Warm Dry | 3-20 | 3.38 (2.66-4.19) | Coarse woody debris is variable in amount, size, species and stages of decay across space and time, emphasizing pieces 10” in diameter and 10’ in length or greater, which are higher value for wildlife. Individual stands may have little or no coarse woody debris, or a higher amount. Very minimal or no coarse woody debris occurs in nonforested potential vegetation types. It may be appropriate for 30 to 50 percent of a forested potential vegetation type area to have little to no coarse woody debris at a given time. Amounts below the desired average are found on hot dry sites, in developed recreation areas, and where the concern for fire impacts to values at risk is elevated. Higher amounts may be found on moist sites and riparian areas, areas with low direct human influence, burned areas, and those with insect/disease infestations. Pulses of coarse woody debris occur following disturbances. Downed wood in pine-dominated forests may increase during the first decade of the Plan due a mountain pine beetle outbreak. |
| Cool Moist | 10-30 | 7.22 (5.81-8.76) | |
| Cold | 10-30 | 7.04 (5.33-8.91) | |

1 The source of the desired tons/acre is Brown et al (2003), and FIA plot data measured in wilderness/roadless areas.

2 Data source for existing: R1 Summary Database, Hybrid 2011 FIA plots. The mean is displayed, with the bounds of the 90% confidence interval in parentheses.

# Plants at Risk

The USFWS is responsible for determining species recognized under the ESA as threatened, endangered, and proposed or candidate. Once identified, the FS is responsible to manage for the ecological conditions that would contribute to the recovery of the listed species and conserve proposed and candidate species. Determining effects to federally-recognized species by alternative considers the degree of management activities or natural conditions that may pose potential stress or threat to the species.

The 2012 forest planning rule provides direction for determining which of species to be potential SCC, as described in the previous introduction section. The list of potential SCCs must meet the following mandatory requirement (FSH 1909.12 Section 12.52): The best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area. This information may be derived from the scientific literature, species studies, habitat studies, analyses of information obtained from a local area, and/or the result of expert opinion or panel consensus. Additional information is available in the assessment, the supplemental botany report in the project record, and the Region 1 Species of Conservation Concern Planning webpage:
https://www.fs.usda.gov/detailfull/r1/landmanagement/planning/?cid=FSEPRD500402&width=full

Once SCC were defined, key ecosystem characteristics for species was evaluated and determinations made on whether forest-wide components maintained habitat quality needed by associated SCC by considering known locations of species and their habitats, as well as key drivers/stressors. Additional species-specific plan components were then considered and developed if needed. In other words, the extent and condition of each ecosystem or special type served as the habitat indicator for individual species, and for assemblages of at-risk species and overall floristic diversity. For most species, extent and condition of habitat typically constitute the best available scientific information indicating whether such populations would continue to persist with sufficient distribution in the planning area (2012 Rule Sec. 219.19), though known occurrences, trend data and known threats to species viability and used when available to compare each alternative.

Determinations for each species consisted of a viability evaluation, which examined whether plan components provide ecological conditions necessary to maintain a viable population of each species of conservation concern in the plan area. The viability evaluation was conducted using both a coarse filter and a fine filter approach, again using known populations, habitat extent and condition, and known threats as indicators. For the coarse filter approach, species were grouped by habitat guilds. This coarse filter approach assumes that viability of SCC is broadly dependent upon the integrity of the coarse ecosystems where they currently occur. We made qualitative, rather than quantitative, evaluations to compare the action alternatives to the no-action alternative forest-wide plan components. The coarse filter approach was used to compare forest-wide plan components of the old forest plans (Alternative A) and the new plan (Alternatives B-E) using habitat guilds and considering species in a broader context. However, the habitat guilds outlined below are roughly, but not exactly aligned with floristic geographic subdivisions, to which at-risk plant populations are often associated. Since the integrity of whole ecosystems does not necessarily ensure persistence of all species of conservation concern, particularly those with very limited distribution, we conducted additional fine filter analyses (by quantitative species-specific population and habitat indicators) to ensure that persistence is provided for all plant SCC to compare each alternative.

The fine filter viability evaluation focuses on species-specific data rather than habitat guilds and was conducted to compare the analysis of (1) percentage of known occurrences within different management areas, such as designated wilderness, recommended wilderness or lands suitable for timber production, (2) estimated percentage of available potential habitat for each species in those management areas, and (3) known threats to each individual species of conservation concern. Each alternative was considered using the fine filter approach. The habitat guilds are not used to quantitatively compare alternatives. For whitebark pine, an at-risk plant species that is also a candidate species for federal listing, an additional indicator, population trend, was also evaluated. For this species, where trend information related to management activities has been documented in the plan area, quantitative, species-specific information was available for analysis. The adjustment of indicators was selected between the coarse and fine filter analysis because relative differences among alternatives could be readily compared. An overview of all at-risk species known in the plan area and species' respective determination rationale are presented in the Botany supplemental report in greater detail.

# Invasive Plants

Effects to invasive species is indicated by evaluating the difference in frequency, intensity, or type of management activity or natural processes by alternative, insofar as they may potentially disturb the ground and result in greater risk of weed spread or invasion. The process for identifying risk and impacts resulting from invasive species is completed by FS botanists and vegetation specialists.

The geographic scope of the analysis for non-native invasive plants are the national forest system lands of the HLC NF. This area represents the lands where changes may occur to vegetation as a result of management activities or natural events. For cumulative effects, the analysis area also includes the non-national forest system lands within and adjacent to the administrative boundary of the HLC NF.

Two temporal scales were chosen to assess the current condition of invasive plants:

- Inventory data collected over the past 14 years (beginning in 2001) has been summarized to characterize current invasive plant infestations (in acres) on the HLC NF.
- Treatment data collected during the past 5 year period (2010-2014) has been summarized to characterize invasive plant treatments (in acres) across the HLC NF. This allows for the use of the most recent and relevant data in regards to invasive plant treatments.

The following methods and associated data were used to analyze the current condition of invasive species:

- Summarization of existing Geospatial Information Systems data as entered through the Threatened, Endangered, and Sensitive Plants, and Invasive Species database and reported through the Geospatial Interface;
- Summarization of existing Forest Service Activity Tracking System data;
- Literature review of the best available science.

# Terrestrial Wildlife Diversity

In developing plan components and in analyzing their potential effects on the diversity of native wildlife communities, we sought information on local wildlife populations and habitat factors from sources described above in the section on best available scientific information. We identified key ecosystem characteristics, including those that support native wildlife species, assessed system drivers and stressors, and estimated the natural range of variation for key ecosystem components. All of these are documented in the Assessment (U.S. Department of Agriculture, Forest Service, Northern Region, 2015). During the planning process, evaluations were made regarding whether wildlife species' needs would be met by plan components that were being developed to maintain or restore ecosystem diversity and integrity.

This report relies on vegetation models (SIMPPLLE and Spectrum) to estimate and predict the current status, NRV, and predicted future condition of key ecosystem characteristics that comprise wildlife habitats. The Terrestrial Vegetation and Timber sections provide information regarding the methods, accuracy, and limits of those models and their products. Estimates and predictions made for key ecosystem characteristics were evaluated using the best available scientific information regarding the habitat needs of native wildlife species, in order to assess the effectiveness of plan components in maintaining wildlife diversity.

For most habitats and species considered in this report, the analysis area is NFS lands within the administrative boundary of the HLC NF. The cumulative effects analysis area considers management of adjoining lands. The anticipated life of the forest plan is about 15 years. Management actions that occur under direction of the plan have the potential to impact wildlife species and their habitats for many decades, however, the analysis of potential vegetation and therefore habitat change spanned the next 50 years (refer to Terrestrial Vegetation section).

# At-Risk Terrestrial Wildlife Species

The 2012 Planning rule states that plan components that provide for ecological conditions for ecosystem integrity and ecosystem diversity are the primary context for the evaluation of at-risk species. For most species, the only practical quantitative evaluation of their required ecological conditions is an assessment of habitat conditions (ecological conditions). Therefore, this report relies on the analysis completed in the Terrestrial Vegetation section, and other sections as appropriate, regarding the ecological conditions required by at-risk species. As such, the methodologies and science used in the analysis of terrestrial vegetation is inherent in the discussion and conclusions provided in this section.

This section also relies primarily on information in the scientific literature, and in published and unpublished reports regarding the presence, distribution, and requirements of at-risk wildlife species and potential impacts on them of existing and proposed management actions. Research reports and literature are frequently not available specifically for the HLC NF or nearby areas, or for the specific management proposed in the draft plan and alternatives to the draft plan. Therefore in this section we have made inferences in applying information and conclusions from reports and literature to species, habitats, and management actions on the HLC NF have been made.

The methods used for selecting species of conservation concern for the HLC NF are documented on the Region 1 Species of Conservation Concern web page (https://www.fs.usda.gov/detailfull/r1/landmanagement/planning/?cid=FSEPRD500402&width=full). That process included extensive coordination with the HLC NF, and review of available data, observations, scientific literature, published and unpublished reports, and other information as documented there.

Habitat models used to estimate current and future habitat for some at-risk species discussed in this report are the same as those used to estimate current and future amount and distribution of terrestrial vegetation. Methods for modelling vegetation, as well as information about accuracy of those models, are described in the Terrestrial Vegetation section, and in supporting materials in the project file. Estimates of wildlife habitat were made using specific queries from those vegetation models, and therefore assume the accuracy of the model that was queried. Information regarding the queries used to estimate wildlife habitats is available in the project file. Models are based on accumulations of assumptions and therefore vary in their ability to predict actual habitat, and they cannot predict whether animals will actually use habitat as depicted.

## SIMPPLLE model results for at-risk wildlife species

### *Flammulated owl*

Flammulated owl nesting habitat is represented by the proportion of land in select warm dry habitat types dominated by ponderosa pine forest, with 1-2 canopy layers, 15-60% canopy cover, and greater than or equal to 15” average diameter. The following figures display forestwide results; GA-specific results are available in the planning record.

**Figure 109. Flammulated owl nesting habitat, average acres/decade for 50 years compared to NRV by alternative**

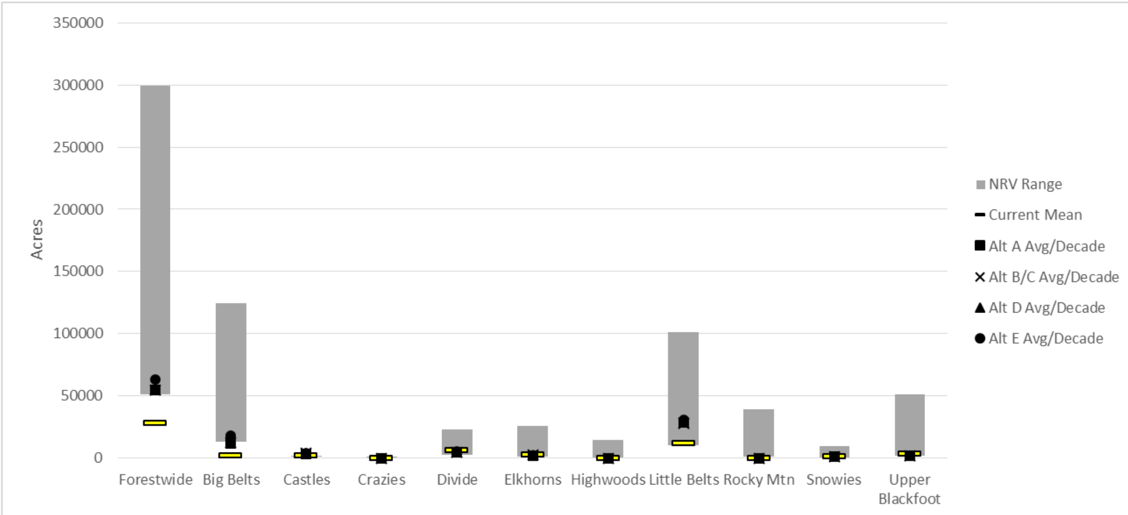
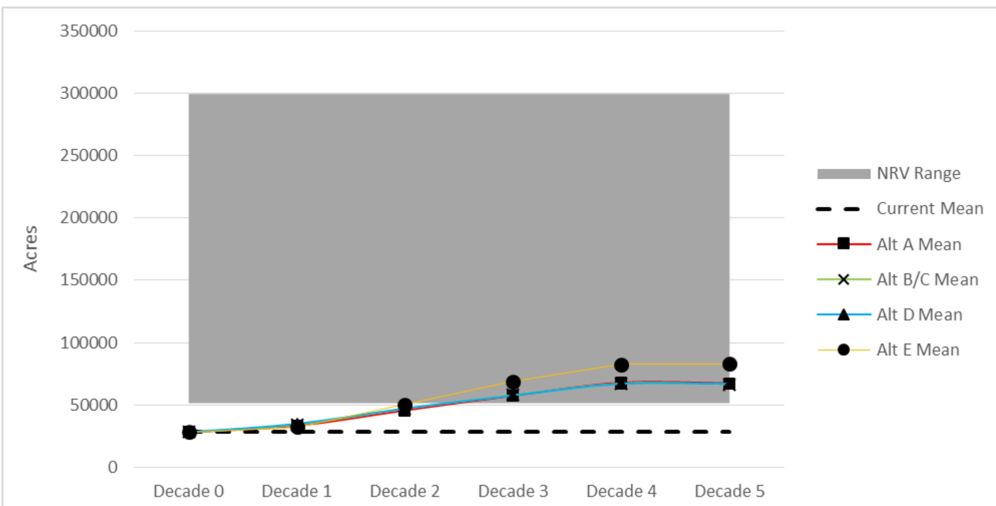



**Figure 110. Flammulated owl nesting habitat over time by alternative Forestwide by alternative**




### *Lewis's woodpecker*

Lewis' woodpecker nesting habitat is represented by the proportion of land on select warm dry habitat types dominated by Douglas-fir, ponderosa pine, aspen, or western larch, with 15-40% canopy cover and greater than or equal to 15" in diameter. The following figures display forestwide results; GA-specific results are available in the planning record.

**Figure 111. Lewis's woodpecker nesting habitat average acres/decade over 50 years compared to NRV by alternative**

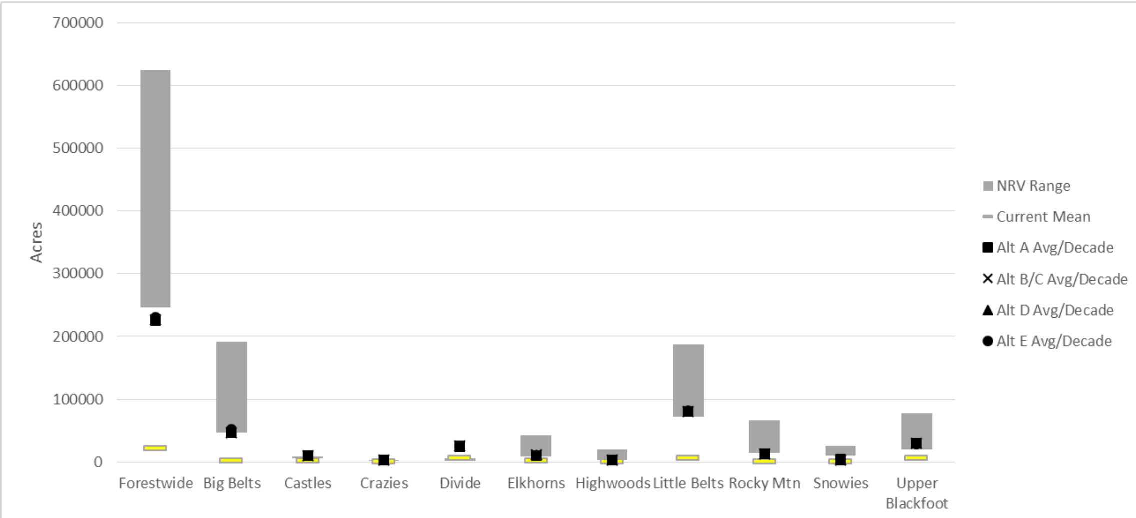
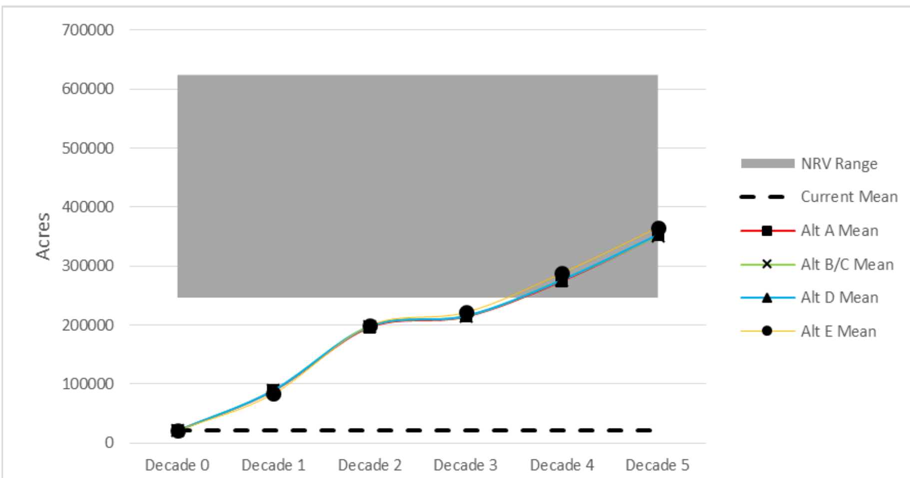



**Figure 112. Lewis's woodpecker nesting habitat forestwide over time by alternative**



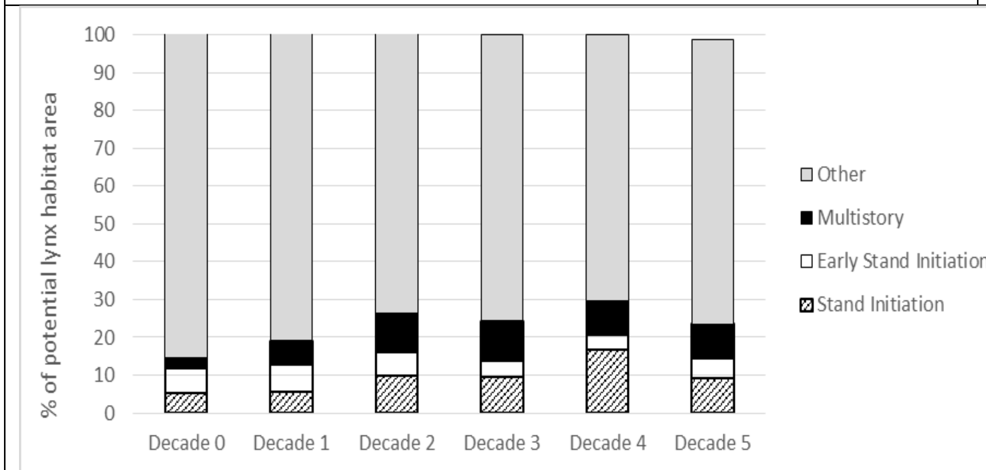

### *Canada lynx*

A variety of Canada lynx habitat conditions were modeled within *potential lynx habitat*, which is represented by subalpine fir, Engelmann spruce, or select moist Douglas-fir habitat types within 300' of the other types, above 5000' elevation. Several summary charts are included in the body of the DEIS. The charts below show results for each habitat condition and GA here to supplement the analysis.

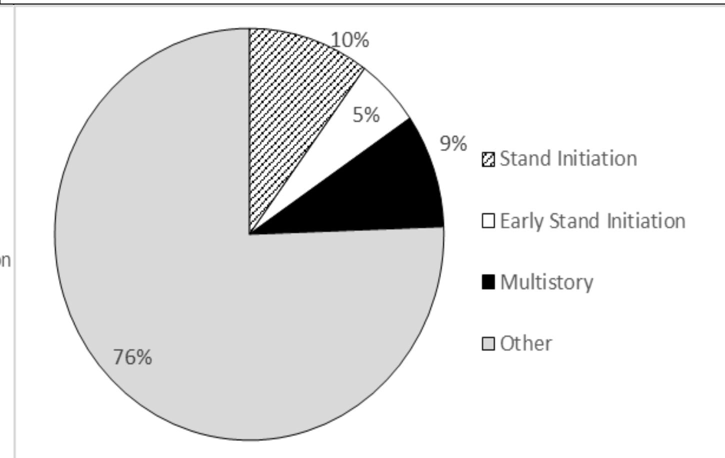
- Stand initiation hare habitat: potential habitat with greater than or equal to 40% forest canopy cover in a seedling, sapling, or pole size class or 15-40 years post-stand replacing fire or even-aged regeneration harvest.
- Early stand initiation hare habitat: potential habitat with less than 40% forest canopy cover in a seedling, sapling, or pole size class or 15-40 years post-stand replacing fire or even-aged regeneration harvest.
- Mature multi-story habitat: potential habitat with more than 2 canopy layers, greater than or equal to 40% forest canopy cover, and greater than or equal to 10" average diameter in size.
- Other: potential habitat that does not meet one of the other habitat criteria.

**Figure 113. Canada lynx habitat over time, average of all alternatives, by habitat category – Big Belts and Castles GAs**

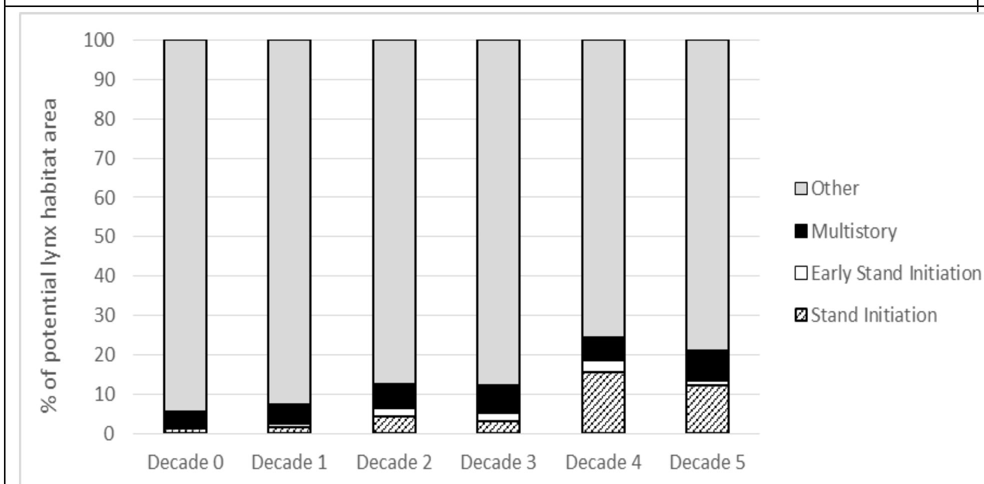
**Big Belts – habitat over time**




**Big Belts – average of 5 decades**




**Castles – habitat over time**




**Castles – average of 5 decades**

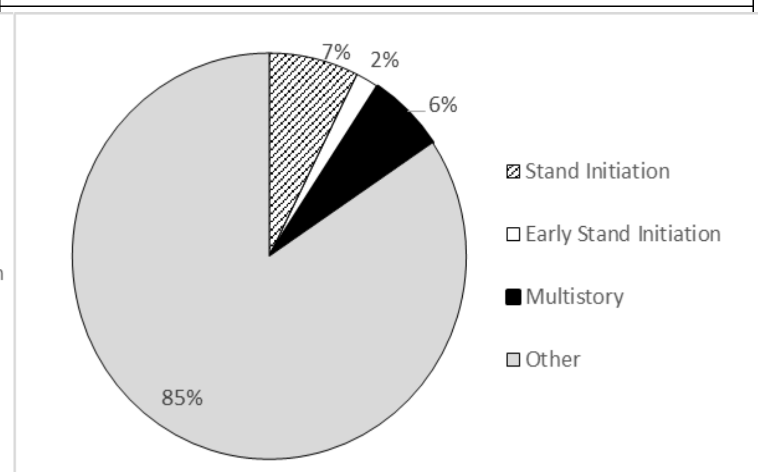
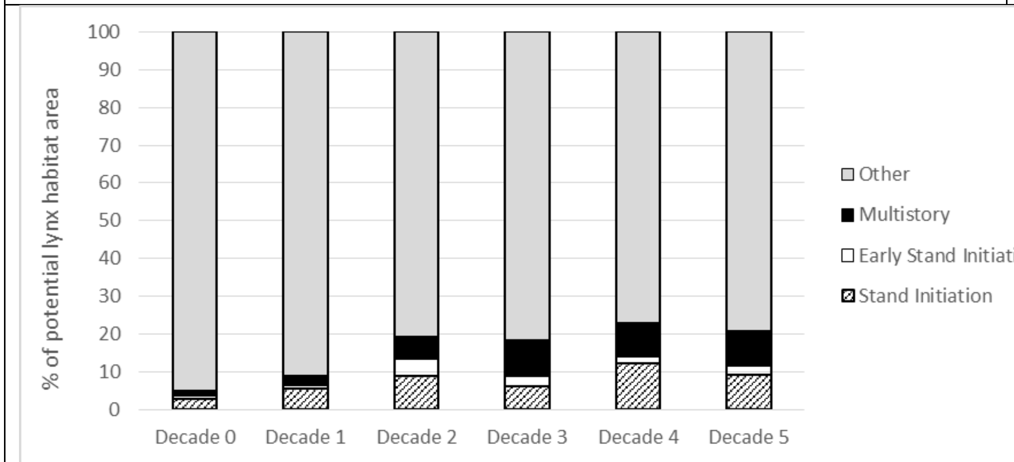
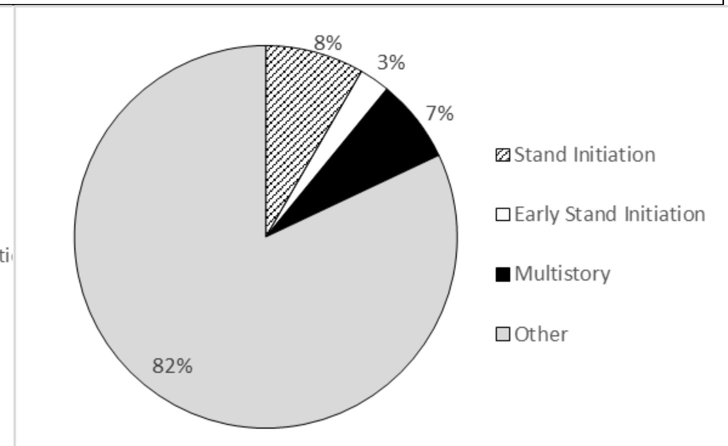


**Figure 114. Canada lynx habitat over time, average of all alternatives, by habitat category – Crazies and Divide GAs**

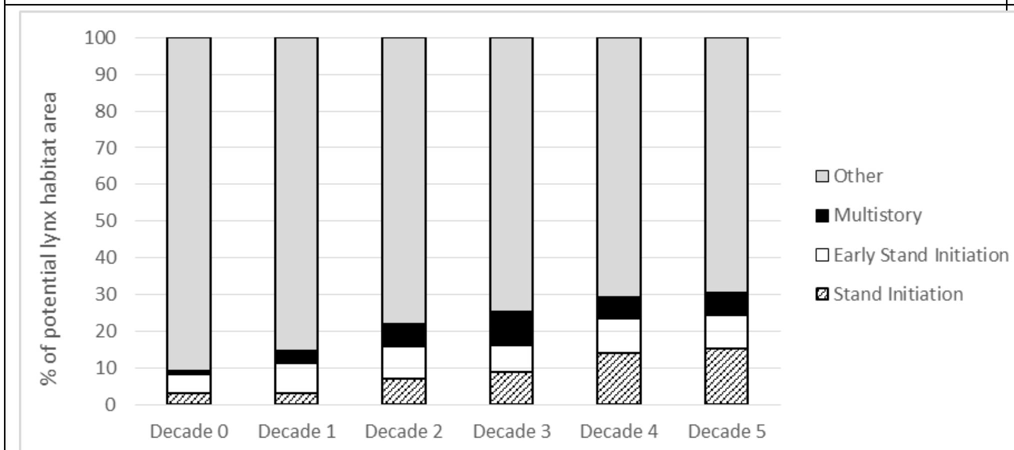
**Crazies – habitat over time**




**Crazies – average of 5 decades**




**Divide – habitat over time**




**Divide – average of 5 decades**

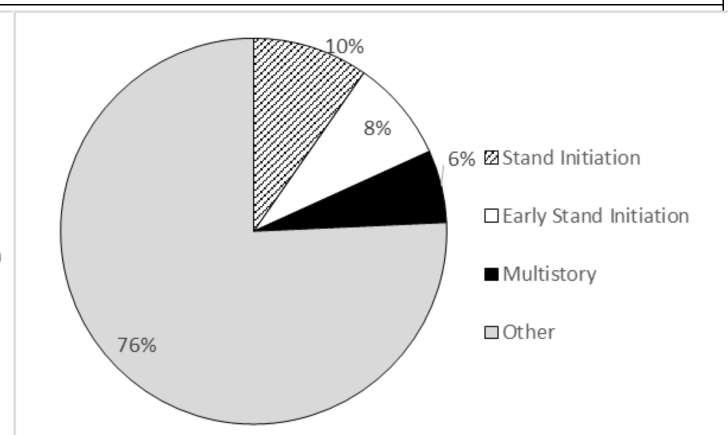
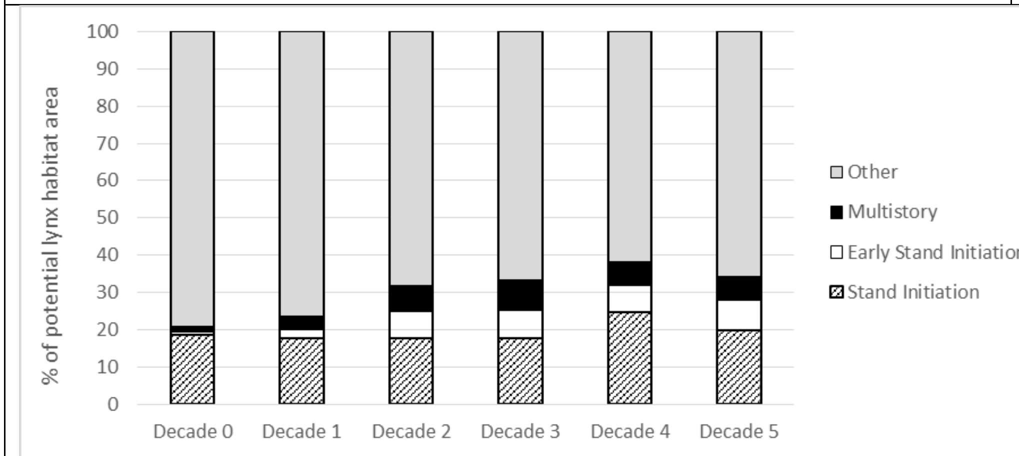
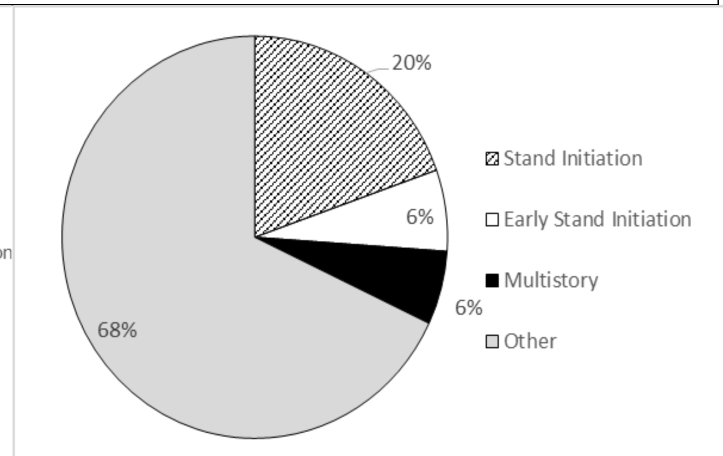


**Figure 115. Canada lynx habitat over time, average of all alternatives, by habitat category – Elkhorns and Highwoods GAs**

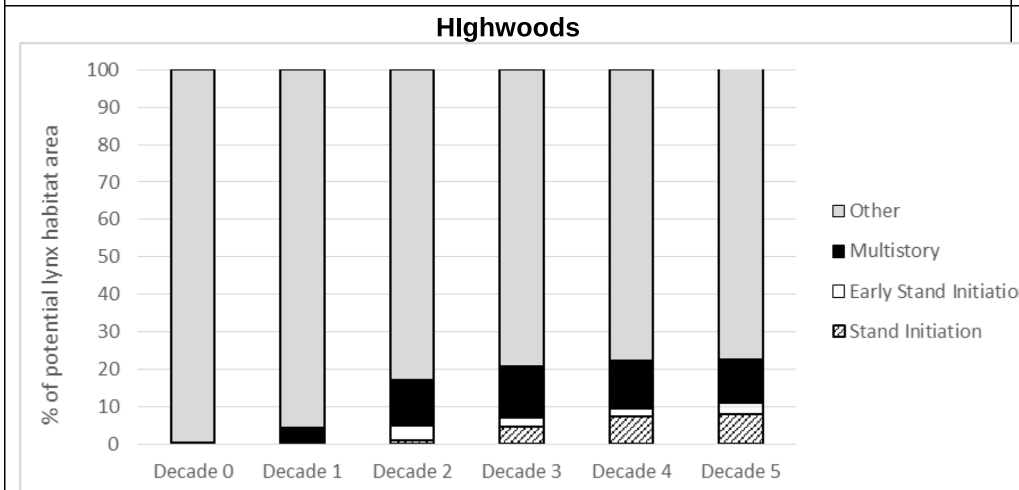
**Elkhorns – habitat over time**




**Elkhorns – average of 5 decades**




**Highwoods – habitat over time**




**Highwoods – average of 5 decades**

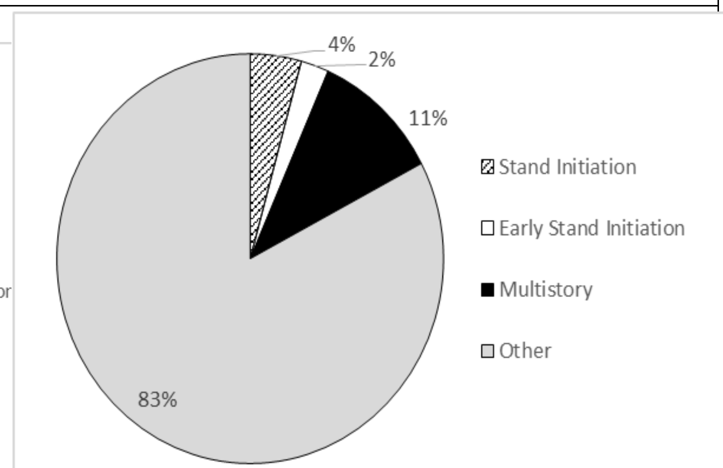
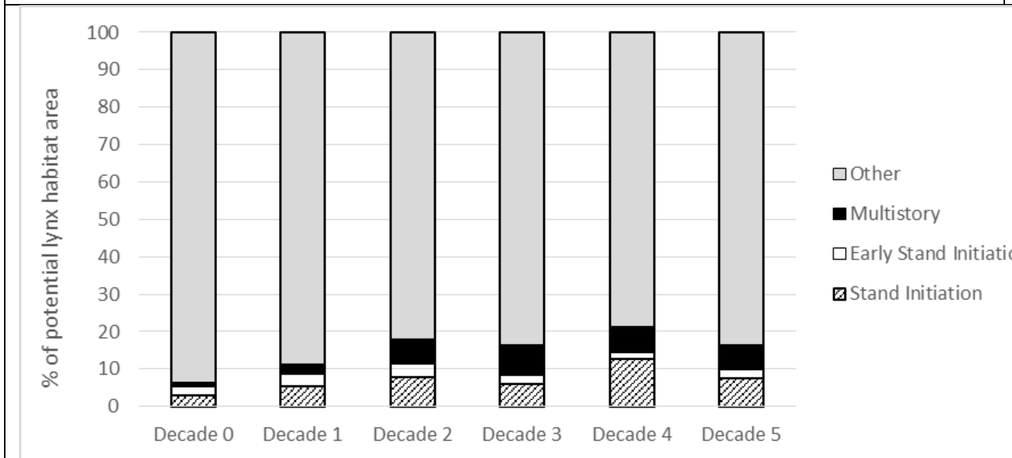
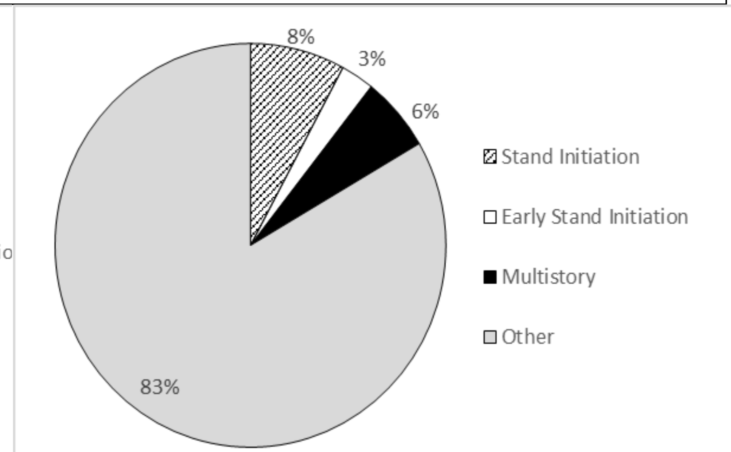


**Figure 116. Canada lynx habitat over time, average of all alternatives, by habitat category – Little Belts and Rocky Mountain Range GAs**

| Little Belts – habitat over time | Little Belts – average of 5 decades |
|---|---|
|  |  |





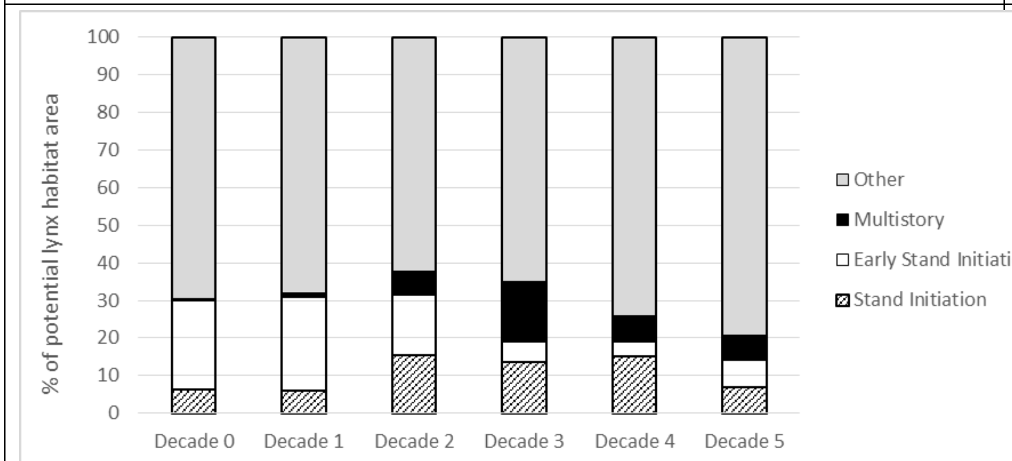
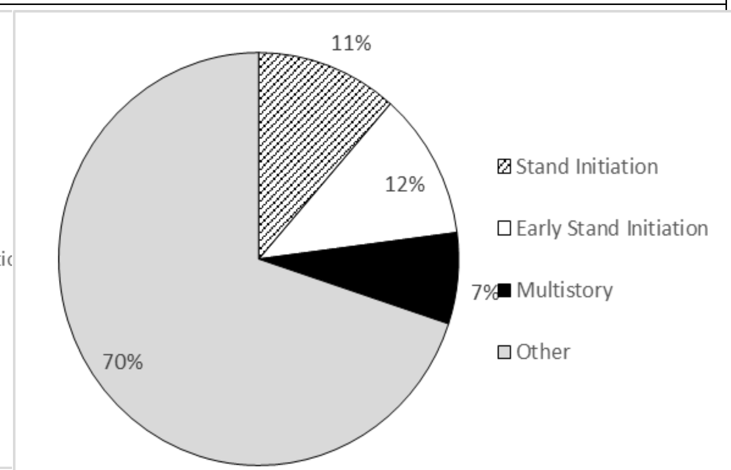
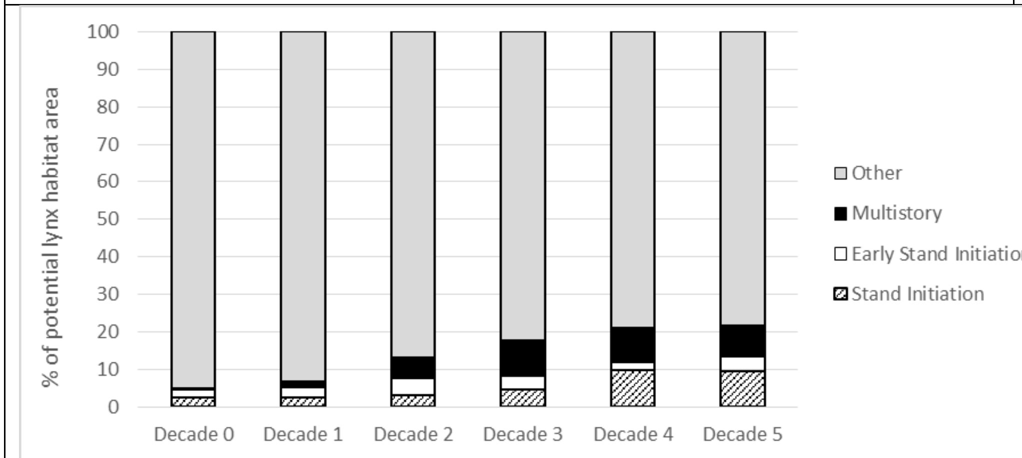
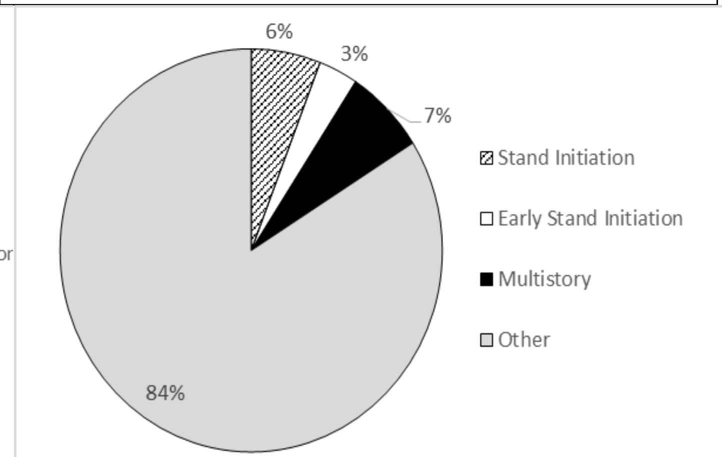
| Rocky Mountain Range – habitat over time | Rocky Mountain Range – average of 5 decades |
|---|---|
|  |  |

**Figure 117. Canada lynx habitat over time, average of all alternatives, by habitat category – Snowies and Upper Blackfoot GAs**

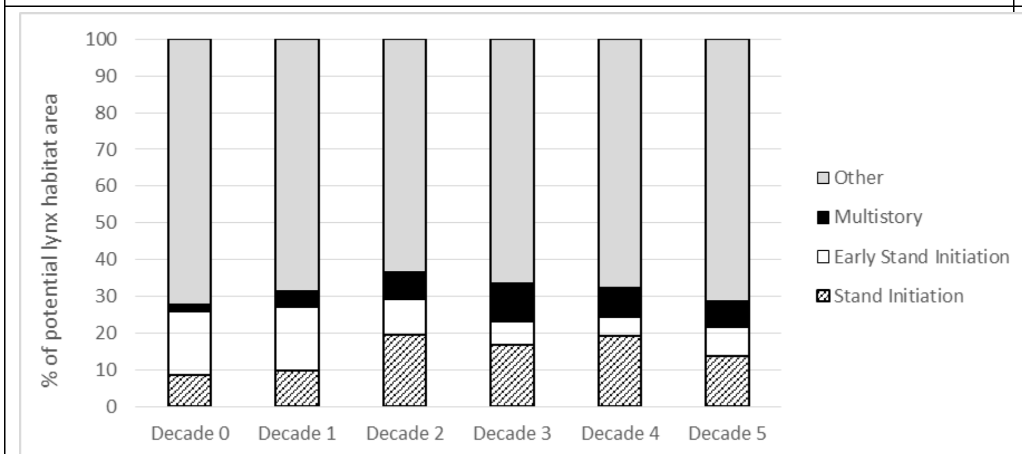
**Snowies – habitat over time**




**Snowies – average of 5 decades**




**Upper Blackfoot – habitat over time**




**Upper Blackfoot – average of 5 decades**

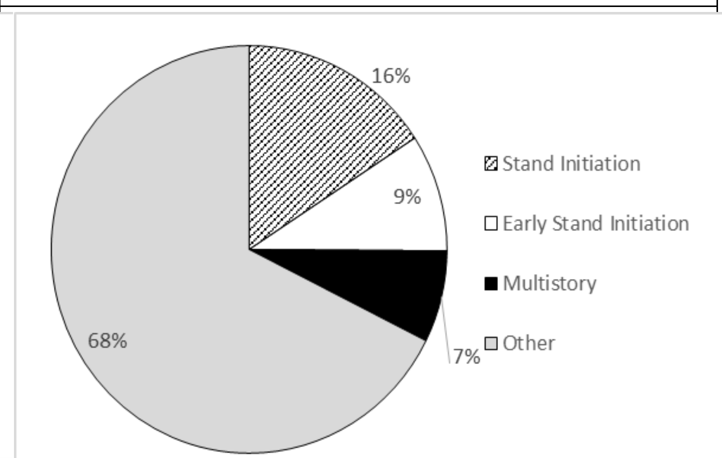


**Figure 118. Canada lynx habitat over time compared to NRV by habitat category and alternative - forestwide**

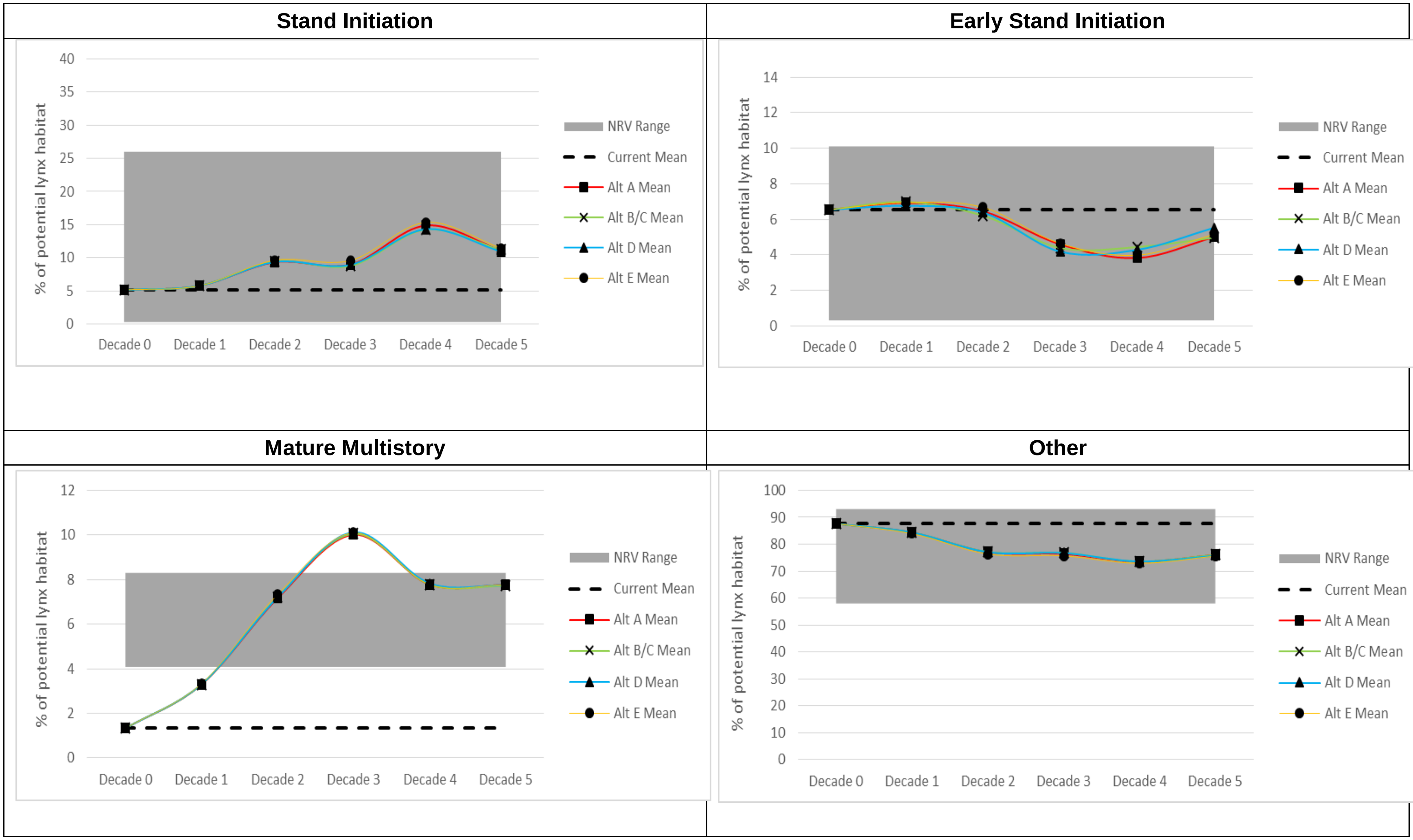


**Figure 119. Canada lynx habitat average/decade across 50 years, compared to NRV by habitat category and alternative - GAs**

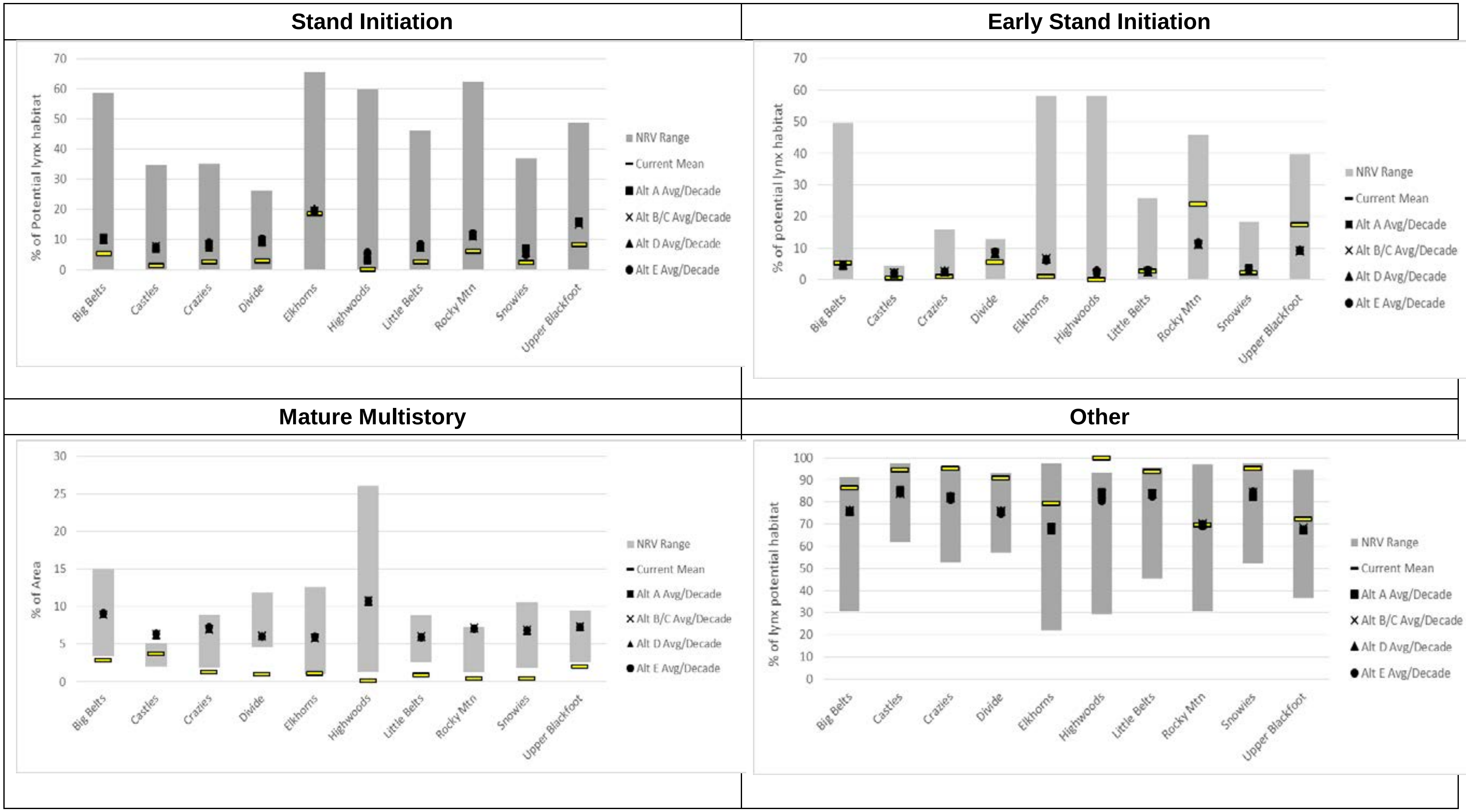


**Figure 120. Canada lynx habitat over time compared to NRV by habitat category and alternative – Big Belts GA**

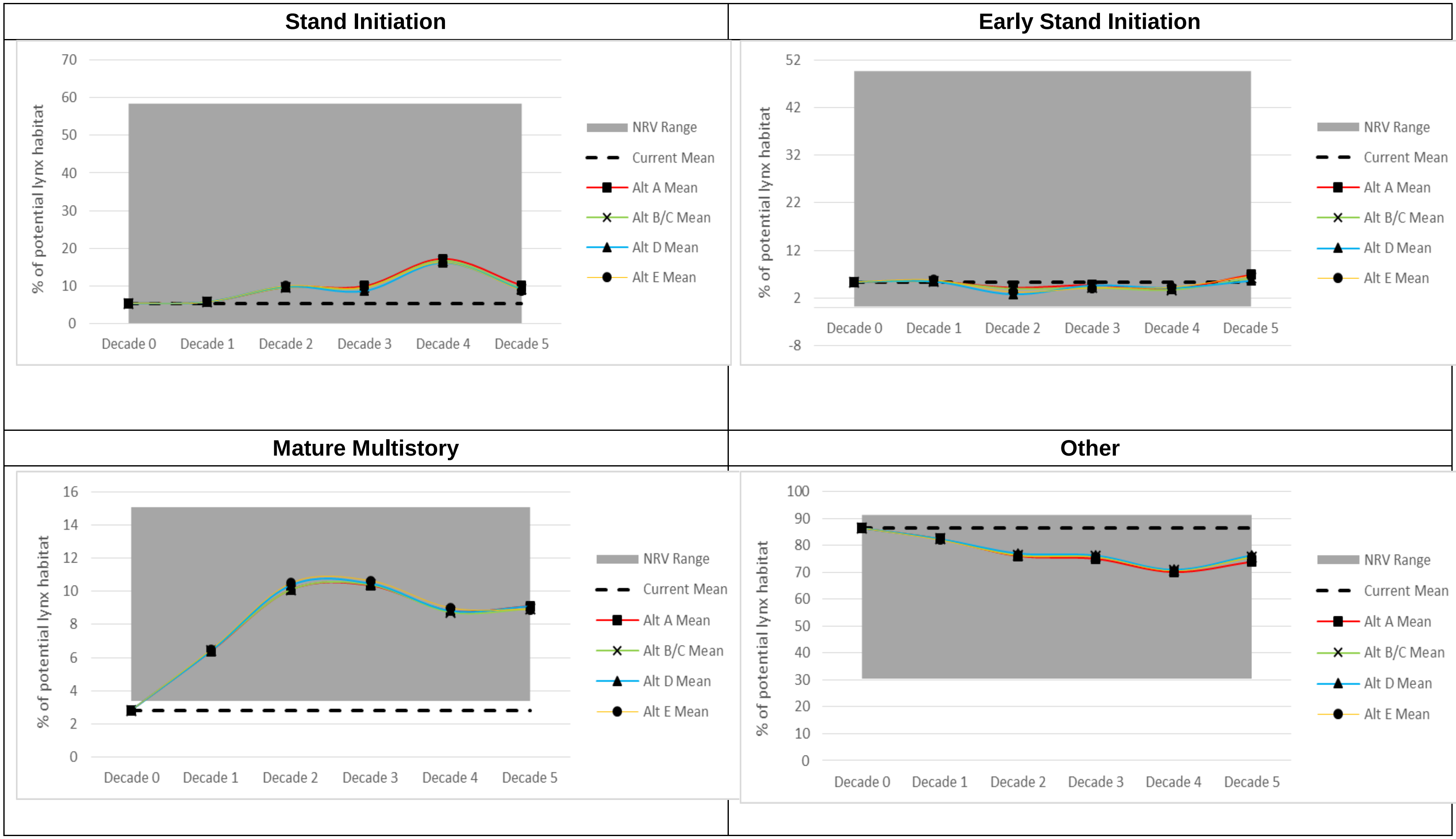
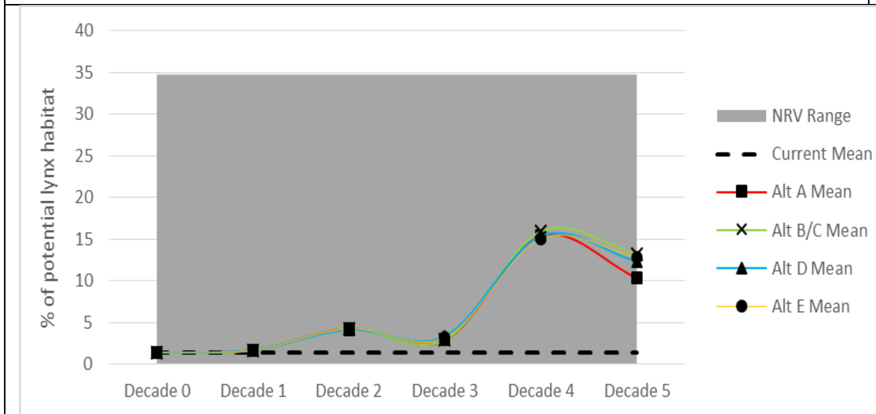
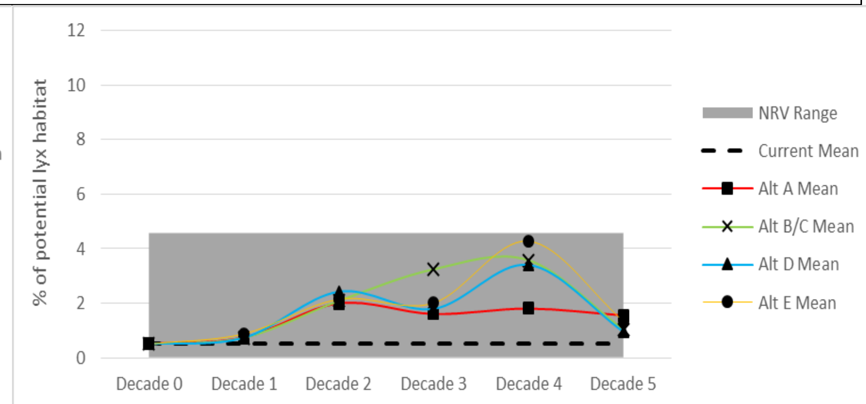


**Figure 121. Canada lynx habitat over time compared to NRV by habitat category and alternative – Castles GA**

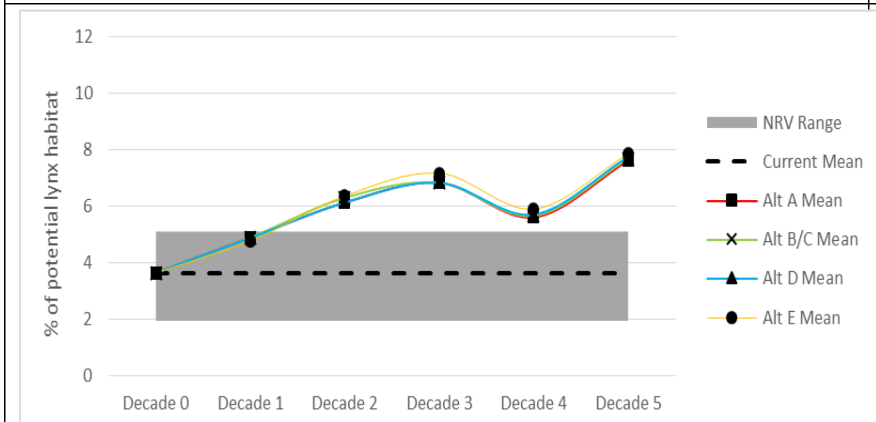
### Stand Initiation




### Early Stand Initiation




### Mature Multistory




### Other

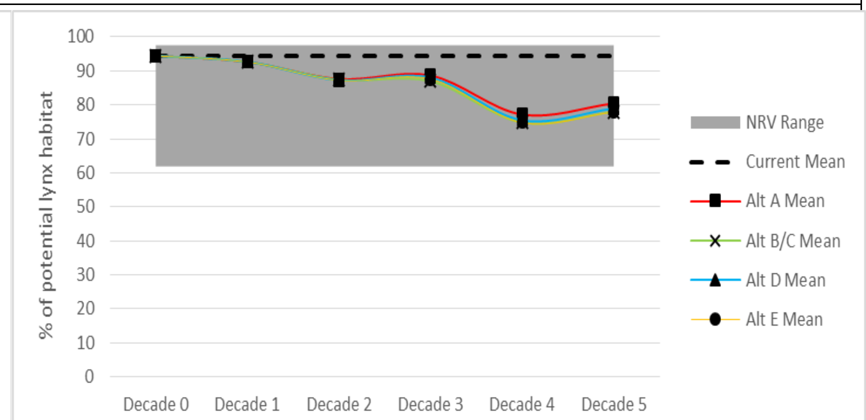


**Figure 122. Canada lynx habitat over time compared to NRV by habitat category and alternative – Crazies GA**

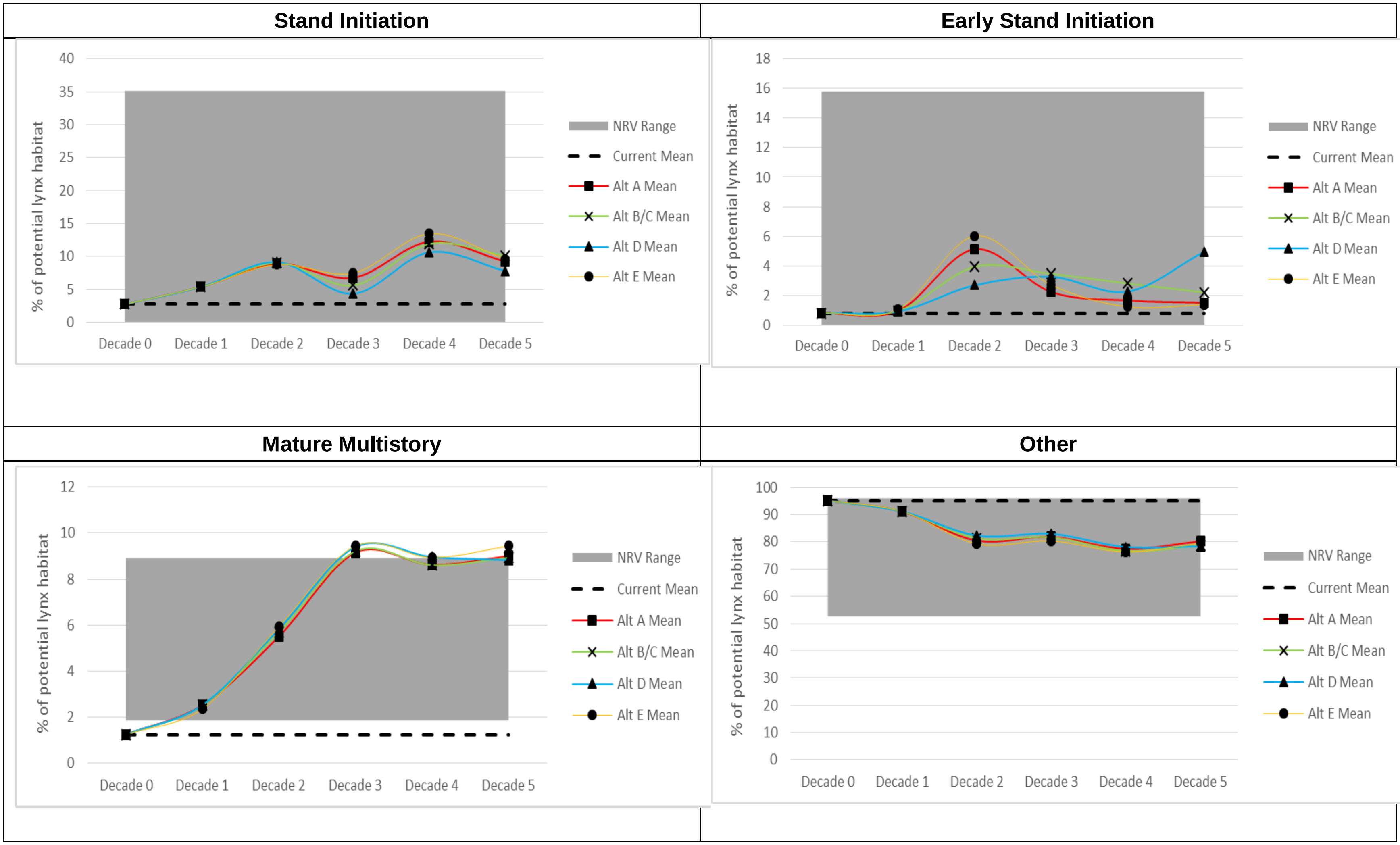


**Figure 123. Canada lynx habitat over time compared to NRV by habitat category and alternative – Divide GA**

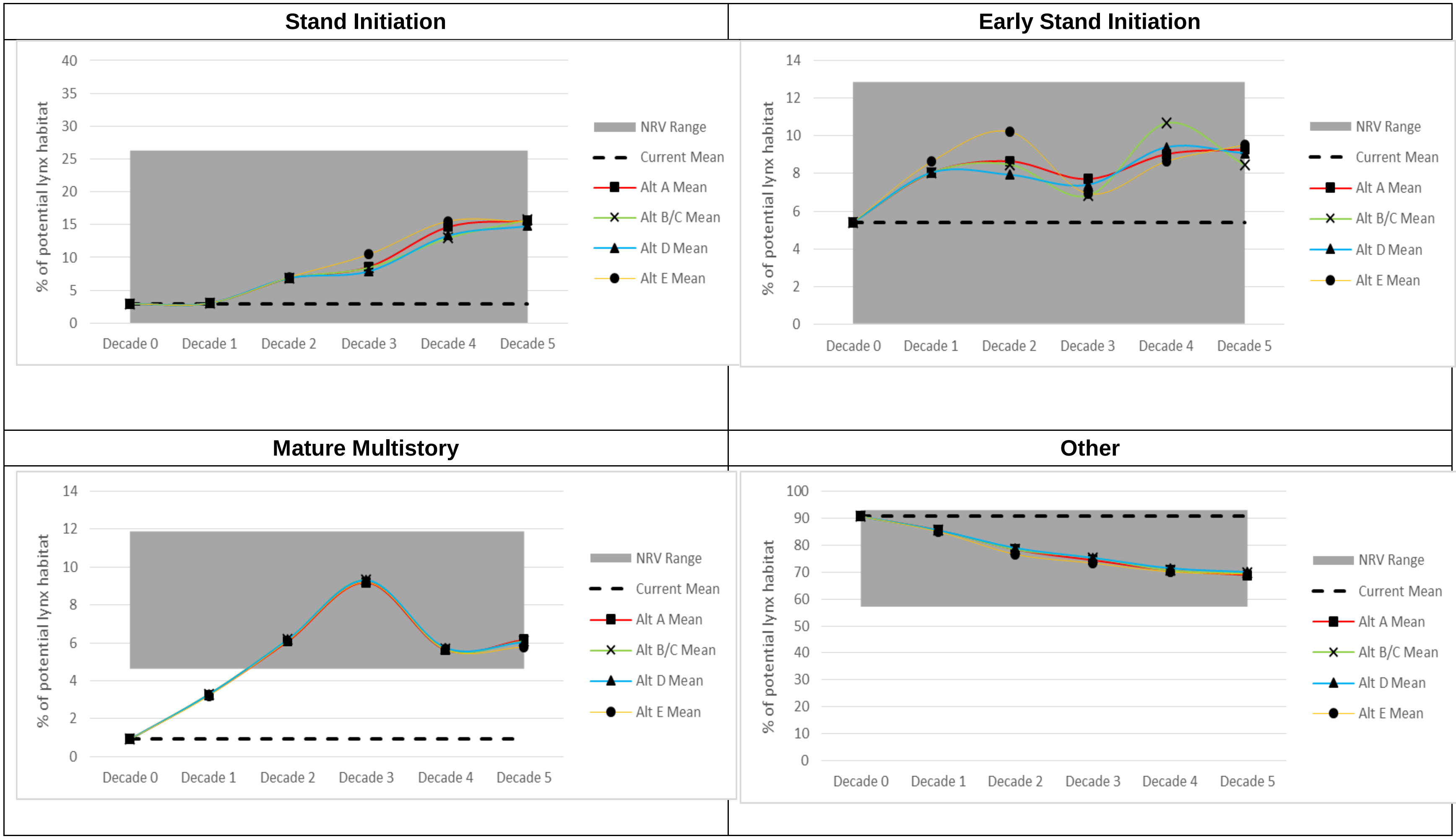
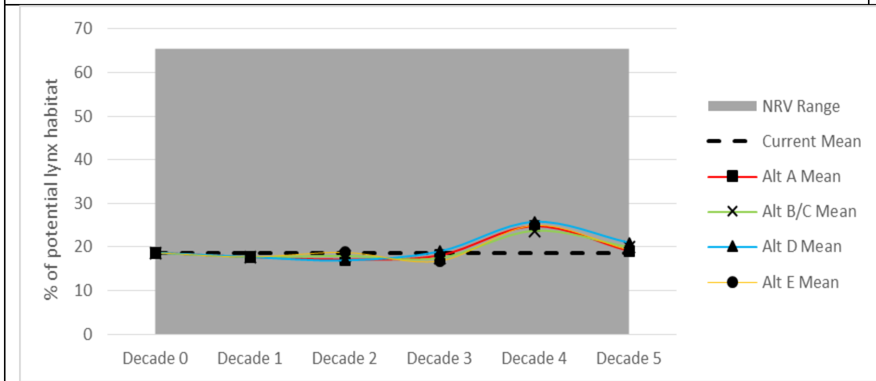
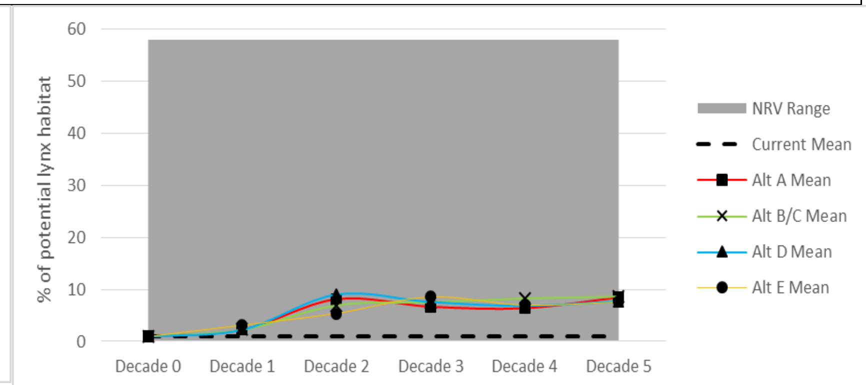


**Figure 124. Canada lynx habitat over time compared to NRV by habitat category and alternative – Elkhorns GA**

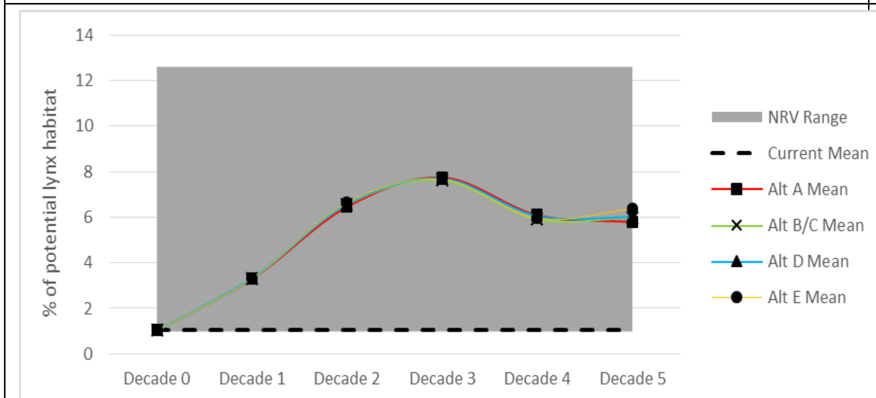
### Stand Initiation




### Early Stand Initiation




### Mature Multistory




### Other

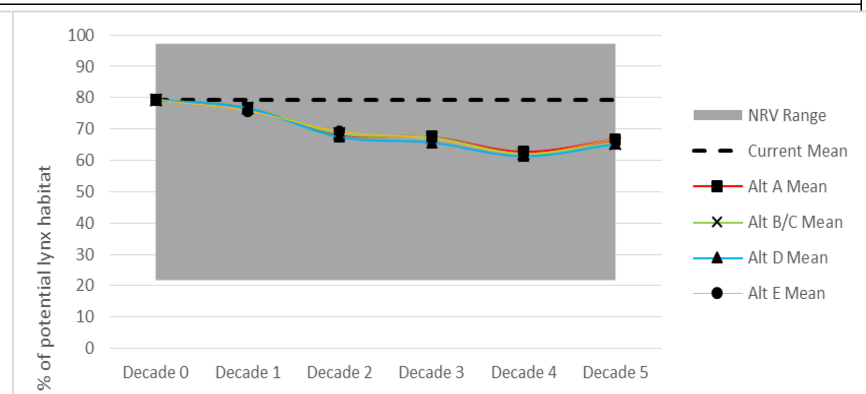
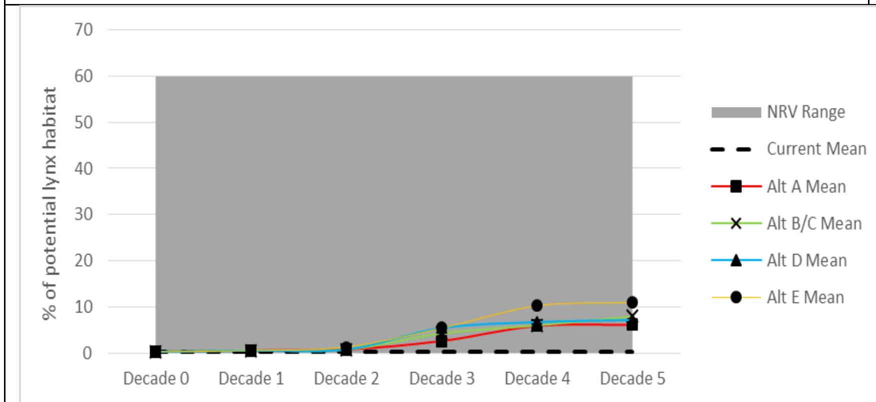
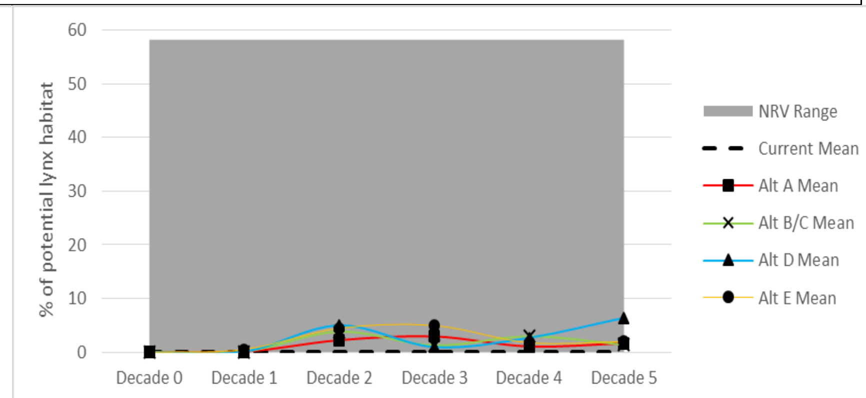


**Figure 125. Canada lynx habitat over time compared to NRV by habitat category and alternative – Highwoods GA**

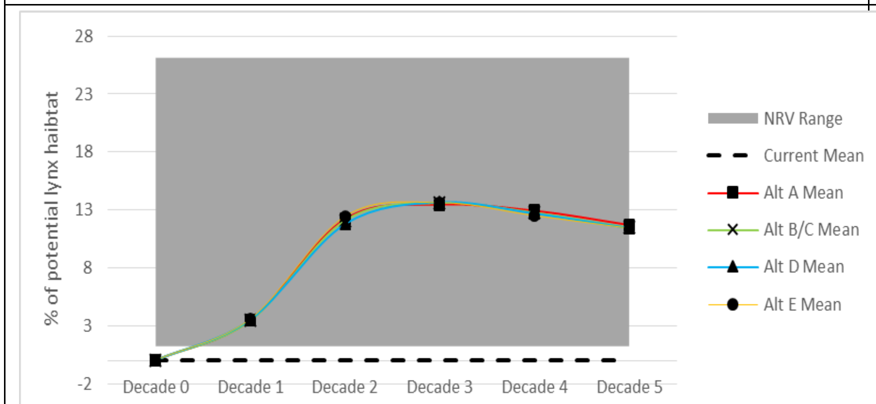
### Stand Initiation




### Early Stand Initiation




### Mature Multistory




### Other

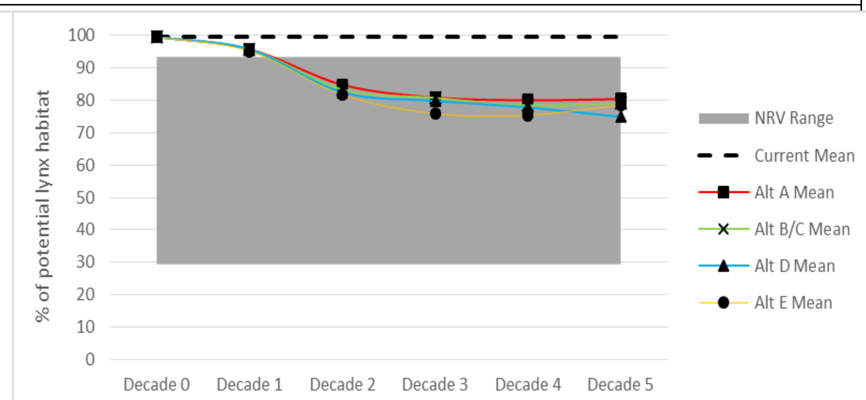
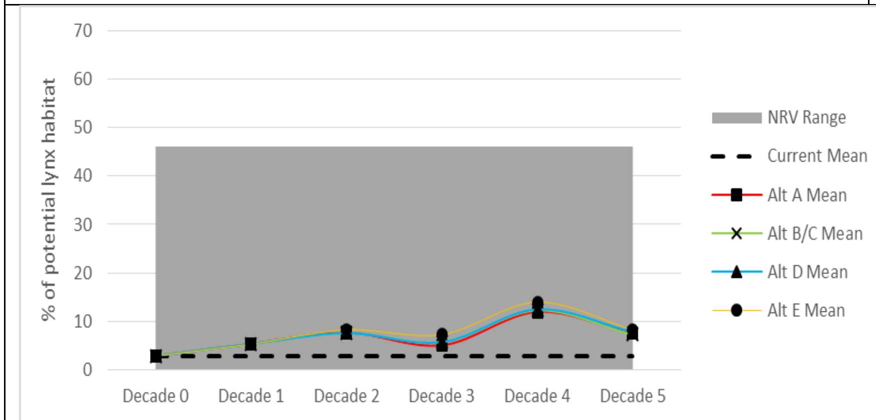
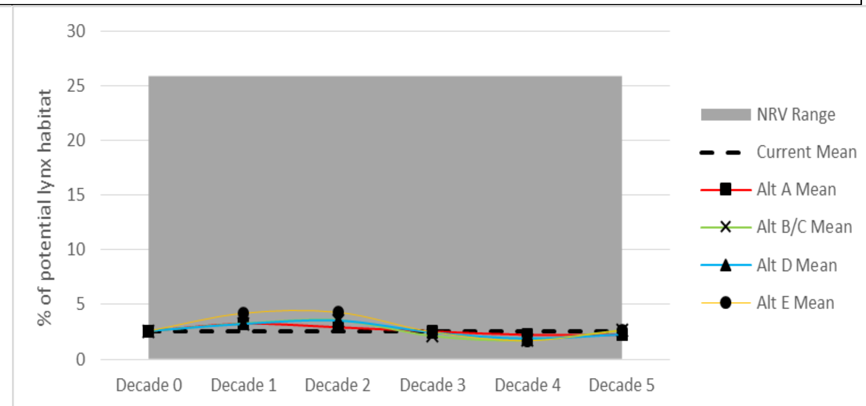


**Figure 126. Canada lynx habitat over time compared to NRV by habitat category and alternative – Little Belts GA**

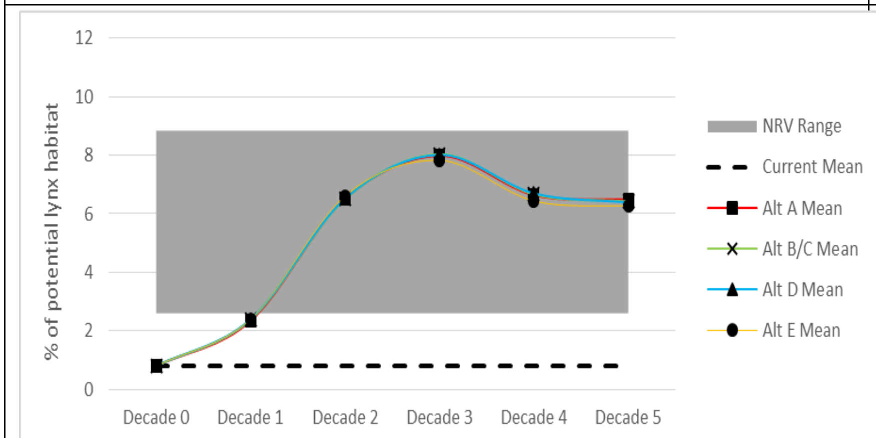
### Stand Initiation




### Early Stand Initiation




### Mature Multistory




### Other

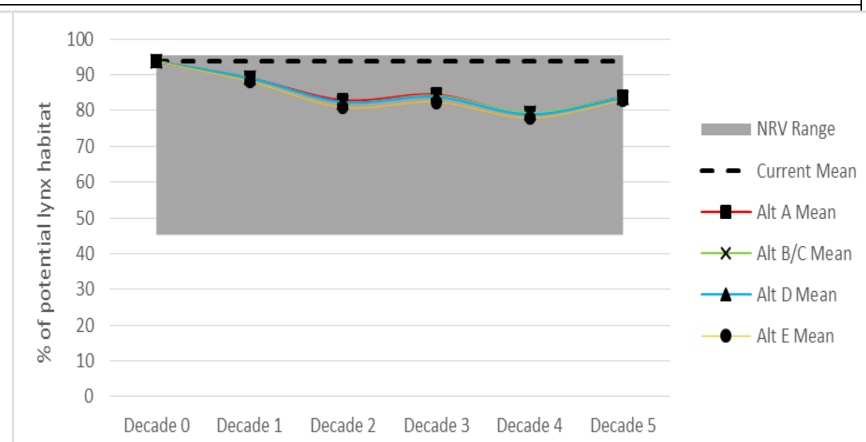


**Figure 127. Canada lynx habitat over time compared to NRV by habitat category and alternative – Rocky Mountain Range GA**

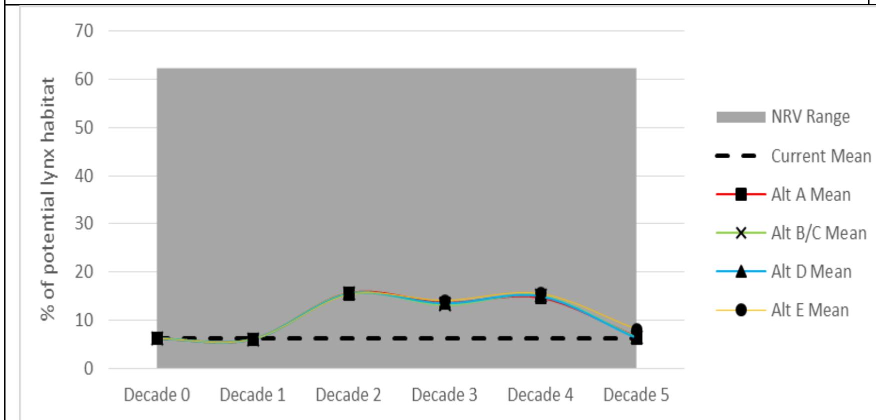
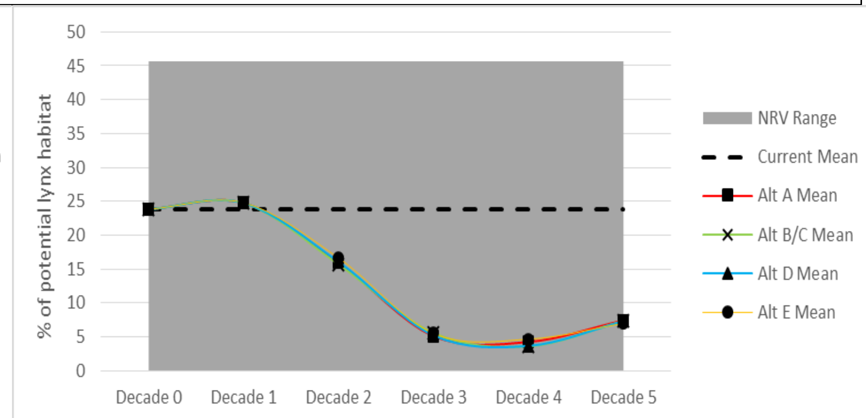
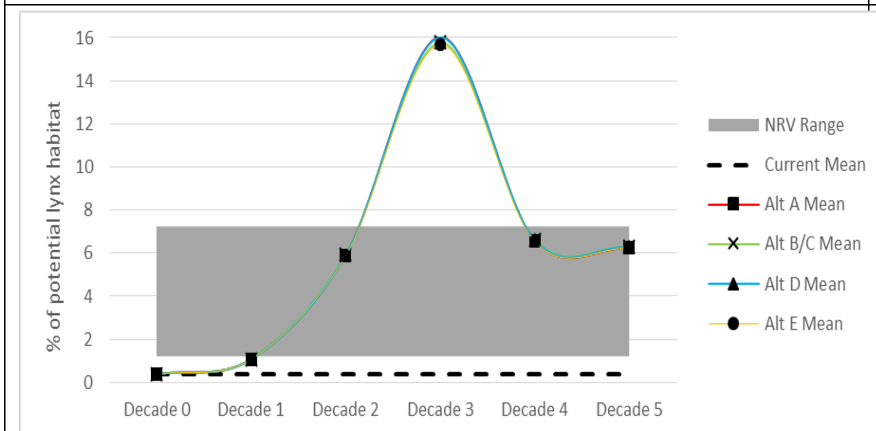
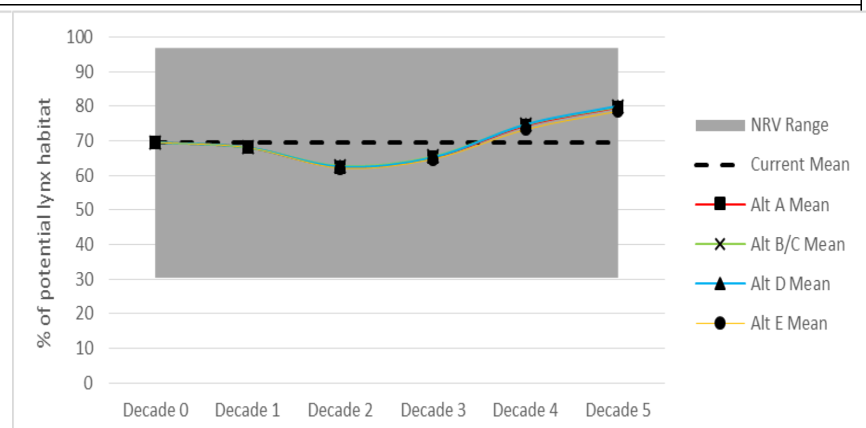
| Stand Initiation | Early Stand Initiation |
|---|---|
|  |  |
| **Mature Multistory** | **Other** |
|  |  |

**Figure 128. Canada lynx habitat over time compared to NRV by habitat category and alternative – Snowies GA**

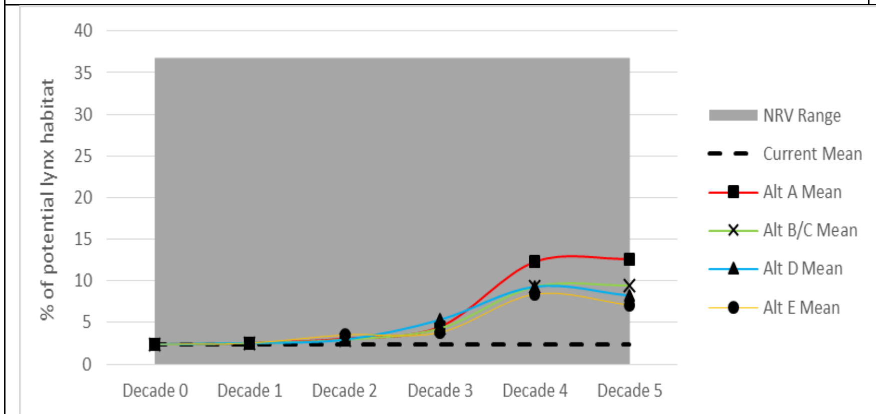
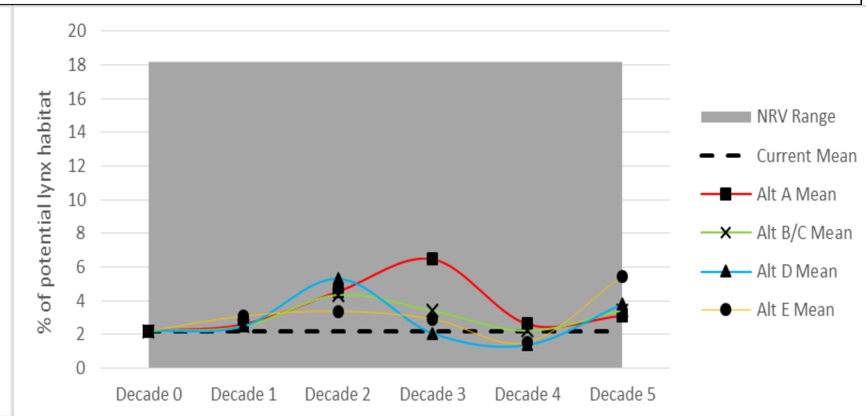
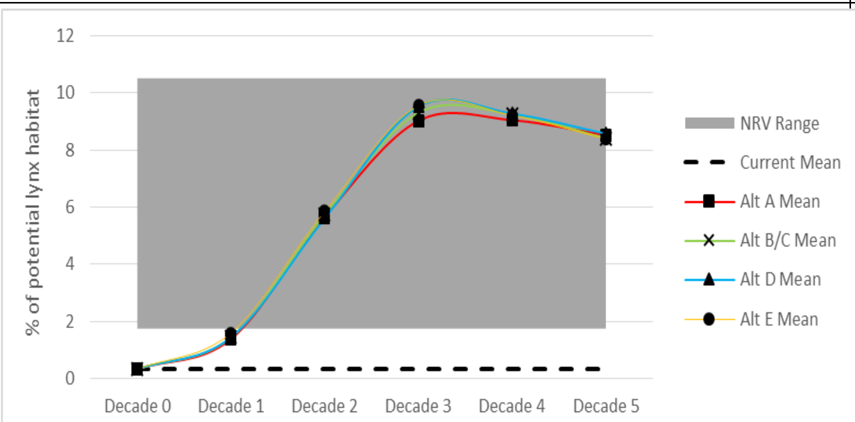
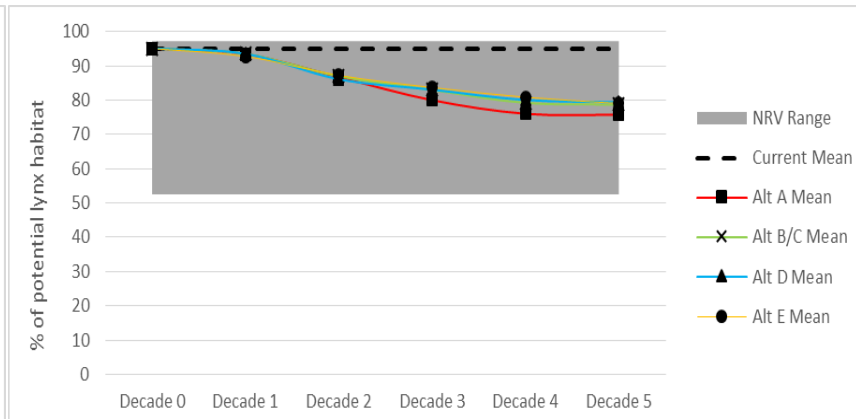
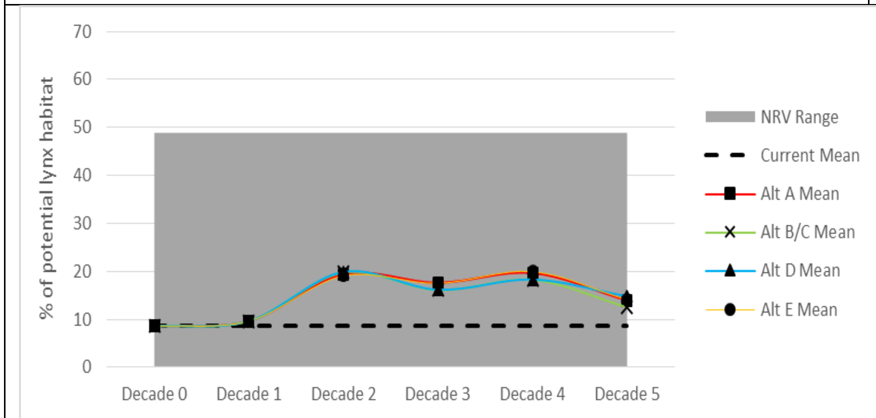
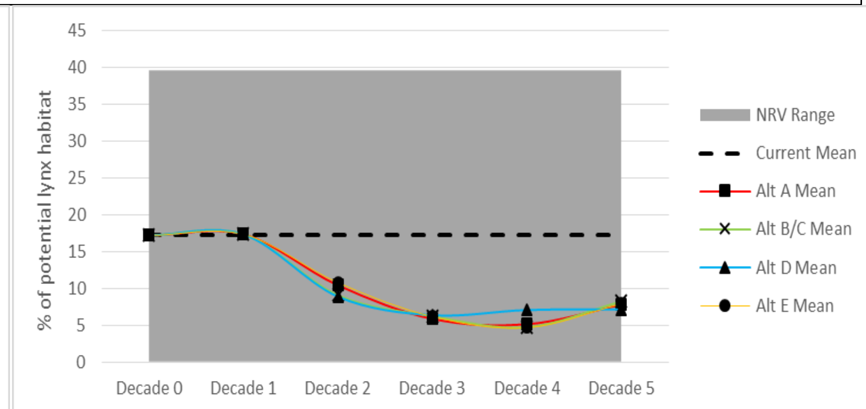
| Stand Initiation | Early Stand Initiation |
| --- | --- |
|  |  |
| **Mature Multistory** | **Other** |
|  |  |

**Figure 129. Canada lynx habitat over time compared to NRV by habitat category and alternative – Upper Blackfoot GA**

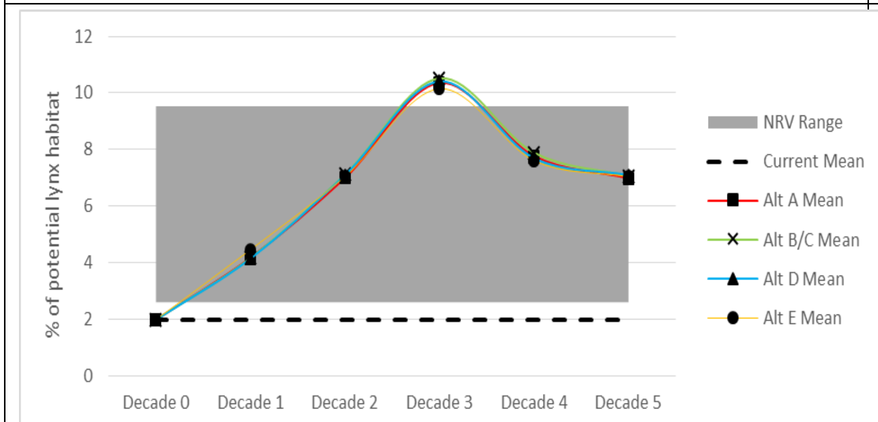
### Stand Initiation



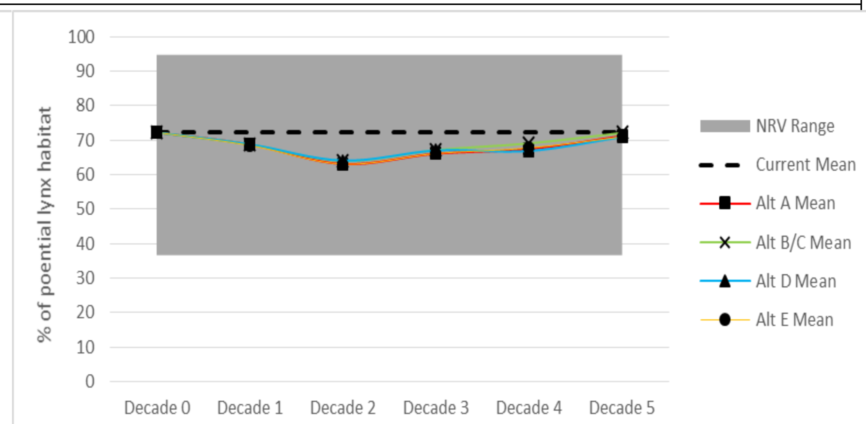

### Early Stand Initiation




### Mature Multistory




### Other



# Elk

This section summarizes the information sources and methodology used in the elk analysis. Additional detail can be found in the Elk Background Report in the project file. Information presented in this analysis and in the Elk Background Report comes from field examination of the planning area, inferences from scientific literature, wildlife survey work in in the planning area, geospatial data, and discussions with other state and federal biologists.

The existing forest plans are described to provide context for the environmental consequence section. Note that both the Helena and Lewis and Clark Forest plans include management area requirements specific to elk. For the purposes of this analysis, however, only Forest-wide requirements are included.

The USFS and MTDFWP Collaborative Recommendations for Big Game Habitat Management on the Custer, Gallatin, Helena, and Lewis and Clark National Forests (U.S. Department of Agriculture, Forest Service and Montana Department of Fish,, Wildlife & Parks, 2013) is also used because this paper reflects the efforts of wildlife biologists from the FS and MDFWP to use the best contemporary information and their collective experiences in managing elk and elk habitat to address current issues and conditions on the referenced NFs.

Habitat-related data are presented according to metrics identified in (1) the 1986 Helena NF Plan; (2) the 1986 Lewis and Clark NF Plan; and (3) the U.S. FS and MTDFWP Collaborative Recommendations for Big Game Habitat Management on the Custer, Gallatin, Helena, and Lewis and Clark National Forests. All vegetation data are based on R1-VMap. R1-VMap data are remotely sensed and represent a broad-scale, coarse filter depiction that is classified into vegetation components such as canopy cover, tree dominance type, and size class. Refer to the Elk Background Report in the project file for additional details regarding habitat mapping and estimation.

## Helena National Forest Plan

The following methods and information have been used to describe the existing condition for elk habitat under the current Helena NF Plan.

- Elk herd units serve as the basis for the analysis; these have been developed in conjunction with MTDFWP.
- Summer range comprises the entire elk herd unit. Winter range is based on updated MTDFWP range maps (2008).
- Hiding cover is based on the MTDFWP definition; both hiding cover and thermal cover are summarized in the Elk Background Report in the project file.
- Road density information is derived from transportation database. Assumptions made regarding which roads are included in calculations of density are detailed in the Elk Background Report in the project file.

## Lewis and Clark Forest Plan

The following methods and information have been used to describe the existing condition for elk habitat under the current Lewis and Clark NF Plan. See also the *Process for Analyzing Big Game Cover*, 2016.

- Sixth and 7$^{th}$ code subwatersheds (ranging from 3,000 acres to 40,000 acres) serve as the basis for the cover analysis under the Lewis and Clark plan.
- Vegetation data are used to develop the photo interpretive (PI) types as defined in the Montana Cooperative Elk/Logging Study (Lyon et al., 1985). Vegetation data from R1-VMap (refer to information in the Elk Background Report in the project file) has been used to assign PI type.

- Effective hiding cover is based on the “Montana Rule” that assigns a hiding cover percent to specific stand characteristics.

## USDA FS and MTDFWP 2013

The following methods and information have been used to describe the existing condition for elk habitat according to the U.S. Forest Service and Montana Department of Fish, Wildlife, and Parks Collaborative Recommendations for Big Game Habitat Management on the Custer, Gallatin, Helena, and Lewis and Clark National Forests (U.S. Department of Agriculture, Forest Service and Montana Department of Fish,, Wildlife & Parks, 2013).

- The geographic area serves as the basis for the analysis.
- Elk security analysis is based on motorized routes (roads and trails). Definitions of elk security areas are in the collaborative recommendation paper cited above, and are described in the Elk Background Report in the project file.
- Elk spring/summer/fall cover is determined primarily by tree canopy cover in certain tree dominance types, and elk winter cover is based on tree canopy cover. Refer to the collaborative recommendation paper cited above, and the Elk Background Report in the project file.

## Elk Population Data

Elk survey data are provided by MTDFWP area biologists for the respective hunting districts (MFWP 2002 – 2016, where available). Elk analyses are also based on the Montana Statewide Elk Management Plan (Montana Fish and Wildlife and Parks, 2004). Elk harvest reports from 2004 to 2016 are located at http://fwp.mt.gov/hunting/planahunt/harvestReports.html

## SIMPPLLE model results for elk

Elk hiding cover spring/summer/fall is represented by the proportion of land in forested potential vegetation types dominated by select forest types, with 40-60% canopy cover. Elk hiding cover winter is represented by the proportion of land in forested potential vegetation types dominated by select forest types that occur in mapped elk winter range.

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 DEIS.

**Figure 130. Elk spring/summer/fall hiding cover forestwide, average acres/decade for 50 years compared to NRV by alternative**

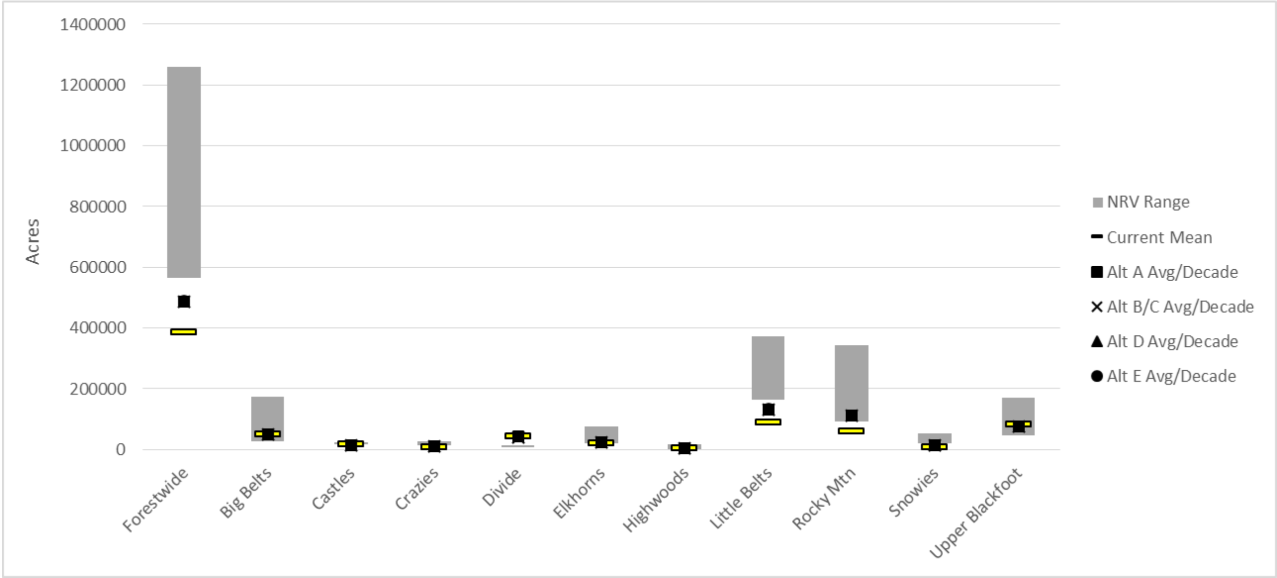



**Figure 131. Elk spring/summer/fall hiding cover forestwide over time by alternative**

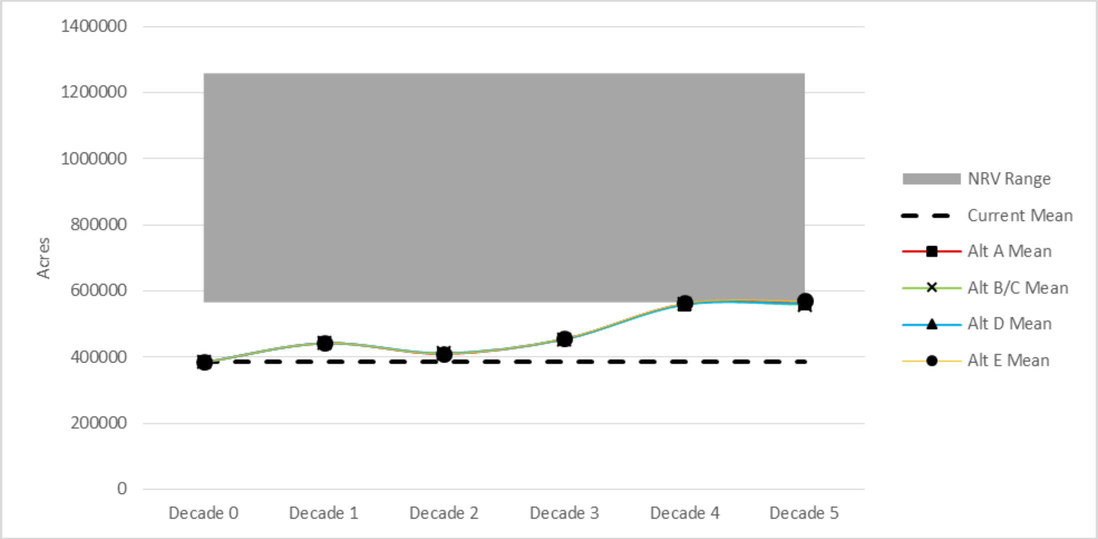


**Figure 132. Elk spring/summer/fall hiding cover by elk analysis unit by alternative – average acres/decade across 50 years – Big Belts GA**

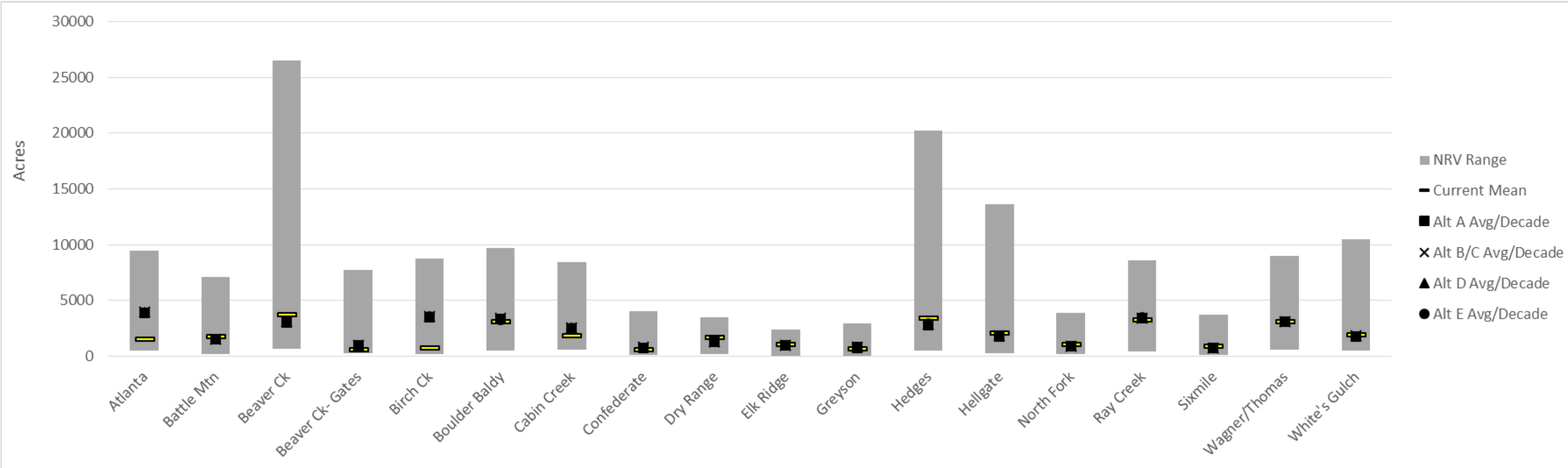



**Figure 133. Elk spring/summer/fall hiding cover by elk analysis unit by alternative – average acres/decade across 50 years - Castles GA**

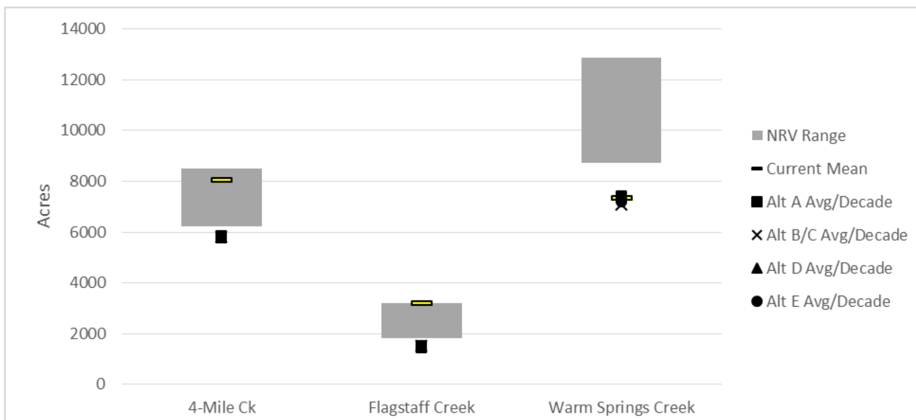


**Figure 134. Elk spring/summer/fall hiding cover by elk analysis unit by alternative – average acres/decade across 50 years - Crazies GA**


**Figure 135. Elk spring/summer/fall hiding cover by elk analysis unit by alternative – average acres/decade across 50 years - Divide GA**

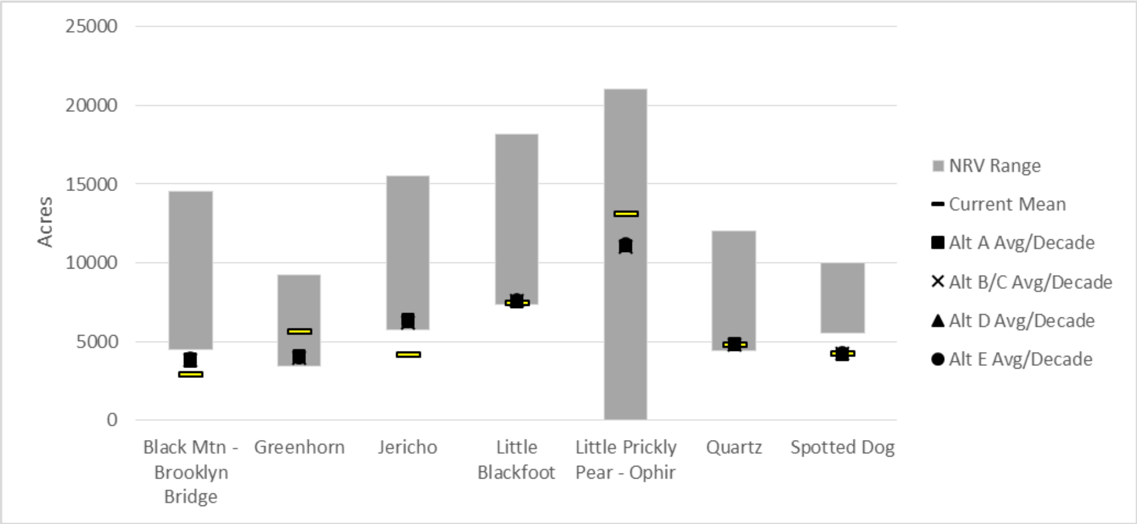


**Figure 136. Elk spring/summer/fall hiding cover by elk analysis unit by alternative – average acres/decade across 50 years - Elkhorns GA**

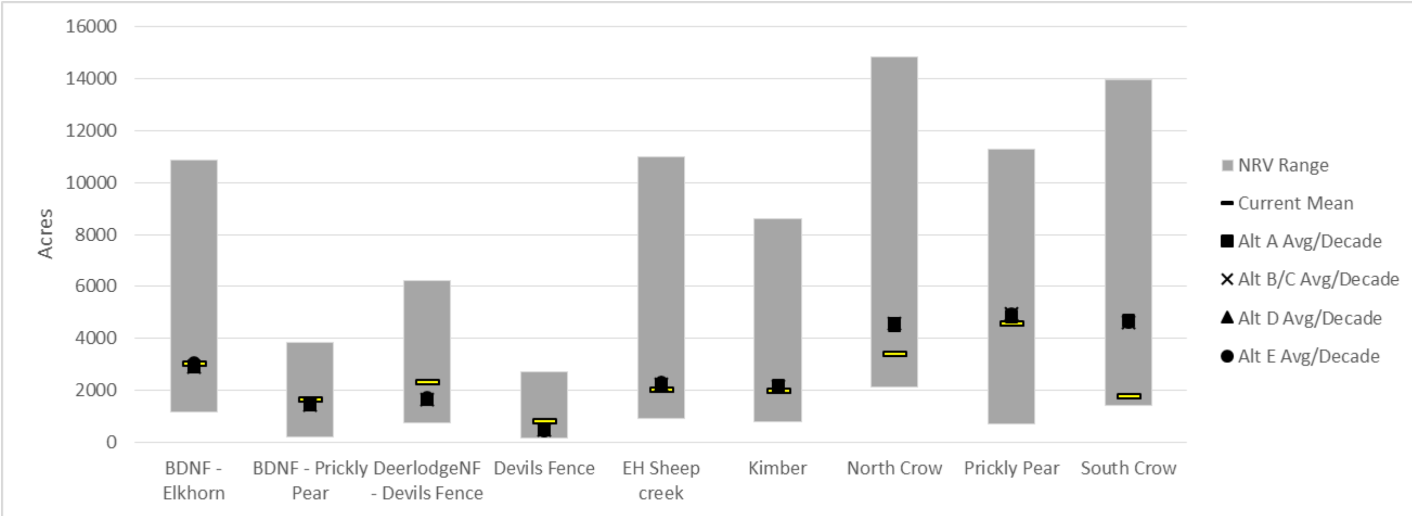



**Figure 137. Elk spring/summer/fall hiding cover by elk analysis unit by alternative – average acres/decade across 50 years - Highwoods GA**

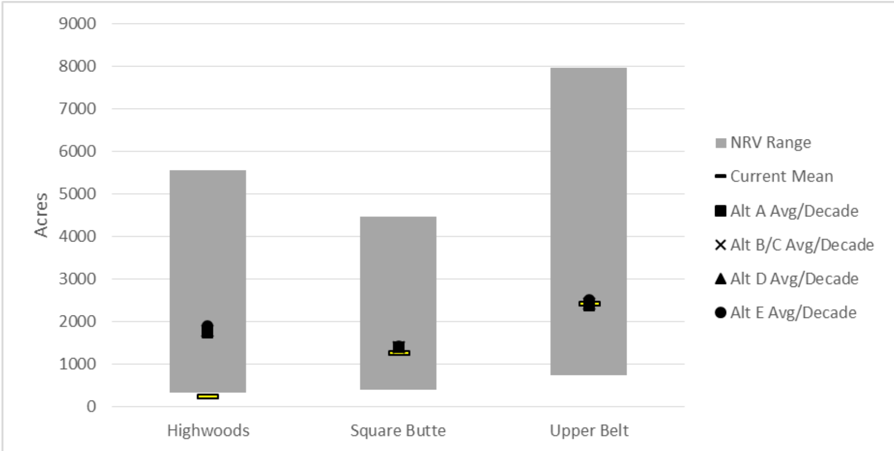


**Figure 138. Elk spring/summer/fall hiding cover by elk analysis unit by alternative – average acres/decade across 50 years – Little Belts GA**

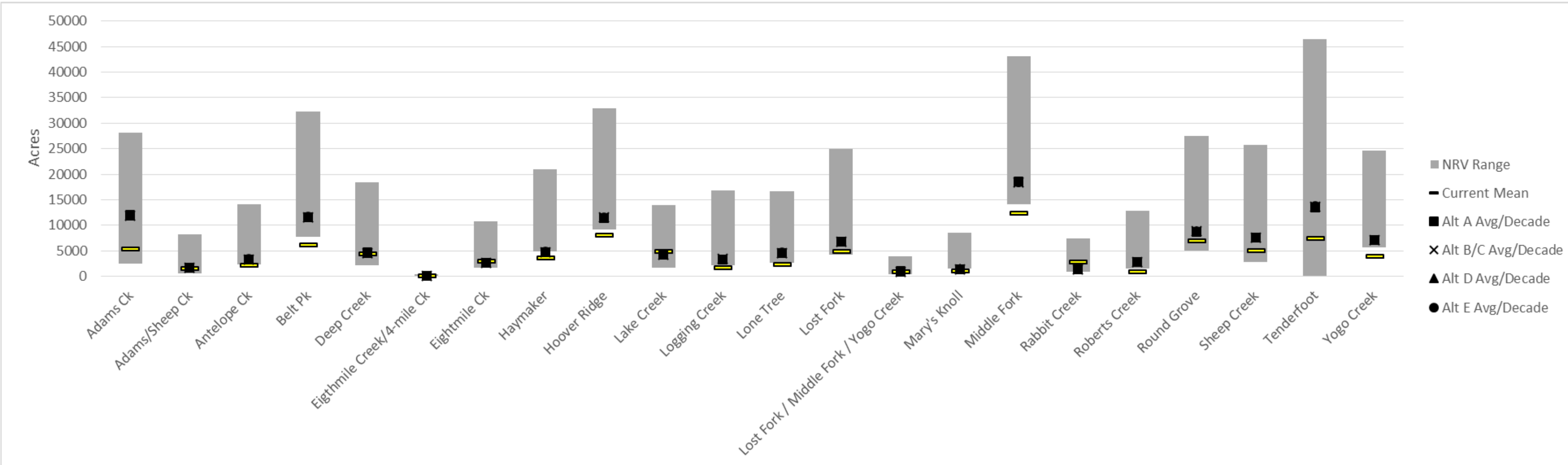



**Figure 139. Elk spring/summer/fall hiding cover by elk analysis unit by alternative – average acres/decade across 50 years – Rocky Mountain Range GA**

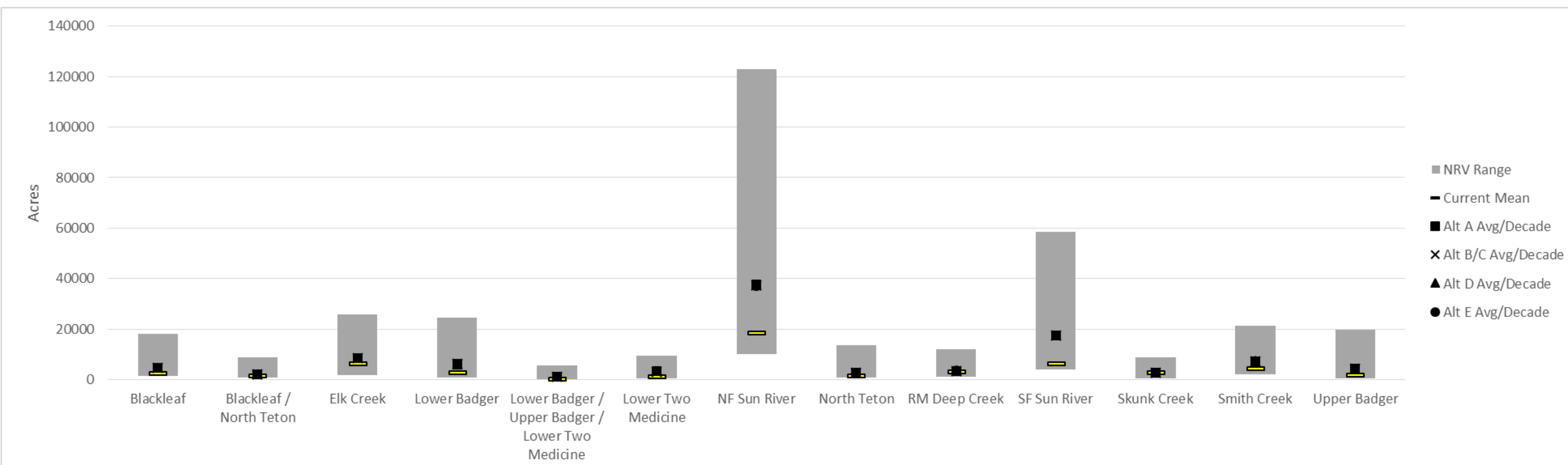


**Figure 140. Elk spring/summer/fall hiding cover by elk analysis unit by alternative – average acres/decade across 50 years – Snowies GA**

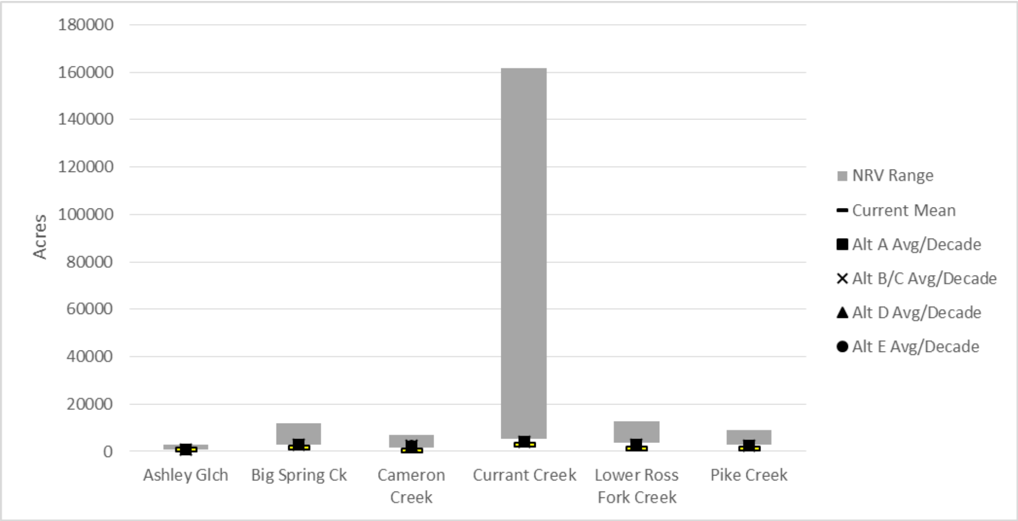



**Figure 141. Elk spring/summer/fall hiding cover by elk analysis unit by alternative – average acres/decade across 50 years – Upper Blackfoot GA**

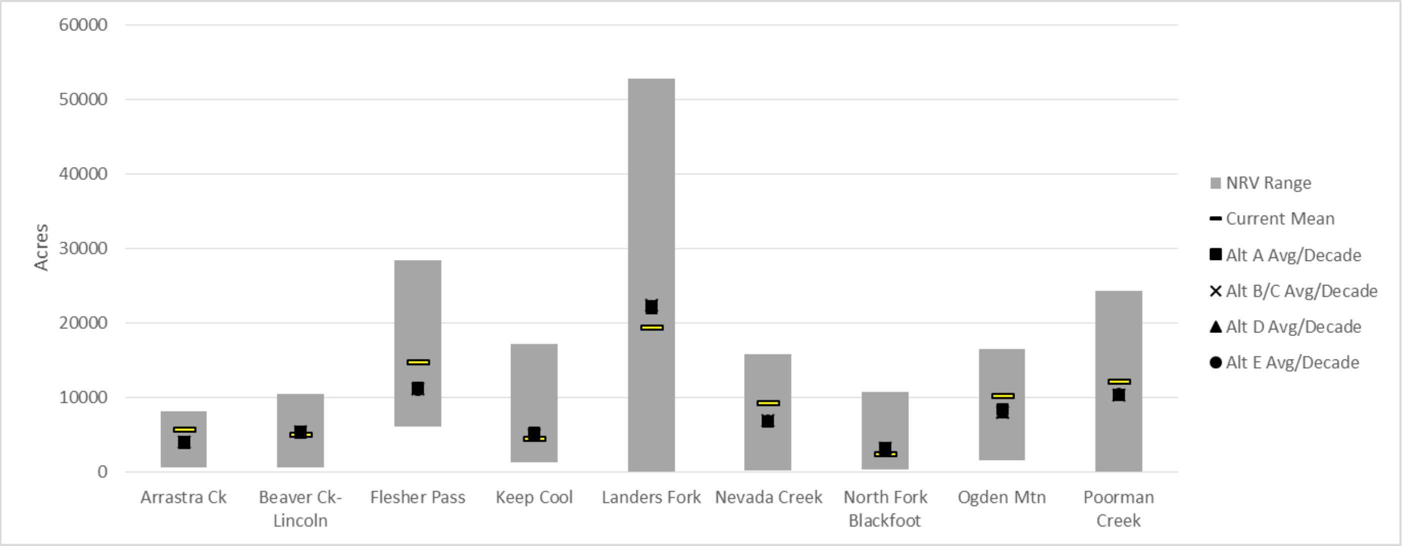


**Figure 142. Elk winter habitat forestwide, average acres/decade for 50 years compared to NRV by alternative**

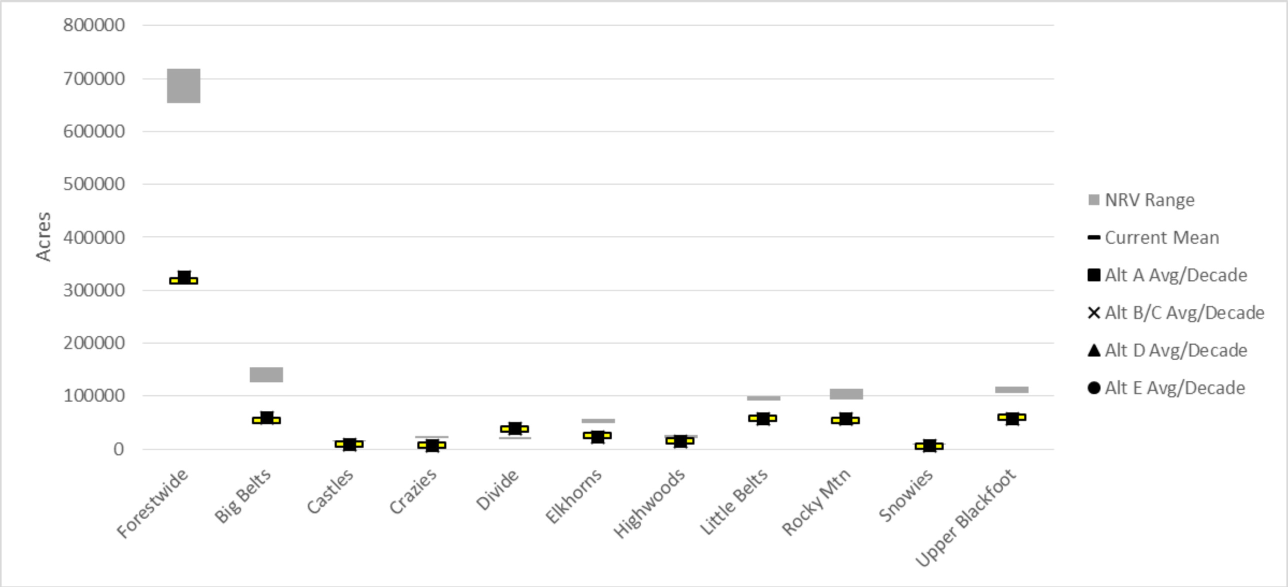



**Figure 143. Elk winter habitat over time by alternative forestwide**

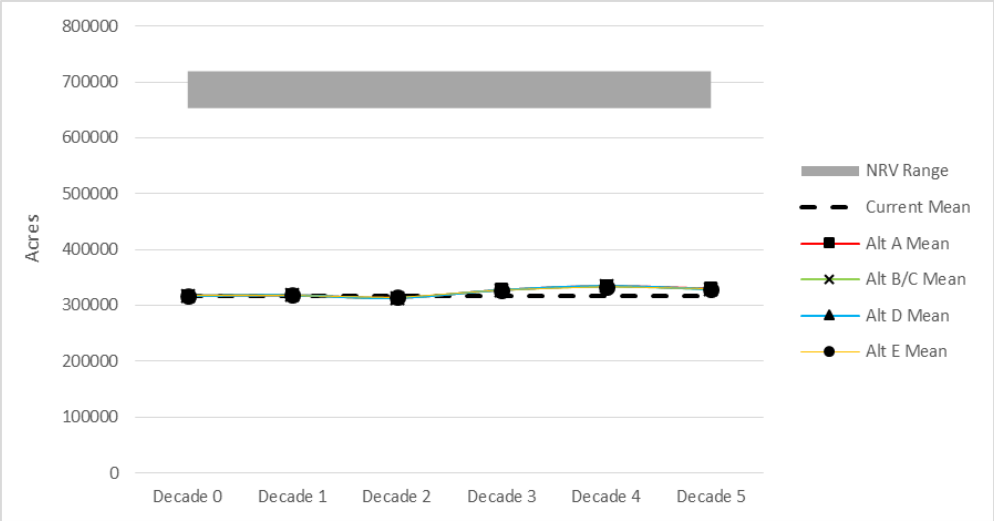


**Figure 144. Elk winter habitat by GA over time by alternative – Big Belts, Castles, Crazies, and Divide GAs**

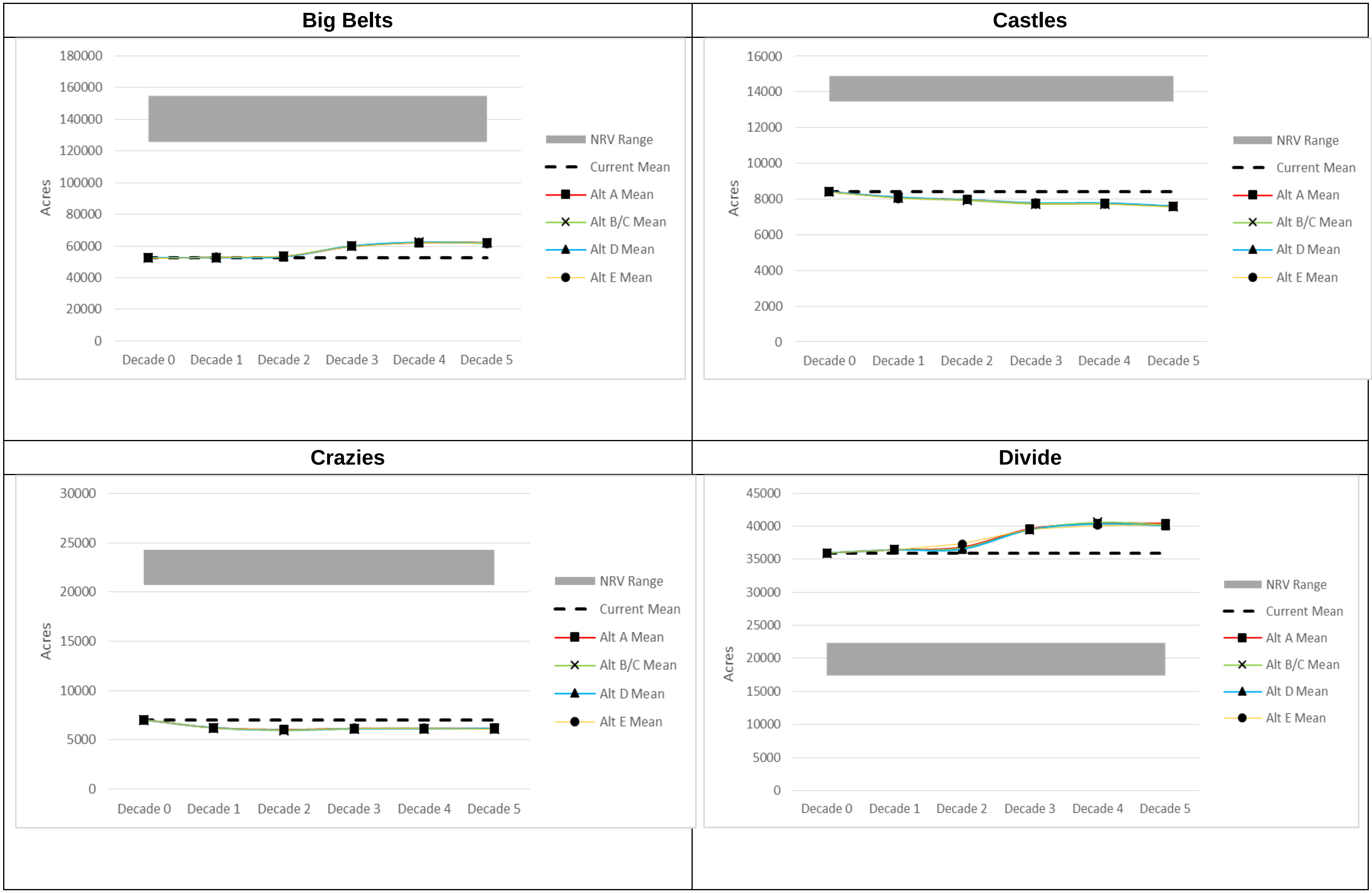
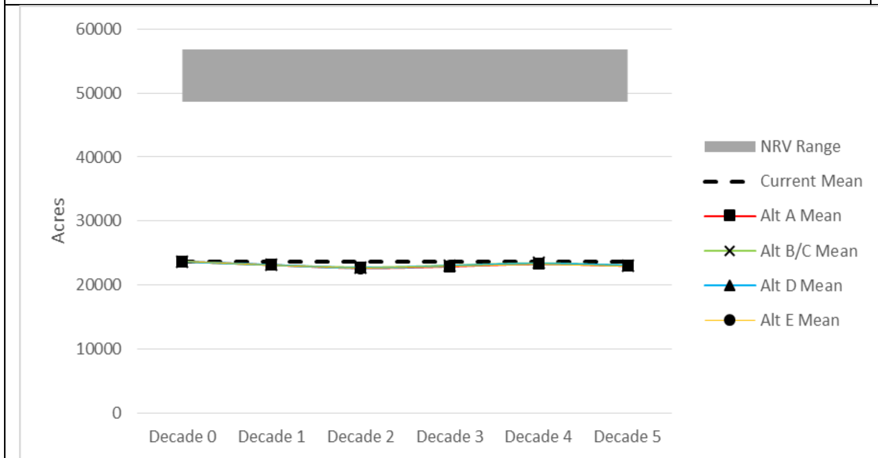
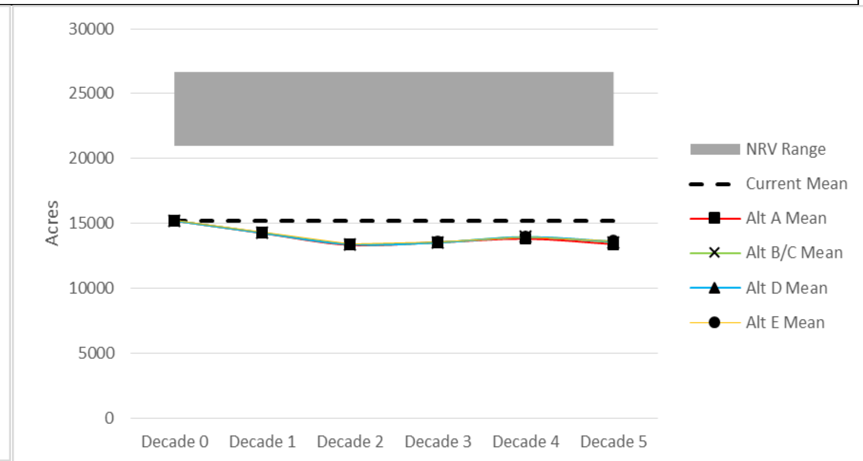


**Figure 145. Elk winter habitat by GA over time by alternative – Elkhorns, Highwoods, Little Belts, and Rocky Mountain Range GAs**

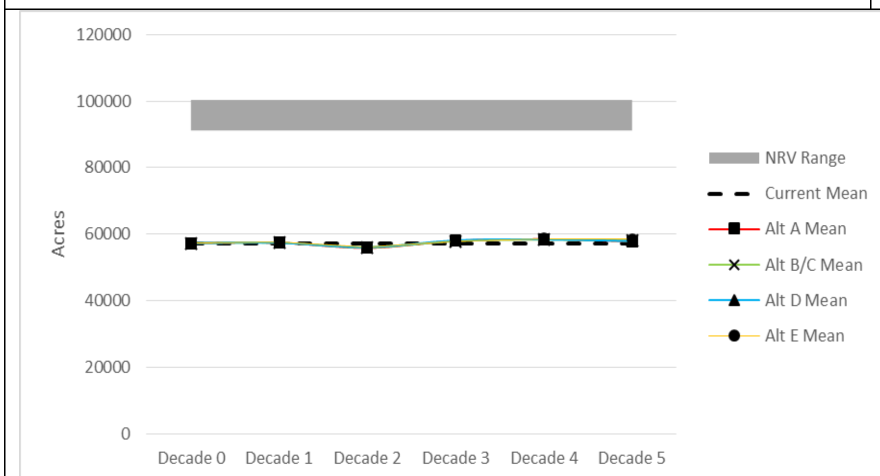
**Elkhorns**




**Highwoods**




**Little Belts**




**Rocky Mountain Range**

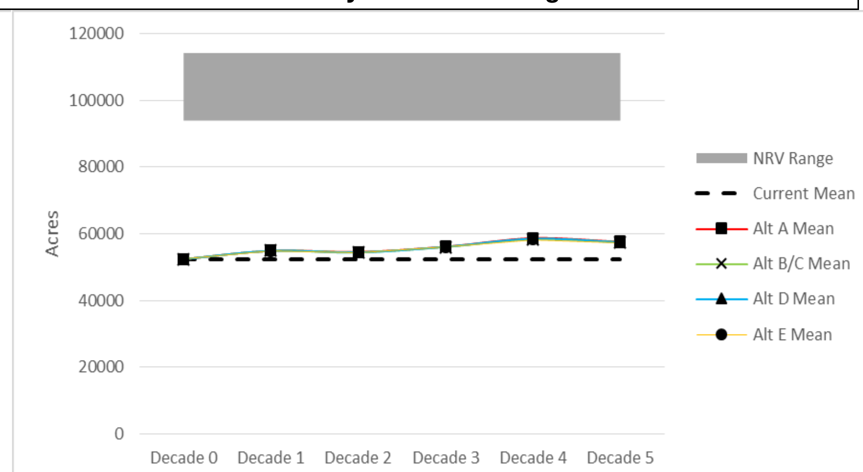
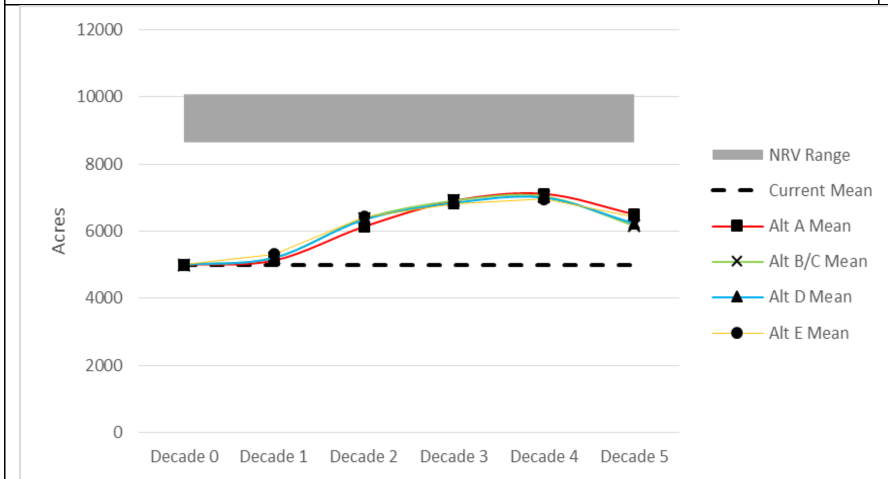
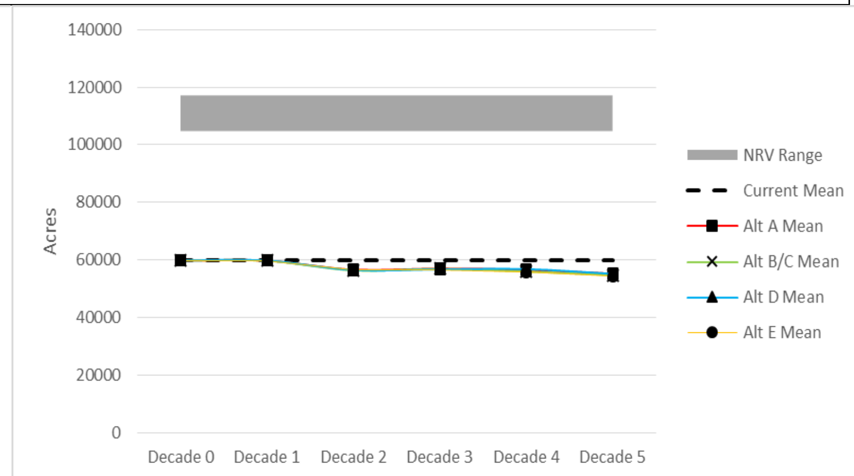


**Figure 146. Elk winter habitat by GA over time by alternative – Snowies and Upper Blackfoot GAs**

| Snowies | Upper Blackfoot |
|---|---|
|   |   |

## Recreation Settings, Opportunities, Special Uses, and Access

The analysis for sustainable recreation settings used existing travel plan information and the geographic information system to map each of the recreation opportunity spectrum classes. These classes were verified with forest personnel familiar with these areas.

Data for the recreation opportunities, recreation special uses, and recreation access portion of this analysis were derived from the Forest Service corporate database, Infrastructure. This database houses the specific information about the numbers, quantities, and types of recreation opportunities and special uses as well as the miles and status of roads and trails. This data was verified by forest personnel prior to inclusion in this analysis.

## Scenery

The FS uses the scenery management system to inventory, analyze, and monitor national forest scenic resources. This system recognizes natural disturbance processes such as fire, insects, and disease to be part of the natural landscape that is dynamic and also important in maintaining healthy, sustainable, and scenic landscapes. The scenery management system is also used in the context of ecosystem management to determine the relative value, stability, resiliency, and importance of scenery; assist in establishing overall resource objectives; and ensure high-quality scenery for future generations. The primary components of the scenery management system are:

- scenic character,
- scenic attractiveness,
- landscape visibility,
- existing scenic integrity,
- scenic classes, and
- scenic integrity objectives

The Forest completed an inventory of landscape visibility and scenic attractiveness, and compiled scenic classes. In 2011, the FS’s Northern Region completed existing scenic integrity mapping at a regional scale. Using this data, scenery was analyzed on a forestwide scale and included the encompassing viewsheds of the HLC NFS lands and the surrounding nonforest system lands. Landscape character descriptions for each of the GAs have been developed and are located in appendix J of the Draft Plan.

Data used to conduct the analysis came from the latest spatial information contained in the geographic information system data. Acreages and percentages of scenic integrity objectives were analyzed to determine how well they support the inherent scenic character and move the landscape toward desired scenic integrity objectives.

## Administratively Designated Areas

The analysis for the existing administratively designated areas used maps stored in the National Forest’s GIS. Existing GIS maps were available for the following areas and were used in this analysis:

- Inventoried Roadless Areas
- National Recreation Trails
- Research Natural Areas
- Tenderfoot Creek Experimental Forest
- Elkhorns Wildlife Management Unit
- Kings Hill Scenic Byway

In addition to these existing administratively designated areas, the HLC NF identified the following 4 new areas on the forest that may be administratively designated in the revised Forest Plan. The boundaries for these areas were identified and mapped for this analysis.

- South Hills Recreation Area
- Missouri River Corridor
- Smith River Corridor
- Badger Two Medicine Area

## Congressionally Designated Areas

The analysis for designated areas used the official maps from the enabling legislation for these lands which are stored in the geographic information system. The HLC NF used the enabling legislation and official designated areas maps to analyze the following areas:

- Designated wilderness areas
- Wilderness study areas
- Continental Divide National Scenic Trail
- Lewis and Clark National Historic Trail
- Lewis and Clark National Historic Trail Interpretive Center
- Rocky Mountain Front Conservation Management Areas

In addition to congressionally designated areas, the HLC NF was required to conduct both a wilderness evaluation and an eligible wild and scenic river study as a part of the forest planning process. The following information outlines the methodology utilized for those two processes.

### Wilderness Evaluation

The analysis for identifying potential recommended wilderness areas used official maps stored in the geographic information system. Specific data used to assess potential wilderness characteristics and overall descriptions were derived from the FS corporate Infrastructure database. This database houses the specific information about the acres, miles of trail, and facilities available within each wilderness area. Data was verified by forest personnel prior to inclusion in this analysis.

The geographic scope of the analysis included all lands administered by the Forest within the planning area. All lands within the HLC NF boundary form the geographic scope for cumulative effects, and the temporal scope was the life of the plan (approximately 15 years).

The process by which lands are recommended for inclusion in the National Wilderness Preservation System was intended to be transparent and consistent across the NFS. To accomplish this, the process occurred in four primary steps (2012 Forest Service Planning Rule and Chapter 70 of the FS Land Management Planning Handbook 1909.12.) Each step of the process required public participation and collaboration, intergovernmental coordination with state and local governments, and tribal consultation (as required by the broader planning process). Steps 1-3 have been accomplished. Step 4 will be completed with the signing of the Record of Decision when the FEIS process has been completed.

1. <u>Inventory:</u> The Responsible Official (the Forest Supervisor) identifies and creates an inventory of all lands that may be suitable for inclusion in the National Wilderness Preservation System.
2. <u>Evaluation:</u> The Responsible Official evaluates the wilderness characteristics of lands identified in the inventory using a set of criteria based on the Wilderness Act of 1964.

3. Analysis: The Responsible Official considers the areas evaluated and determined which areas to further analyze for recommendation as part of one or more alternatives identified in a NEPA document.
4. Recommendation: The Responsible Official decides, based upon the analysis and input from Tribal, State, and local governments and the public, which areas, if any, to recommend for inclusion in the National Wilderness Preservation System.

All plan revisions are required to complete this process before the responsible official determines, within the plan decision document, whether or not to recommend lands within the plan area to Congress for wilderness designation. Wilderness recommendations are only preliminary administrative recommendations; Congress has reserved the authority to make final decisions on wilderness designation.

Wilderness characteristics are based on natural quality, undeveloped area, unconfined or primitive recreation or solitude, and unique or other features. Oftentimes, the ecological characteristics are discussed in terms of natural quality and undeveloped and can be represented by landscapes where the ecosystems of the area are intact and/or evidence of human disturbance is not readily apparent. Social characteristics can be discussed in terms of solitude or unconfined or primitive recreation and are often represented by remote, quite landscapes where recreation activities such as hiking, climbing, fishing and hunting are predominant.

The HLC NF conducted a wilderness evaluation process outlined in the 2012 FS Planning Rule, Chapter 70 (Forest Service Land Management Planning Handbook 1909.12). Additional lands with potential for inclusion in the National Wilderness Preservation System were identified and evaluated in this process.

The inventory and evaluation steps were completed and displayed as an appendix in the proposed action. This draft environmental impact statement describes the analysis step. The recommendation step will result from the final environmental impact statement and will be recorded in the record of decision. Recommendations of potential wilderness areas are only preliminary administrative recommendations. Congress reserves the authority make final decisions on wilderness designation. The ecological and social characteristics of recommended wilderness areas that provide the basis for suitability for inclusion into the National Wilderness Preservation System are identified for each recommended wilderness area by alternative and can be found in appendix E of the DEIS.

## Eligible Wild and Scenic Rivers Study

The 2012 Planning Rule's Final Directives (FSH 1909.12 Chapter 80) provided guidance for conducting a wild and scenic rivers eligibility study during forest plan revision. The HLC NFs used this guidance to conduct the wild and scenic rivers eligibility study for the planning area using the following steps.

Step 1: Identified free-flowing named streams/rivers.

Step 2: Identified regions of comparison for each resource.

Step 3: Developed evaluation criteria for identifying outstanding remarkable values.

Step 4: Evaluated named streams/rivers and determine if they possess outstanding remarkable values.

Step 5: Reviewed level of development/determined classification of wild, scenic, or recreational.

Step 6: Developed forest plan management direction (included in the proposed action).

The eligibility study was conducted through a series of meetings and workshops aimed at each of the steps identified in the process paper. Much of the base information was developed from GIS, such as the base maps, determining the number and location of all "named streams", and identifying the location of developments along or nearby these rivers and streams. Specific resource information about each river/stream was gathered from maps and professional knowledge provided by forest resource specialists.

The geographic scope of the wild and scenic rivers eligibility study was the free flowing rivers and streams located within lands administered by the Forest. Rivers and segments of rivers that pass through private lands were not considered in the eligibility study. All lands within the HLC NF boundary form the geographic scope for cumulative effects, and the temporal scope is the life of the plan (15 years).

The document that summarizes the wild and scenic rivers eligibility study, as well as, descriptions of each eligible river and maps is located in appendix G of the Draft Plan.

## Cultural, Historical, and Tribal Resources

The Regional Programmatic Agreement and the forest-specific Site Identification Strategy address details of National Historic Preservation Act/Sec. 106 compliance. They prescribe certain percentages of survey coverage for various types of undertakings, in order to adequately complete Sec. 106 effects analysis. The amount of survey and research anticipated depends on the undertakings involved. Information from project-level analyses assigns the 'potential for the occurrence of cultural resources' used in both NEPA and National Historic Preservation Act reviews.

The primary goal of a cultural resource inventory is to locate and describe archaeological, historic and cultural sites and to make a recommendation of significance when such sites are found. Significance evaluations of known cultural resources and new sites discovered during inventories of a project area would follow general guidelines as set forth below:

1. Cultural materials were observed in depositional or surficial settings where cultural remains may have been buried or disturbed in essentially their original positions, thus preserving spatial context.
2. Artifacts diagnostic of historic or prehistoric cultural periods were found. Presence of such artifacts allows dating of cultural components and establishment of temporal and cultural context.
3. Presence of diagnostic artifacts in potentially preserved context makes it possible for a site to contribute significantly to understanding of local and regional history and prehistory.
4. Historic sites were found to associate with the lives of person(s) significant to local or regional history. Such associations can be apparent through archival research.
5. Historic or prehistoric sites were found to contain well-preserved features such as buildings, roads, trails, tipi rings, cairns, effigies, pictographs, or petroglyphs. Such features may be representative of or associated with an important period, architectural style, artistic style, or a unique or specialized activity.
6. Physical evidence of past or present cultural use of a locality for prayer, fasting, vision questing, piercing, burial, and other ceremonial activities were found. That evidence could include prayer cloth, rock structures, marked trees, sweat lodge remnants or hearths, or other lodge remnants. Presence of these things allow for identification of Traditional Cultural Properties.

Information from historic maps, the heritage resource database, and from numerous surveys completed in previous project areas identifies specific locations of prehistoric and historic sites. This information provides historic context and helps identify both specific sites present and the kind of sites which may exist across the Forest.

Evaluation of all potential historic properties, including traditional cultural properties, follows a set of criteria established by the Montana State Historic Preservation Office and the National Park Service. Historic properties are determined to be significant if they meet one or more of the following criteria (USDI-NPS Bulletin 15):

a. They are associated with events that have made a significant contribution to the broad patterns in our history; and/or
b. They are associated with the lives of persons significant in our past;
c. They embody distinctive characteristics of a type, period, or method of construction that represents the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction;
d. They have yielded, or may likely yield, information important in prehistory or history.

If sites do not meet the criteria for eligibility for the National Register of Historic Places after consultation with the appropriate parties, Section 106 of the National Historic Preservation Act stipulates no further consideration of cultural resources is necessary and the undertaking may proceed.

If a site meets any of these criteria, Section 106 requires an agency to determine the effect of the proposed action on the site. One of the following three determinations is possible:

1. No historic properties affected – a Heritage Specialist has determined that either there are no historic properties present or there are historic properties present, but the undertaking will have no effect upon them. The agency will notify all consulting parties and make the documentation available for public inspection before approving the undertaking.
2. Historic properties affected – a Heritage Specialist finds that there are historic properties the undertaking may affect or the State Historic Preservation Office/Tribal Historic Preservation Office or the Advisory Council objects to the agency's findings. The agency then will notify all consulting parties, invite their views on the effects, and assess adverse effects, if any.
3. Adverse effect – the Heritage Specialist determines that the effect on eligible cultural resources will be adverse. When an undertaking has been determined to have an adverse effect on a property eligible for listing, the agency is directed to consult with the State Historic Preservation Office/Tribal Historic Preservation Office and other consulting parties to develop and evaluate alternatives or modifications to the undertaking that could avoid, minimize or mitigate adverse effects on historic properties. Mitigation of effects to a significant cultural resource entails a range of options including project redesign, avoidance, documentation (photography and archival research), or restoration and data recovery (through archaeological excavation). Mitigation options are selected on a case-by-case review and are tailored to the distinct values of the property and the planning options available within the project design. Once the agency and the State Historic Preservation Office agree on the mitigation measures for eligible properties and the conditions or stipulations have been met, the project may proceed.

The FS relies on its relationship and consultation with tribes to identify areas of tribal importance that may be impacted by FS actions. The consultation process affords both Tribes and the FS opportunities to identify sites, interests, and values of tribal importance as well as to design protective measures that avoid or mitigate effects to cultural or historical resources that are important to tribes.

Land use management plans, heritage reports, survey and research information, information from FS heritage resource specialists, and consultation with Tribe members are the primary sources of information used for this analysis.

## Lands

The total acres of NFS lands are derived using a GIS measuring process. The total is comprised of lands under FS jurisdiction both within and outside of the proclaimed NFS boundary. The total acres of non-NFS lands are provided by the Washington Office Lands group and are only those lands within the proclaimed NFS boundary. The data source for the number of special use authorizations is the national special uses data system.

The FS uses the Land Status Record System (LSRS) as the repository for realty records and land title documents. The LSRS includes accurate information on ownership acreages, condition of title, administrative jurisdiction, rights held by the United States, administrative and legal use restrictions, encumbrances, and access rights on land or interests in land in the NFS.

The FS uses the Special Uses Data System (SUDS) to create and administer special use authorizations. The data in SUDS is supported by hard copy files at Ranger District and Forest Supervisor's offices.

The FS uses the Title Claims and Encroachments Program to store data related to encroachments. This program provides a consistent, standard, operating method to inventory, process and resolve title claims and encroachment cases, and sort the data needed to prepare summary reports for management. The primary focus of Title Claims and Encroachments Program is the defense and protection of the lands and title of the public's estate managed by the FS.

## Infrastructure

Information used to conduct the analysis generally comes from the national Infrastructure database. This database is a collection of web-based data entry forms, reporting tools, and mapping tools (GIS) that enables forest staff to manage and report accurate information about their inventory of constructed features and land units.

## Social and Economics

### Scale

The spatial scale for the analysis was determined as part of the Assessment process. Several factors were taken into account including FS staff expertise, commuting patterns, recreational visitation, trade, travel corridors, social and cultural identity and timber processing areas. The temporal scope is the life of the plan (15 years). For a complete discussion of the process for determining the analysis area, please see the Helena-Lewis and Clark Assessment (Ch 5, p2), as well as the USDA Forest Service Protocols for Delineation of Economic Impact Analysis Areas (METI, 2010).

### Analysis

Economic and social benefits of the Forest are measured by identifying how ecosystem services (including multiple uses), infrastructure and operations, either directly or indirectly, contribute to economic and social sustainability. Specifically, ecosystem services are those societal benefits the Forest provides, including both goods and services, that are of value to people. Infrastructure and operations benefits include both physical elements, such as roads and facilities, as well as all the services the Forest staff provide such as fire suppression and educational programs.

The FS manages NFS lands according to the principle of multiple use. This principle allows the agency to manage land for a variety of uses, including amenity, commodity, non-commodity, and recreation. The Multiple-Use Sustained-Yield Act (P.L. 104–333) formalized this management philosophy, stating that the FS is to manage resources to best meet the needs of the American public, with flexibility to provide for "periodic adjustments in use to conform to changing needs and conditions" (Section 4(a) of the Act [16 U.S.C. 531]). For instance, areas suitable for timber production may contribute to the local economy by sustaining timber sector jobs and income; thereby maintaining social fabric and lifestyles of the community. Wilderness areas generate significant social well-being by providing world-class recreational settings and inspiration. Visitors from near and far may benefit from experiencing solitude in these pristine locations while contributing to the regional economy (i.e. travel and tourism related sectors) in terms of jobs, income and other economic activities.

Numerous approaches exist for measuring society's condition or progress towards achieving social and economic sustainability. In the forest planning context, a broad ecosystem services framework, which catalogues societal benefits of forests, is an ideal framework for identifying how the plan area contributes to social and economic sustainability.

Societal benefits of the Forest are used and/or valued differently by different groups and communities. The Assessment provided a brief overview of social and economic conditions and highlighted the benefits the Forest provides to the affected communities. In the Affected Environment section, the social and economic conditions of affected communities are summarized alongside a discussion of the key societal benefits the Forest provides to beneficiaries.

# Livestock Grazing

The analysis area includes NFS rangelands within grazing allotments across the entire HLC NF plan area. While the HLC NF has recently been combined into one administrative unit, the existing forest plan guidance and much of the available data is split by the old forest boundaries. Therefore, the units are described separately where appropriate in the analysis. A portion of the Beaverhead-Deerlodge National Forest in the Elkhorns GA is managed by the HLC NF as well.

The proposed action and alternatives to the proposed action include components that describe actions that may, or may not, impact the management of grazing livestock. For this analysis, each alternative is evaluated using one or more key indicators to determine the overall impacts to livestock grazing on NFS land. When the degree of impact cannot be quantified, a qualitative assessment is used based on professional judgment and, when possible, in conjunction with available data.

# Timber and Other Forest Products

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

## Analysis area

The analysis area for timber suitability, supply, harvest, and other forest products is comprised of the NFS lands administered by 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, as shown in Table 10.

**Table 10. 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 |

## Identification of Lands Suitable for Timber Production

The National Forest Management Act ("National Forest Management Act of 1976," 1976) 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 detailed 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 must be determined at the project level.

Harvest of timber on NFS lands occurs for many reasons, including but not limited to habitat or ecosystem restoration, community protection, protection of municipal water supplies, and contribution to economic sustainability through providing timber products and fuel as renewable energy. *Timber harvest* is the removal of trees for wood fiber use and other multiple-use purposes. In contrast, *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).

The identification of lands suitable for timber production was accomplished using GIS. Lands that are unsuitable for timber production, but where timber harvest may occur to meet other objectives, were also mapped. Criteria for determining lands not suitable for timber production are assessed with two-steps:

5. 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. The factors to be used to identify lands at this stage are:

(i) Statute, executive order, or regulation prohibits timber harvest on the land;
(ii) The Secretary of Agriculture or the Chief of the FS has withdrawn the land from timber production;
(iv) The technology is not currently available for conducting timber harvest without causing irreversible damage to soil, slope, or other watershed conditions;
(v) There is no reasonable assurance that such lands can be adequately restocked within 5 years after final regeneration harvest; or
(vi) The land is not forest land.

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

6. 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 considered. The factor used to identify lands at this stage is:

(iii) Timber production would not be compatible with the achievement of desired conditions and objectives established by the plan.

### *Lands that may be suitable for timber production*

Table 11 lists the technical factors and definitions used to identify that lands that are not suited for timber production. These lands were subtracted from the total NFS land acreage, and the remaining areas are those that *may be suited for timber production*. This preliminary classification as described above. 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 11. Criteria for the Identification of lands that may be suited for timber production**

| Technical Factor (36 CFR 219.11(a)) | Definition and Description FSH 1909.61.1 (USDA, 2015) |
|---|---|
| (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 Forest Service has withdrawn the land from timber production. Examples include wilderness, eligible and/or designated wild river segments, research natural areas, and other designated areas where timber production is specifically prohibited. |
| (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; for example, shallow or excessively wet soils; excessively steep slopes; avalanche areas; and floodplains. Criteria should take into account information such as landforms, soil conditions, vegetation, and available technology for harvest. Information may be used to assess soil vulnerability to physical, chemical, and biological damage. |
| (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. Consider relevant information such as soil maps, geological maps, monitoring, and other best available scientific information. |
| (vi) The land is not forest land | Lands less than 10% occupied by trees of any size or that formerly had tree cover but are developed for nonforest uses (such as agriculture, pasture, residential areas, improved roads, recreation areas, and 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 naturally or artificially regenerated in the near future. Canopy cover of live trees at maturity may be used to estimate if an area is at least 10 percent occupied. Unimproved roads, trails, intermittent or small perennial streams, and clearings may be included as forest if < 120’ wide. |

A spatial analysis was conducted that methodically subtracted unsuitable lands from the total land area based on legal or technical factors, as shown in Table 12. 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. For example, relatively few acres were eliminated for soil or stability concerns; this is because some of these areas were already eliminated through the exclusion of wilderness, inventoried roadless areas, and nonforest lifeforms. Due to the resolution of data sources, there will be inclusions of suitable lands in unsuitable areas and vice versa; thus it is important to validate suitability at the project level.

**Table 12. Areas eliminated from lands that may be suitable for timber production**

| Factor | Areas Eliminated | Approximate Acres |
|---|---|---|
| | **Total NFS lands** | 2,883,339 |
| 36 CFR 219.11(a) (i) and (ii) | Designated wilderness | 564,562 |
| | Designated wild & scenic rivers | 0 |
| | Rocky Mountain Front Conservation Management Areas | 195,653 |

| Factor | Areas Eliminated | Approximate Acres |
|---|---|---|
| | Wilderness Study Act areas | 161,688 |
| | Research Natural Areas | 11,848 |
| | Tenderfoot Experimental Forest | 7,671 |
| | Inventoried Roadless Areas | 1,017,320 |
| | Total acres eliminated for this factor | 1,958,854 |
| 36 CFR 219.11(a) (vi) | Administrative sites & campgrounds[1] | 278 |
| | Roads, railroads, and utility corridors[2] | 19,800 |
| | Water bodies and streams >120' wide | 927 |
| | Nonforest lifeforms[3] | 148,363 |
| | Total acres eliminated for this factor | 169,368 |
| 36 CFR 219.11(a) (iv) and (v) | Areas with soil stability or damage concerns[4] | 15,155 |
| | Areas with low growth/regeneration potential[5] | 72,956 |
| | Total acres eliminated for this factor | 88,111 |
| | **Lands that may be suitable for timber production** | 667,119 |

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 Areas with average slopes >80%; severe slump/mass failure risk; or with 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. These lands are identified based on the desired conditions, goals, and objectives developed for the draft plan and for each alternative.

**Table 13. Criteria for the Identification of lands that are suited for timber production**

| Factor | Definition 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 14.

**Table 14. Considerations for determining lands suitable for timber production, by alternative**

| Alternative | Considerations and Rationale |
|---|---|
| Alternative A, No Action | Alternative A, No Action, represents the current forest plans as amended and implemented. Suitability for timber production was mapped by starting with suitability as defined in the 1986 plans, and then updated to reflect the changes that have occurred since then that would continue to drive management into the future. The primary change incorporated was the removal of suitability where inventoried roadless areas were established. It was also updated to be consistent with the new may be suited layer in terms of the technical factors, because it is based on new data. |
| Alternative B, Proposed Action | Alternative B is the proposed action. Lands suitable for timber production was initially mapped prior to public scoping. The areas that were subtracted from the may be suited acreage because timber suitability was not compatible with plan objectives included the Elkhorns GA, the Highwoods GA, the Snowies GA, the Badger-Two Medicine area, the Dry Range, the South Hills Recreation Area, the Tenderfoot land acquisition area, and the Missouri River Corridor. Lands that overlapped with recommended wilderness was also dropped. Other cultural or historical sites were removed, including the Alice Creek Historic District, the Chinese/Robertson wall, the Smith River corridor, the Mann Gulch Historic District, and the Lincoln Gulch Historic District. Updates were made to campground and utility corridor buffers based on new available data. The modified proposed action for the DEIS was further updated to eliminate areas with a Recreation Opportunity Spectrum (ROS) class of Semi-Primitive Non-Motorized, where timber production would be precluded due to poor access, low feasibility, and ROS objectives. In addition, eligible wild and scenic river corridors were excluded. |
| Alternative C | The lands suitable for timber production are identical to Alternative B. |
| Alternative D | Alternative D was mapped starting with the suitability layer for Alternatives B/C, and further reducing lands suitable for timber production where they overlapped with the additional recommended wilderness, semi-primitive non-motorized, and primitive ROS areas. |
| Alternative E | For Alternative E, the may be suited layer was included to the greatest extent. Compared to Alternative B/C, the only landscape areas excluded are the Badger Two Medicine and Elkhorns GA, along with special cultural or historical sites. ROS classifications were adjusted to be compatible with timber harvest where possible (roaded natural or rural). There are no recommended wilderness areas, so lands that were excluded in these areas in other alternatives were added back in. The South Hills Recreation area is not included in this alternative, and therefore the lands that may be suited within this area were included as suitable for timber production. |

Riparian management zones are also not suitable for timber production. For the DEIS, these areas are unsuitable inclusions where they occur within lands suitable for timber production, because mapping was not readily available to identify them. The DEIS discusses the potential influence and magnitude of the management restrictions within these areas relative to timber production and harvest.

In addition, eligible wild and scenic rivers were identified for the action alternatives (B, C, D, and E). These corridors are excluded from the final timber suitability maps and acreages, as described in the table. However, these areas were not excluded in the mapping that was used for the timber modeling with Spectrum. This resulted in roughly 456 acres being incorrectly included in the modeling for alternatives B/C and E, and 284 acres in alternative D; these overlaps occurred in the Little Belts GA. This acreage is negligible (representing less than 0.06% of the Little Belts GA) and would not materially affect the timber modeling and other conclusions reached with this programmatic analysis. The acres of suitability as mapped and reported in the DEIS correctly exclude the wild and scenic river corridors.

## Spectrum Model Design

Spectrum is a software modeling system designed to assist decision makers in evaluating resource management choices and objectives. Models constructed with Spectrum apply management actions to landscapes through a time horizon and display outcomes. Management actions are selected by the model to achieve desired goals (objectives) while complying with management objectives and limitations (constraints). Spectrum makes it possible to display management actions to landscapes at multiple spatial and temporal scales. It is effective for modeling alternative resource management scenarios in support of strategic and tactical planning. Examples of this include scheduling vegetation treatments to achieve desired conditions; modeling resource effects and interactions within management scenarios; and exploring "tradeoffs" between alternative management scenarios.

Spectrum was used to model potential vegetation treatments and outcomes across the HLC NF over time under each alternative. The alternatives were modeled with an objective 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. Alternative E was also modeled with an objective of achieving 95% of the maximum possible timber output based on the theme of that alternative.

The model applies constraints based on factors that would limit potential treatments, such as lynx habitat, operational or logistical limitations, and management regimes (such as suitability for timber production and recreation opportunity spectrum settings). Limits associated with expected budget levels are also evaluated. Spectrum model formulation and outcomes provide a schedule of activities for the HLC NF that help provide answers to the following questions:

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

The key variables and assumptions used for Spectrum modeling are summarized in this section. Please see the report *Helena and Lewis & Clark National Forests Plan Revision: Construction of Vegetative Yield Profiles & SPECTRUM Model Design*, for 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. For example:

- Treatment prescriptions represent commonly used activities and schedules based on vegetation types, but actual site-specific prescriptions would be specifically tailored to each site.
- The budget constraint is based on recent and reasonably foreseeable budget levels, but actual budgets may vary and so too would the amount of vegetation management that occurs.
- Project costs as well as timber values are estimated using the best available information, but these could change in the future.
- Expected disturbance levels were applied to best approximate future vegetation conditions, but there is a high level of uncertainty in the timing and location of future disturbance events.
- Resource-based constraints such as dispersion of openings, the proportion of treatment types in various land allocations, and lynx habitat requirements are applied broadly, but project design and analysis may apply such considerations differently based on a site specific analysis that follows the most current law, regulation, and policy at the time of implementation.

- The desired conditions that can be specified for the model are limited in number and complexity. 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 as well as the vegetation types that are treated.

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 Draft Plan, and inform the objectives for vegetation treatments in the Draft Plan. They are not precise targets, and actual implementation of the plan may vary based on the factors described above as well as other considerations such as litigation.

### *Planning horizon*

The planning horizon is a specified time frame broken down into periods of an equal number of years. The HLC NF Spectrum 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 – Forest Vegetation Simulator*

Growth and yield tables were developed using the Forest Vegetation Simulator, which is a family of forest growth simulation models. Since its initial development in 1973, it has become a system of highly integrated analytical tools. These tools are based upon a body of scientific knowledge developed from decades of natural resources research. Available data from FIA base and intensified grid plots was stratified according to vegetation type and structure, and the Forest Vegetation Simulator was run to estimate key variables throughout the life of the plot under several possible management scenarios. Spectrum 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 the following outputs:

- Stand age, basal area, diameter, trees per acre, and culmination of mean annual increment
- Merchantable cubic feet board feet, harvested and remaining on the site
- Diameter of removals and residual volume
- Fire risk
- Snags per acre and presence
- Bark beetle risk and defoliator risk
- Large trees per acre and presence
- Carbon total tons
- Tons/acre downed woody material
- Vegetation type and structure class
- Presence and composition of key tree species (ponderosa pine, whitebark pine, whitebark pine, aspen, western larch, and limber pine)

### *Land stratification and analysis units*

The planning area is subdivided into areas that facilitate analyzing land allocation and expected management. In Spectrum, each stratum is a layer and a unique combination of layers results in an “analysis unit.” The HLC NF used five layers of information to develop analysis units. The combination of classes in each layer creates a repeatable land unit with unique characteristics. The land stratification layers identified for each alternative are all of the unique combinations of the following five layers:

- Geographic area and wildland urban interface (Upper Blackfoot GA or island mountain ranges, and wildland urban interface delineations)
- Management area group (combinations of suitable or unsuitable for timber production; whether harvest is allowed in unsuitable lands; and recreation opportunity spectrum setting)
- Wildlife condition (lynx and/or grizzly bear habitat)
- Vegetation type (potential vegetation type and existing vegetation composition)
- Vegetation structure (size class and density class)

Only forested vegetation types were included in the Spectrum modeling; therefore, the total acres modeled are less than the HLC NF as a whole, and results do not represent treatments such as prescribed fire which could occur on nonforested vegetation types.

### *Management actions and timing*

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 conditions. Table 15 describes the prescriptions that were developed. The detailed prescriptions can be found in the planning record.

**Table 15. Prescriptions and management activities used in spectrum**

| Prescription | Possible Activities |
|---|---|
| Natural growth | None |
| Stand Replacing Wildfire | Wildfire |
| Mixed Severity Wildfire | Wildfire |
| Severe Bark Beetle | Severe bark beetle |
| Natural Attrition | None |
| Clearcut/Seedtree | Precommercial thin, commercial thin, understory burn, broadcast burn, seed cut, overstory removal, regeneration |
| Shelterwood | Precommercial thin, commercial thin, understory burn, broadcast burn, seed cut, overstory removal, regeneration |
| Uneven-aged Cut | Group selection opening, single tree selection, Precommercial thin, commercial thin, understory burn, broadcast burn, regeneration |
| Prescribed Burn | Understory burn, broadcast burn |

Several timing choices were applied to the prescriptions. Timing choices specify the range of ages in which a stand may be treated. The earliest point at which a stand could be regeneration harvested was based on culmination of mean annual increment. Based on constraints and the specified management goals or objectives, the Spectrum model determines the management prescription to apply to an analysis area as well as the timing of the implementation.

### *Costs for management activities*

Costs were developed for the following management activities, and applied to prescriptions selected by Spectrum. All costs are part of the budget constraint, and are taken into account when the model schedules treatment activities.

- Timber planning (analysis, sale prep, and administration), applied based on volume harvested
- Reforestation, applied on a per acre basis

- Timber stand improvement, applied on a per acre basis
- Road re-construction and administration, applied on a miles per acre treated basis
- Prescribed burning, applied on a per acre basis
- Weed treatments, applied on a per acre basis
- Treating heavy downed fuels, applied on a per acre basis for the first three decades (in response to beetle-killed stand conditions)
- Treatments in whitebark pine, applied on a per acre basis

### *Timber values*

Stumpage values for timber were developed with a residual value calculation, meaning that stumpage value is the difference between the delivered log price at a mill and the estimated harvest and delivery costs incurred by a buyer who purchases the timber. Forest product values were developed by species group, which were cross walked to Spectrum cover type strata. The following assumptions were used:

- 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, cable, cut-to-length, and helicopter logging systems reflecting the typical mix on the HLC NF.
- Typically ponderosa pine “sawlogs” are sold as “nonsaw”.
- Nonsaw material is cut and removed as a product. This material adds approximately 15% more volume to all types. Volume estimates are adjusted accordingly to calculate the PWSQ. PTSQ is based solely on sawlog volumes.
- An additional 1.35 mmcf of volume was added to PWSQ to represent the firewood program.

### *Management constraints*

Management constraints are limits defined to model resource thresholds, relations between and among activities and outputs, policy requirements, or monetary limitations. The following constraints that were incorporated into the Spectrum model in response to Forest Plan direction, regulations, and as a means of improving the model's ability to simulate actual management. Constraints were for modeling purposes only and do not create limitations for Plan implementation.

- Budget constraint is based on a 3-year average of actual budgets for 2013, 2014, and 2015, including a break out of funds required to be spent in the wildland urban interface. Outputs are shown with and without the budget constraint.
- Harvest policy is to achieve non-declining yield and long term sustained yield. Non-declining even flow is applied to each congressionally designated national forest separately (the Helena and Lewis and Clark respectively) for the sustained yield limit run. Non-declining even flow is not required for the projected timber and wood sale quantities for the alternatives; however, it was applied across the combined HLC NF to reflect the desire for even timber flow.
- Dispersion of openings limits the amount of area within a management area group that can be regenerating at one time, to ensure that treatments are distributed spatially.
- Lynx habitat constraints include timing and treatment acreage limits apply to lynx habitat areas.
- Harvest and silviculture method constraints define the expected focus of treatments by management area group.
- Prescribed burning constraints set a minimum and maximum range of acres that reflects the capability of the forest to achieve the needed weather windows.

Constraints were also considered for requiring a minimum amount of old forest; limits on harvest in grizzly bear habitat; and goals specific to lynx multistoried habitat. However, preliminary model reviews showed that other design elements provided for these factors without specific constraints.

### *Disturbance processes*

The amount of natural disturbances (stand replacing fire, mixed severity fire, and severe bark beetle infestation) expected in the future was determined using SIMPPLLE. Disturbance levels were input into Spectrum to ensure that the model took those disturbances into account when scheduling treatments. The following assumptions were used:

- The climate will be consistent with the hot/dry natural range of variation throughout the projection.
- For fire by vegetation type, the average from the first 5 decades is used for all model periods.
- 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 set.
- Fire suppression was modeled by correlating 2000-2014 fire occurrence/size data (which resulted from current day suppression tactics).
- Severe bark beetle only includes mountain pine beetle in lodgepole pine. Because the HLC NF recently underwent a wide-scale outbreak, no substantial infestations are anticipated in the next several periods. The constraint is set to capture the episodic nature of mountain pine beetle.
- Minimum defined time periods must pass before a site is eligible to receive another disturbance of the same kind.
- Fire disturbances are more likely to occur in certain management area groups, based on fire management policies and accessibility for fire suppression.

### *Management objectives*

Optimization models such as Spectrum minimize or maximize an objective function subject to constraints. For all alternatives, one objective function was to move towards the desired condition for vegetation. The desired conditions are defined by forestwide proportions of cover type, density class, and size class, and do not vary by alternative. Desired conditions for the model are based on those developed for the revised plan, but for Spectrum the ranges only represent forested acres and be stratified differently. The ranges depict the 25th-75th percentile range around the means across all areas and runs.

For alternative E, the model was also run with an objective function to maximize timber output levels in the first decade. The results were then ‘rolled over’ (achieving 95% of first decade harvest levels input as a constraint) and the model re-run with the objective to move towards vegetation desired condition.

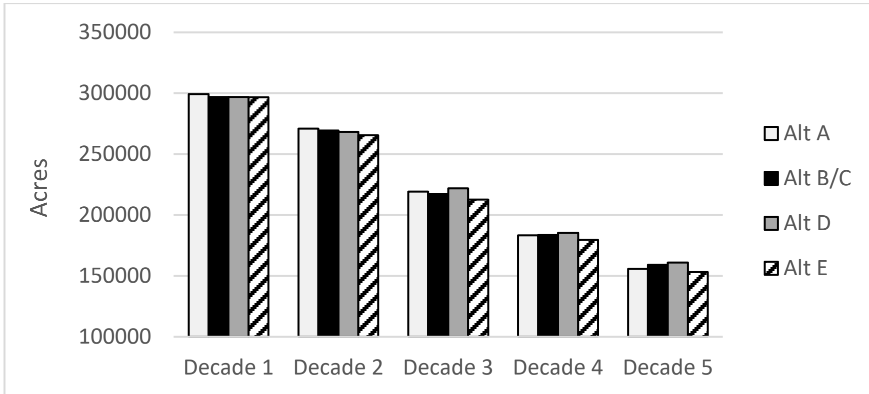
## Spectrum Model Results

The following sections discuss key outputs across alternatives from the Spectrum model, with and without the budget constraint, for the first 5 decades of the modeling horizon.

### *Hazard of stand replacing fire and insects*

The hazard of stand replacing fire in forested vegetation types was estimated in the yield tables used for Spectrum modeling, which were developed using the fire and fuels extension of the Forest Vegetation Simulator. The results do not include the iterative modeling with climate and disturbances that SIMPPLLE provides. This metric shows only the hazard of stand replacing fire, based on stand characteristics – it does not indicate fire risk or expected fire acres burned.

**Figure 147. Acres with high hazard of stand replacing fire by alternative**




Hazard to bark beetles (mountain pine beetle and Douglas-fir beetle) and defoliators (primarily western spruce budworm) was also estimated in the yield tables used for Spectrum modeling, which were developed using the Forest Vegetation Simulator (Randall & Bush, 2010).

**Figure 148. Acres with high hazard to bark beetle infestation by alternative**

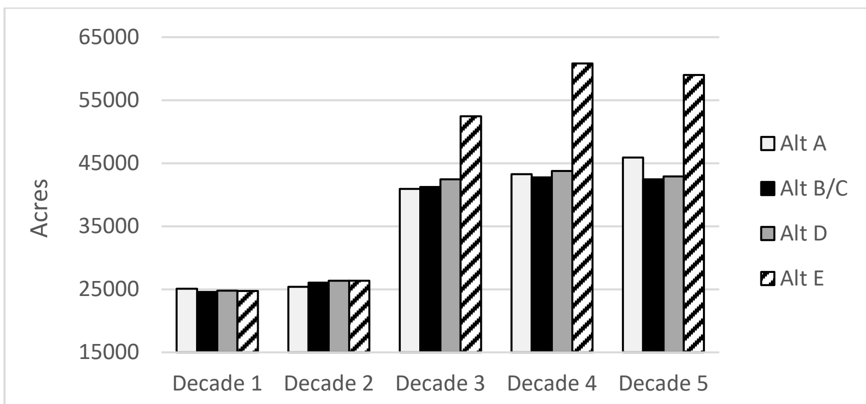
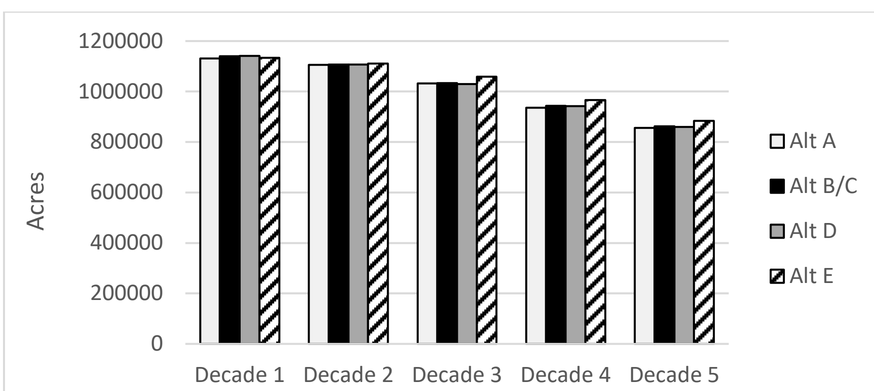



**Figure 149. Acres with high hazard of defoliation by alternative**




### *Acres of harvest*

Harvest as modeled in Spectrum is of two general types: even-aged regeneration (clearcut, seedtree, shelterwood harvest and associated overstory removals), and non-regeneration (intermediate thinning and uneven-aged harvest). 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.

**Figure 150. Harvest acres by decade, by alternative, with and without budget constraint**

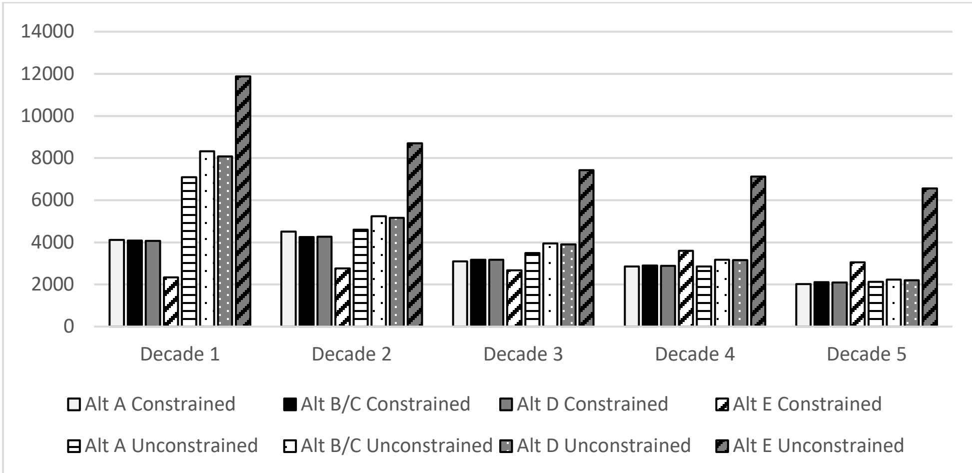
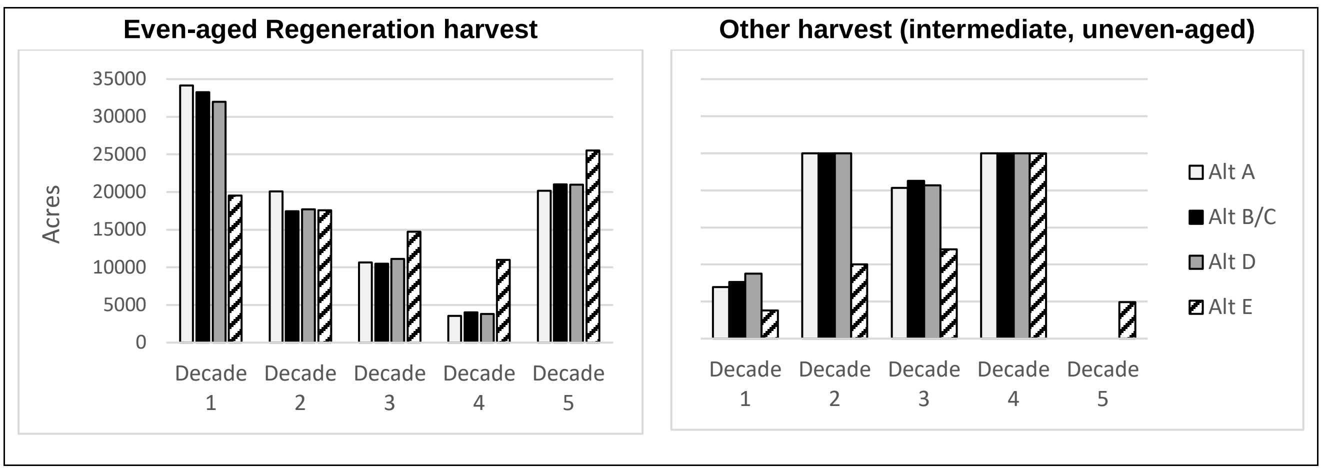


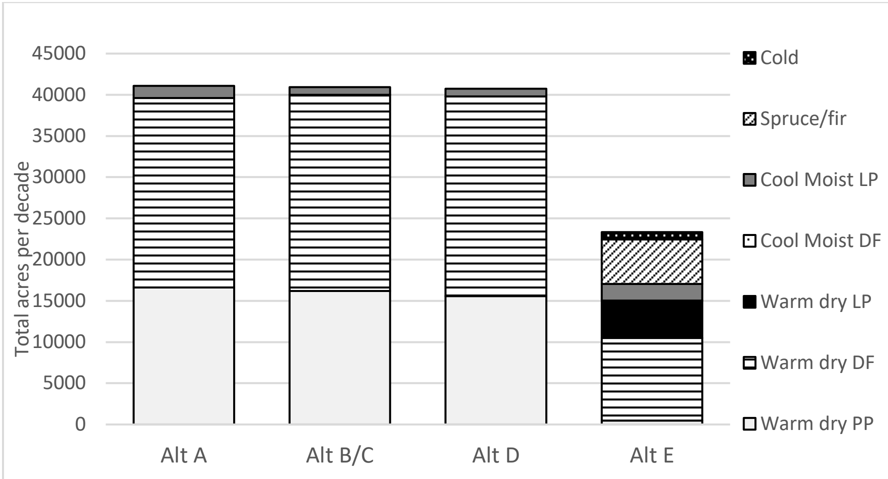

Figure 150 displays the projected acres of timber harvest by type for a five-decade period, on lands both suitable and unsuitable for timber production, assuming a reasonably foreseeable budget.

**Figure 151. Acres harvested by decade and alternative by type, reasonably foreseeable budget**




The projected harvest by vegetation type is displayed in the figure below.

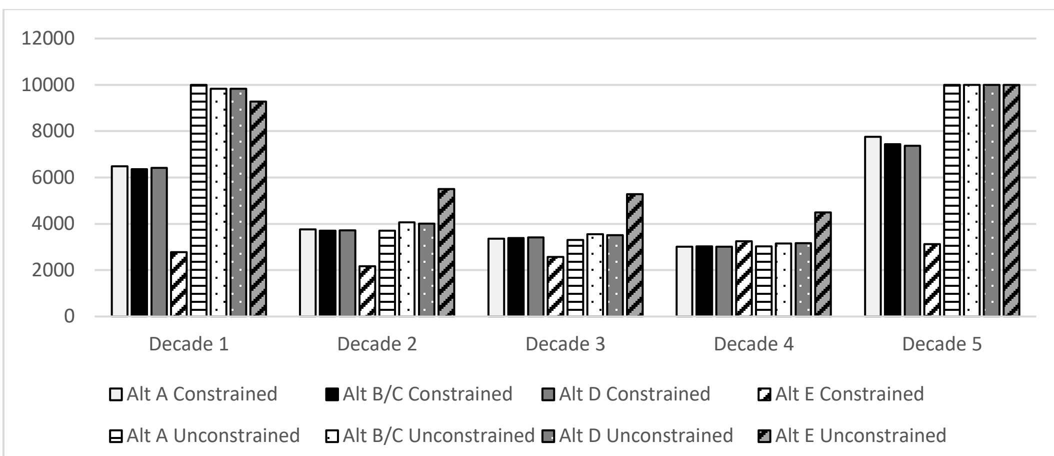
**Figure 152. Projected harvest acres by vegetation type by alternative for decade 1**




### *Acres of prescribed burning*

Prescribed burning was also scheduled by Spectrum. 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. The forest currently conducts 130,000 acres on average per decade, or 13,000 per year, based on accomplishment records from 1980 to 2013. The Spectrum projections are lower than this level but only represent forested vegetation.

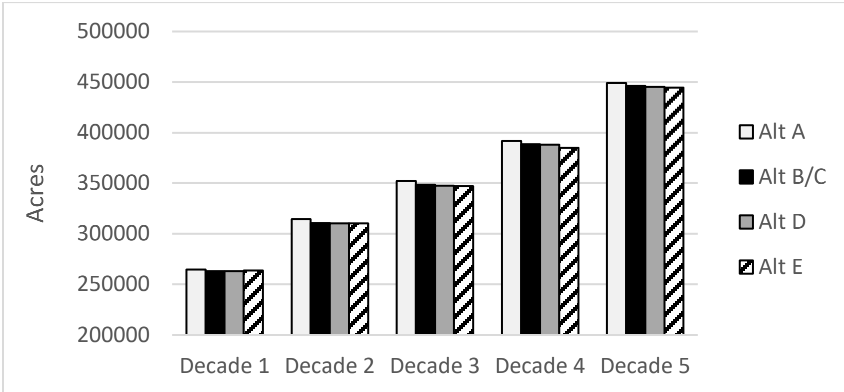
**Figure 153. Prescribed burning acres by decade, by alternative, with and without budget**




### *Old forests*

Old forests were tracked in Spectrum. These forests are defined based on the minimum age identified in Green et al (1992) for each vegetation type. Many of these forests would not be old growth because they lack other characteristics. The amount of old forest estimated by Spectrum is less than the amount of old growth currently present, due to the generalization of age in yield tables. Therefore, this information provides only a relative potential trend across alternatives.

**Figure 154. Acres of old forest forestwide, by alternative over 5 decades**




### *Timber outputs: PTSQ and PWSQ*

Spectrum provides estimates of the following timber volume outputs expected to be sold during the life of the plan, as required by the 2012 planning rule and associated directives (USDA, 2015):

1. Projected timber sale quantity (PTSQ), or the volume of timber that meets sawlog specifications;
2. Projected wood sale quantity (PWSQ), which includes the PTSQ timber volume plus other wood products such as nonsaw and biomass (we assume a 15% increase in volume to account for this material); and firewood (we assume a 1.35 mmcf increase in volume assumed based on the current firewood program);

Neither of these estimates includes potential salvage or sanitation harvest that may occur in response to disturbances. The expected timber outputs which are disclosed in Appendix C are based on fiscal capability and organizational capacity. For analysis purposes, these are also estimate without a budget constraint. Figure 154 and Figure 155 display the expected PSTQ and PWSQ by alternative, expressed as average annual figures by decade.

**Figure 155. Projected timber sale quantities (average annual mmcf and mmbf) by alternative, with and without budget constraint**

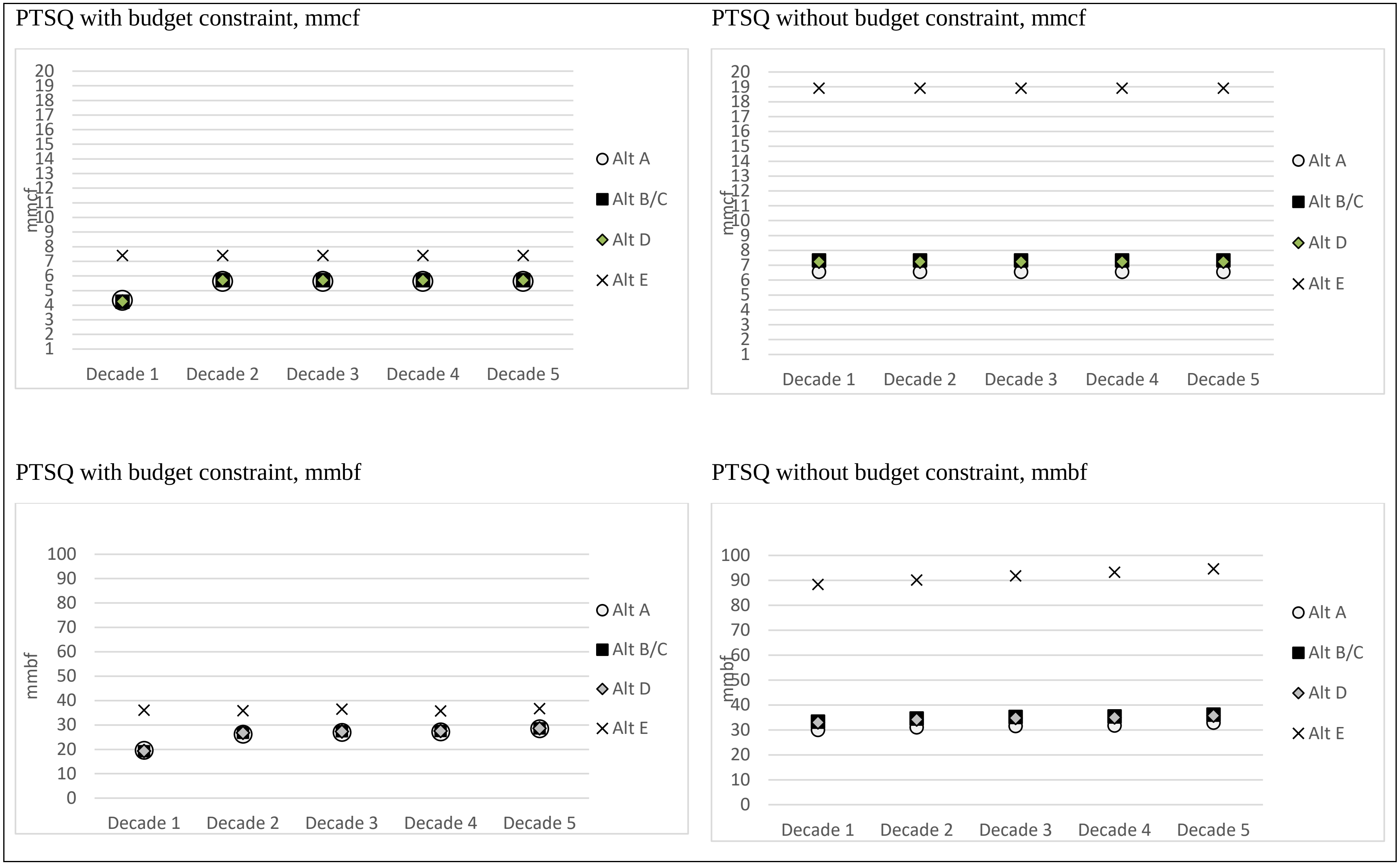
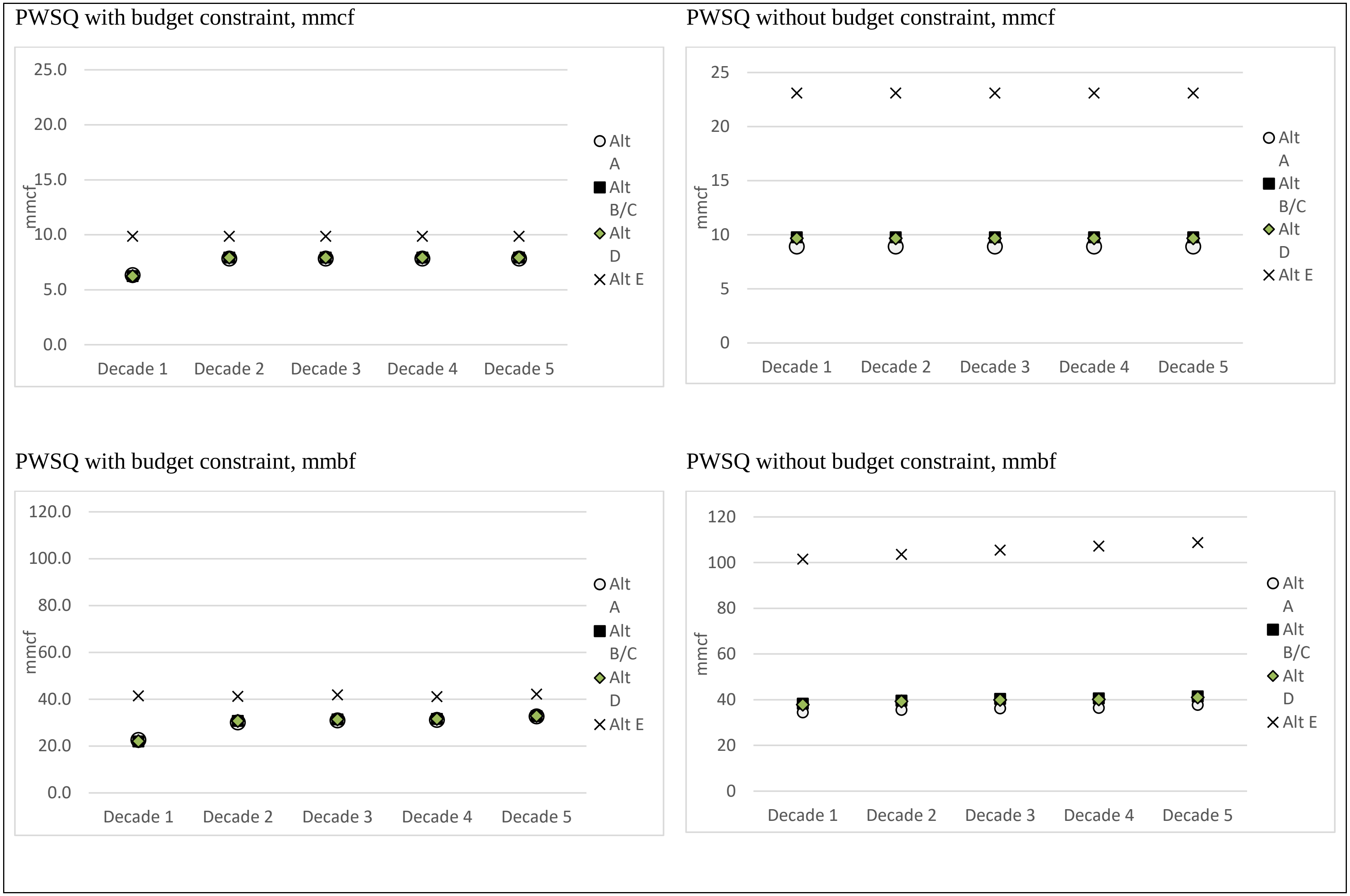


**Figure 156. Projected wood sale quantities (average annual, mmcf and mmbf) by alternative, with and without budget constraint**



### *Sustained yield limit*

Spectrum also provides an estimate of the sustained yield limit, as required by the 2012 planning rule and associated directives (USDA, 2015). 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. This value 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. A sustained yield limit of 5.03 mmcf (26.68 mmbf) was calculated for the proclaimed Helena National Forest; and 4.02 mmcf (21.30 mmbf) for the proclaimed Lewis & Clark NF, totaling **9.05** mmcf (**47.98** mmbf) for the administratively combined HLC NF.

The projected timber sale quantity (PTSQ) 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. As shown in the figures above, alternative E, without a budget constraint, estimates a PTSQ above the sustained yield limit. This occurred because the objective of alternative E is to achieve 95% of the maximum timber possible from the Plan area. Emphasizing timber production in this way, and having no budget limitations, resulted in the model demonstrating a scenario in which PTSQ could theoretically exceed the sustained yield limit, due to two interrelated factors.

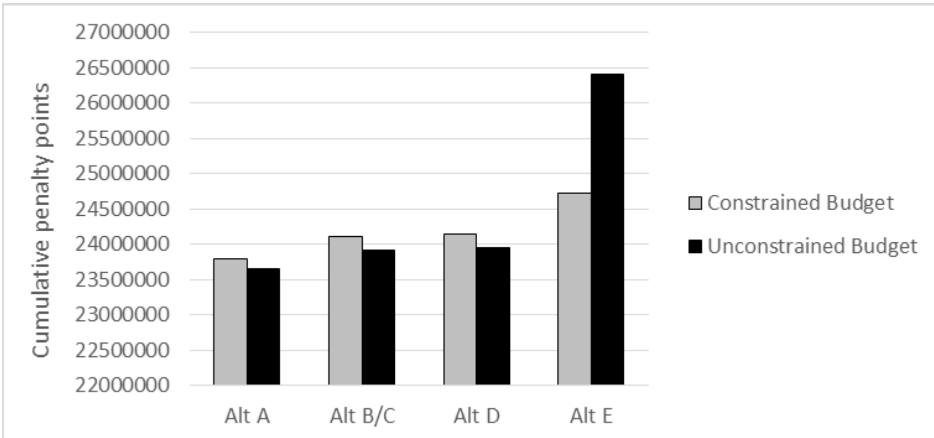
1. There is a difference in the landbase considered for the sustained yield limit versus lands where volume can be removed to contribute to the PTSQ. In all alternatives, some harvest is allowed to occur outside the lands that may be suitable for timber production. These are primarily lower productivity forests where harvest is used for restoration purposes. These lands were not included in the calculation of the sustained yield limit, but harvest volume from these lands contributes to the PTSQ. Although the model was calibrated to limit harvest in these areas in keeping with management objectives, alternative E (unconstrained) utilized harvest on these lands to the extent allowed.
2. The application of non-declining even flow is different between the sustained yield limit run and the projected alternatives. Non-declining even flow, or non-declining yield, means that the volume from a certain area is steady or increasing into the future. A non-declining even flow constraint was applied to each proclaimed national forest for the sustained yield limit. For the alternatives, the constraint was applied to the two forests combined. This allowed more flexibility in the timing and location of the sustainable harvest to best meet the desired conditions across the combined unit. It is also consistent with the current management paradigm for the HLC NF. The law and directives do not require a non-declining even flow constraint when estimating PTSQ or PWSQ; however, it was determined that this was important to provide for an even flow of timber. This resulted in the model being able to achieve more volume than would have been possible with the sustained yield limit run.

The modeling of alternative E, unconstrained by budget, provides insight into the potential level of timber volumes that could be achieved given more flexibility in scheduling where harvest occurs. However, the directives require that the Forest Plan display levels of harvest that are within the fiscal capability and organizational capacity of the HLC NF. Further, the selected PTSQ cannot exceed the sustained yield limit unless a departure analysis is done, and the increased volume could only occur for the first two decades. Because alternative E with an unconstrained budget is not within fiscal capability of the HLC NF and would not be selected for implementation, a departure analysis would not be conducted.

### *Desired condition penalty points*

In the model, every acre that is not within the desired condition minimum and the desired condition maximum is assigned a "penalty point." Penalty points can accrue in any time period in the model, but can become less as the forest moves toward desired conditions through time. The objective is to minimize total penalty points. Thus, alternatives with lower overall penalty points do a better job of moving vegetation towards desired conditions than those alternatives with higher penalty points. The desired condition penalty points provide a relative comparison of how well treatments in Spectrum contribute to terrestrial vegetation desired conditions; however, these results do not include dynamic interactions between treatments and ecological processes over time.

**Figure 157. Desired condition Spectrum penalty points by alternative**




### *Sensitivity analysis*

Sensitivity analysis is conducted to examine the trade-offs caused by the constraints and determine if the Spectrum model is working correctly. 8 runs were made to test the major features and the effect of constraints. The sensitivity analysis runs used the analysis units from alternative B; results would be similar for all alternatives. All runs were made with the objective to move towards vegetation desired future condition. Table 16 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 two key constraints (lynx and budget) against the baseline.

**Table 16. 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. |
| 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. |

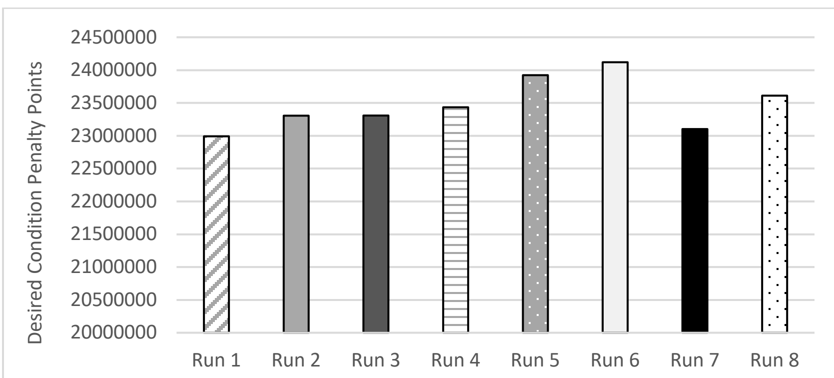
The results of the sensitivity analysis is displayed by comparing selected outputs. For most attributes, the budget was the most constraining factor, followed by operational and/or management area group constraints. For all outputs, runs 2 and 3 were identical, indicating that the opening limitations were not constraining. Run 3 is not compared in further detail.

### Desired condition score

The first attributes compared is the desired future condition score (Figure 157). This score indicates the amount of penalty points incurred by the run; i.e., the higher the score, the worse the run does at achieving the desired condition. The points are accumulated over all 15 decades; the relative comparison of numbers is more important than the values. The best desired future condition score is attained under the baseline run (#1), with the most flexibility in management and no constraints. The desired future condition is not greatly affected by any one set of constraints in the model, but budget and operational limits are the most influential to achievement of the desired condition.

- Management area group constraints (run 2 versus run 1) reduce attainment of desired condition 1% compared to the baseline.
- Lynx constraints (run 4 versus 2) incrementally reduce the attainment of desired condition an additional 0.54%. Lynx constraints independent of other variables (run 7 versus 1) reduce attainment of desired condition 0.48% compared to the baseline.
- Operational constraints (run 5 versus run 4), incrementally reduce attainment of desired condition an additional 2%.
- Budget constraints (run 6 versus 5) incrementally reduce attainment of desired condition an additional 1%. Budget constraints independent of all other variables (run 8 versus run 1) reduce attainment of desired condition 3% compared to the baseline.

**Figure 158. Desired future condition score across spectrum sensitivity runs**



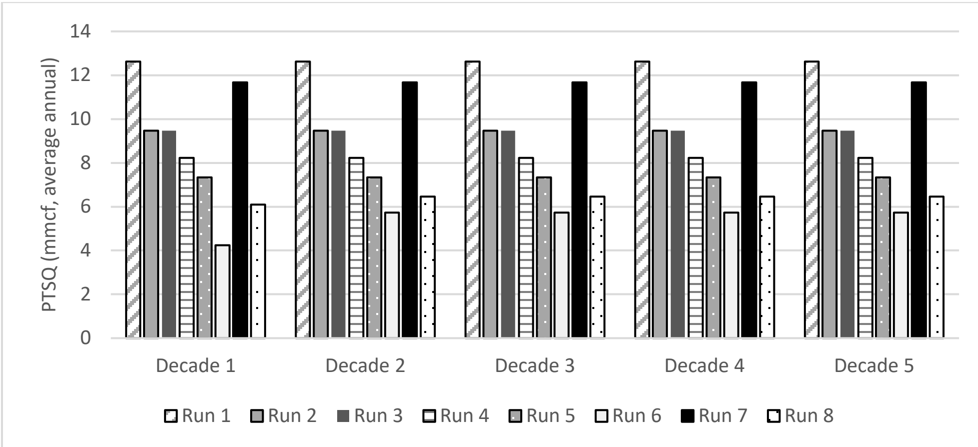

### Projected timber sale quantity

The second attribute compared was projected timber sale quantity (PTSQ). Projected wood sale quantity trends are identical. The following 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 to PTSQ, but it was also sensitive to lynx and operational constraints.

- Management area group constraints (run 2 versus run 1) reduce PTSQ 25% compared to the baseline.
- Lynx constraints (run 4 versus 2) incrementally reduce PTSQ 13%. Lynx constraints independent of other variables (run 7 versus 1) reduce PTSQ 8% compared to the baseline.
- Operational constraints (run 5 versus run 4) incrementally reduce PTSQ 11%.

- 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 52%.

**Figure 159. Projected timber sale quantity across Spectrum sensitivity runs**

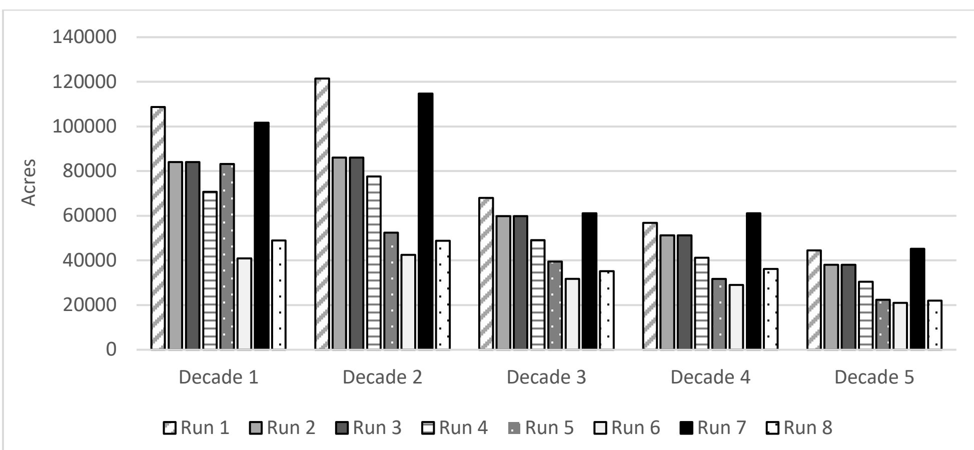



### Projected harvest acres

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 23%.
- Lynx constraints (run 4 versus 2) incrementally reduce harvest acres 16%. Lynx constraints independent of other variables (run 7 versus 1) reduce harvest acres 6% compared to the baseline.
- Operational constraints (run 5 versus run 4) incrementally increase harvest acres in the first period by 18%, and then decrease the harvest level in future decades.
- Budget constraints (run 6 versus 5) incrementally reduce harvest acres an 51%. Budget constraints independent of all other variables (run 8 versus run 1) reduce harvest acres 55%.

**Figure 160. Projected harvest acres across Spectrum sensitivity runs**

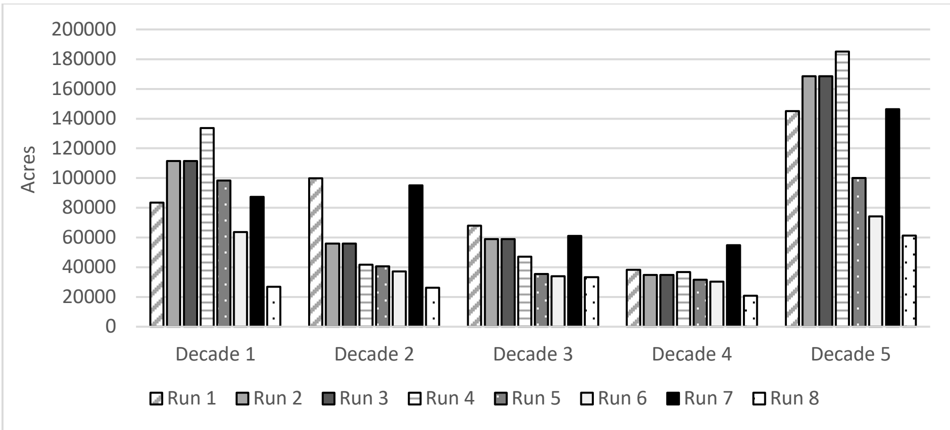



### Projected prescribed burning acres

The following summary compares the impact of constraints on the projected burning acres estimated for Decade 1 of the planning period. Budget and management area constraints are the most influential. Some constraint sets have mixed influences (decreasing versus increasing burn acres) in future decades. Constraints that may limit harvest (i.e. lynx) result in increased burning.

- Management area group constraints (run 2 versus run 1) increase burning acres 34%.
- Lynx constraints (run 4 versus 2) incrementally increase burning acres 20% in Decade 1. Lynx constraints independent of other variables (run 7 versus 1) increase burning acres 5%.
- Operational constraints (run 5 versus run 4) incrementally decrease burning by 27%.
- Budget constraints (run 6 versus 5) incrementally reduce burning acres 35%. Budget constraints independent of all other variables (run 8 versus run 1) reduce burning acres 68%.

**Figure 161. Projected prescribed burning acres across Spectrum sensitivity runs**

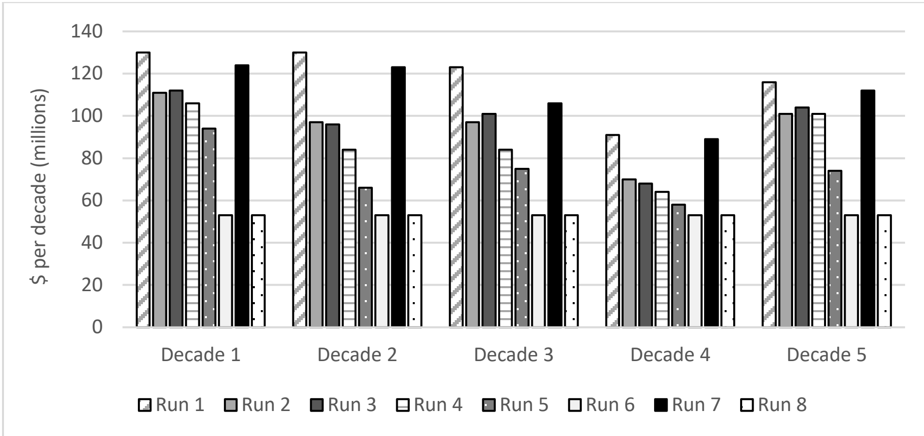



### Budget

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 run 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) reduces budget used by 15% compared to the baseline scenario.
- Lynx constraints (run 4 versus 2) incrementally reduces budget used by 5%. Lynx constraints independent of other variables (run 7 versus 1) reduce costs 5% compared to the baseline.
- Operational constraints (run 5 versus run 4) incrementally decreases budget used by 11%.
- Budget constraints (run 6 versus 5) incrementally reduce budget used 44%. Budget constraints independent of all other variables (run 8 versus run 1) reduce budget used 59%.

**Figure 162. Comparison of projected budget used across Spectrum sensitivity runs**




# Geology, Energy, and Minerals

There are approximately 2,883,226 acres of NFS lands that are the administrative responsibility of the Forest. This is the result of the original Congressionally-designated lands and the conveyances (acquisitions, disposals, and exchanges) that have occurred to date.

The acres that are available for locatable mineral resource development are determined by subtracting the number of acres that are withdrawn from locatable mineral entry from the total number of acres for the HLC NF. The number of acres that are withdrawn from mineral entry is a matter of record. By law, the Bureau of Land Management keeps official records in the General Land Office.

The number of acres that are available for leasing proposals is determined by subtracting the number of acres that are legally unavailable from the total number of acres on the HLC NF. There are no active leases on the forest aside from 3 leases which are subject to litigation (Badger Two Medicine and Connor v. Burford). No activity can take place on any active leases until an EIS is completed. A leasing decision will not be a part of this Forest Plan Revision.

Lands which are legally unavailable for leasing are:

- Lands withdrawn from mineral leasing by an act of Congress or by an order of the Secretary of the interior;
- Lands recommended for wilderness allocation by the Secretary of Agriculture;
- Lands designated by statute as wilderness study areas, unless oil and gas leasing is specifically allowed by the statute designating the study area; and
- Lands within areas allocated for wilderness or further planning in Executive Communication 1504.

The number of acres that are available for disposal of mineral materials is determined by subtracting from the total number of acres on the HLC NF the number of acres where the FS has exercised its discretion to refrain from authorizing the disposal of mineral materials.

# Carbon Sequestration

Existing regional-scale climate projections are used to understand the type and magnitude of climate change effects that could occur. The most recent National Greenhouse Gas Inventory (EPA, 2015) provided information at the national level on forest contributions and conditions related to carbon sequestration. The update to the FS 2010 Resources Planning Act Assessment (USDA 2016) was also a source of summary information on recent findings related to forest carbon conditions on all forest lands in the U.S., and projected future carbon stocks and flows were also provided.

Climate projections embody a number of uncertainties, the sources of which include the uncertainty of future emissions driven by socioeconomic processes and unpredictable policy choices, variability internal to a given global climate model's simulation of weather and climate, variability related to parameterization and other model characteristics, and uncertainty or error in observed climate data used in downscaling global climate model output (Daniels et al., 2012). Uncertainty also exists regarding ecosystem carbon stocks. The uncertainty of forest carbon flux at the national-scale often ranges between 15-25%, suggesting that uncertainty simulations at the individual national forest scale should exceed 25% (USDA 2015). The critical sources of uncertainty in the harvested wood products analysis include, but are not limited to, reported harvest, timber product ratios, primary product ratios, conversion factors, end use product ratios, product half-lives, disposition ratios, decay limits, landfill half-lives, dump half-lives, and burned with energy capture ratio (Stockmann et al., 2014). The range of distributions found in the uncertainty analyses conducted for these sources ranged from +/- 5 to 30% (Stockmann et al., 2014).

There are three models used to develop regional and forest-scale carbon estimates, as reported in publications from the Forest Service Climate Change Advisor's Office (USDA 2017; USDA 2015). These models provide the foundation for this analysis.

1. The Carbon Calculation Tool uses Forest Inventory and Analysis program data to estimate baseline carbon stocks and carbon stock change from 1990 to 2013, based on data from two or more years of inventories conducted since 1990 (Woodall, Smith, & Nichols, 2013). Carbon stocks are estimated by linear interpolation between survey years. Recent estimates of baseline carbon stocks and trends for forests and harvested wood products have been provided for forestlands on national forest land in the United States (USDA 2015).
2. The Forest Carbon Management Framework (S. P. Healey et al., 2016; Sean P. Healey, Urbanski, Patterson, & Garrard, 2014) estimates the effects of individual disturbances such as fires, insects, harvests, and weather on non-soil carbon storage from 1990-2011 by integrating remotely sensed disturbance maps (Sean P. Healey et al., 2014) along with Forest Inventory and Analysis data and a growth and yield model (S. P. Healey et al., 2016; Raymond, Healey, Peduzzi, & Patterson, 2015). This model estimates how much more carbon would be stored in the forest if those disturbances had not occurred and provides information on the patterns of disturbance and how disturbances has impacted carbon storage.
3. The Integrated Terrestrial Ecosystem Carbon model (Chen, Chen, & Cihlar, 2000; Zhang et al., 2012) uses FIA program data, Landsat disturbance data, plus environmental data (climate, atmospheric concentrations) to determine if a forest is accumulating carbon (a sink) or losing carbon (a source). It determines the relative effects of disturbances and environmental/non-disturbance factors on the changes in carbon stocks and the accumulation of carbon from 1950 through 2010 and puts the effects of disturbance and management activities into the context of broader environmental and climatic processes.

The models produce very similar results (i.e., sink vs. source), but use different datasets and modeling approaches, so results vary. Though these models use some of the same data sets as other models used in baseline carbon assessments and for calculating existing carbon stocks, results are not entirely compatible. This is because these models integrate high resolution remotely sensed disturbance maps from satellite imagery; report different carbon pools; have differences in timing of data sources (remotely sensed data is more up-to-date than Forest Inventory and Analysis data); and the models themselves are different. Refer to the methodology, uncertainties, and interpretation of model result sections within the regional disturbance assessment (USDA 2017) for detailed information regarding appropriate interpretation of results and comparison to other estimates. Using these models, forest carbon disturbance assessments expand upon assessments of baseline carbon stocks across national forests by assessing how stocks are affected by timber harvesting, natural disturbances, land-use change, climate variability, increasing atmospheric carbon dioxide concentration, and nitrogen deposition (ibid). The assessment assists in the evaluation of effects of forest management strategies and potential disturbance factors on carbon flux in the plan area. To generate forest carbon and disturbance assessments at the regional-scale, the analyses and models were carried out for the individual national forests and summarized across the region. Thus the analyses for the national forest scale use the same modeling framework and tools.

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