Construction of Vegetative Yield Profiles for the Black Hills National Forest Phase II Amendment

February
2004

Black Hills National Forest

Phase II Amendment

Description of the Analysis Process

regarding the

Construction of Vegetative Yield Profiles

by:

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February
2004

Acknowledgement

The complexities of the Black Hills project could not have been fully developed without the input and oversight provided by Blaine Cook, Forest Silviculturalist, Black Hills National Forest. Blaine's in-depth knowledge of local history, ecology, and silviculture proved invaluable. Many thanks to Blaine.

Black Hills National Forest
Vegetative Yield Profiles

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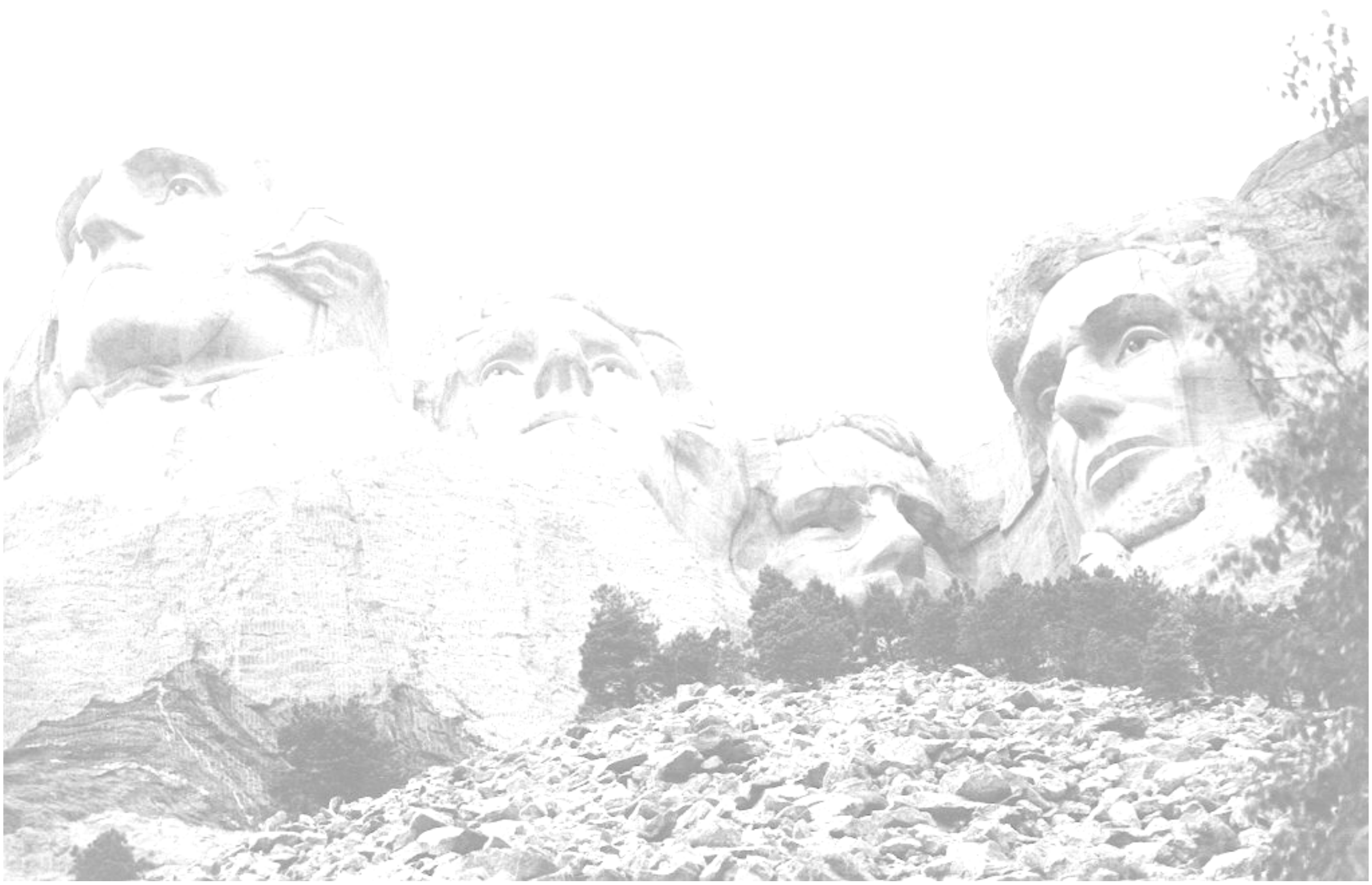


Executive Summary

Purpose

The intent of the Phase II Amendment to the Black Hills National Forest, 1997 Land and Resource Management Plan was to re-evaluate the sufficiency of the plan with regard to the diversity of plants and animal communities, and species viability. Long term management strategies would be examined during the amendment process. A forest planning model was to be constructed to assist in alternative evaluation. Vegetation projection would be an important aspect of the computer model. Development trends would vary for each of the differing management strategies.

Forecasting vegetation structure through time needed to follow a logical progression of events. A forestland classification needed to establish stand types for projecting. Stand types are homogeneous land units with respect to their physical, vegetative, and developmental characteristics. Inventory data needed to be assembled to represent the assortment of stand types. Estimates derived from a vegetation simulation model needed to be adjusted in accordance with observed information. Special considerations needed to be made regarding regeneration and mortality components. Silvicultural prescriptions needed to be formulated to represent proposed management strategies. Vegetation yield profiles needed to be prepared for input into the forest planning model.

It is the goal of this paper to document the steps that were used in the process of developing vegetation files for the Phase II Amendment. An aside objective is to describe the current methods and technologies used to accomplish vegetation projection tasks.

Synopsis

The Forest Vegetation Simulator (FVS) was the principle tool used to develop the yield profiles for the Phase II Amendment. FVS is a suite of computer programs that support vegetation decision efforts.

A forestland classification scheme was implemented to determine land suitability for management activities. Stand types were the primary unit for describing the vegetation resource on the Black Hills. Stand types attributes were:

- Overstory Cover Type
- Size Class
- Storied-ness
- Crown Density
- Site Productivity
- Understory Component

In all, 47 different forest strata or stand types were identified. These formed the basic building blocks for the vegetative yield profiles.

Inventory sources to represent the various stand types included data sets assembled for the 1997 Revised Forest Plan. Additionally, Forest Inventory Analysis (FIA) measurements from 1999 and 2001 were also incorporated into the data pool. A total of 647 sample units were used in the analysis. The plot/stand count breakout was as follows:

- 241 plots – 1986 Stage I Inventory
- 182 stands – 1995 Stage II Inventory
- 190 plots – 1999 FIA Measurement
- 34 plots – 2001 FIA Measurement

Use of the Pre-Suppose program facilitated data querying of the stand types. Links to the FVS model were produced by Pre-Suppose.

Model calibration involved a concerted effort to ensure that modeled estimates of stand development closely match measured values. Baselines trends of the raw inventory data were graphed using the MS-Excel spreadsheet program. Scatter plots for the following y-axis attributes were charted:

- Trees per acre
- Basal area per acre
- Cubic foot volume per acre
- Board foot volume per acre

The x-axis arrayed computed stand age for each inventory sample. This allowed inferences of the upper capacity of stand development over age. Each plot/stand was projected by FVS for a 150-year time period then overlaid on the scatter plots of measured data points. FVS has a self-calibrating feature that captures the individual plot's site characteristics and subsequently modifies the embedded regional growth functions. The ability to develop 'mean scale factors' for non-calibrating plots also aided in refining modeled results.

Natural growth runs were prepared to examine two stand development elements that still needed to be addressed following FVS model calibration. These were:

- Regeneration inputs
- Mortality outputs

Regeneration imputation files were constructed for the stand types using the Repute program. This application investigates measured values for the seedling/sapling component to imply expected occurrence. These observations can then be input at the proper time to replenish the understory. Mortality effects also needed adjustment. FVS does not automatically kill trees at a given age. Tree size is used as a proxy for attainable age. Examining measured data renders appropriate values. Finally, modeled mortality impacts through the stand profile needed to match measured values. Using the FixMort keyword, these tendencies were obtained.

Silvicultural prescriptions were modeled by FVS. Keyword file sets were constructed for the following systems:

- Natural Growth
- Shelterwood
- Seed-Tree
- Clearcut
- Group Selection
- Aspen Preference
- Oak Preference
- Individual Tree Selection
- Wildland Urban Interface/Community at Risk
- Perpetual Thinning

For even-aged silvicultural systems, existing stand types were grown through rotation age. Second growth or regenerated stand profiles were then produced. For uneven-aged treatments, cutting cycles dictated the entry interval. For both even- and uneven-aged prescriptions, the planning period was 150 years.

Accounting variables residing in the yield profiles included classic forest metrics such as trees per acre, average diameter, average height, basal area per acre, cubic volume per acre, and board volume per acre. Live tree, harvest tree, and mortality tree components were tracked per these attributes. In addition, several classification variables were computed. These included:

- Overstory Cover Type
- Understory Component
- Habitat Structural Stage
- Mountain Pine Beetle Hazard
- Snag Counts
- Wildfire Hazard

Upwards of 700 vegetative yield profiles containing 300 columns of accounting variables were produced for the Black Hills Phase II Amendment. The Spray program was used to accomplish this work. Additionally, the YEP and YIP computer programs were develop to post process the base yield profiles to extend coverage of the stand age range from 0 to 300 years. These resultant column delimited files were made available for the forest planning model to guide vegetation development for the different management strategies.

Black Hills National Forest
Vegetative Yield Profiles

INTRODUCTION

According to Forest Service Handbook FSH 1909.12 – Land and Resource Management Planning, Chapter 4 – Forest Planning Documents, Section 4.19 – Appendices:

> "Three appendices are mandatory in the draft environmental impact statement – {Appendix A} Issues, Concerns, and Opportunities; {Appendix B} Description of Analysis Process; and, {Appendix C} Roadless Area Evaluation."

Guidance for preparation of Appendix B – Description of Analysis Process can be found in Chapter 3 – Forest Planning Process, Section 3.3 – Inventory Data and Information Collection:

> "Document as part of the planning record: the delineation of capability, analysis, and management areas; the criteria used to delineation analysis and management areas; the data sources and coefficients used in the analysis process; the results of monitoring the previous land and resource management plan; and, other analytical tools used in planning."

Regarding documentation requirements applicable to all resource data collected or generated in the planning process, Subsection 3.32 – Data, paragraph 1.a states:

> "Record the source or method of data collection or generation…Also, describe or cite the {vegetation} timber inventory and yield projection procedure. List and describe simulation models used to generate certain coefficients and model assumptions and results."

This report addresses the process used to construct vegetative yield profiles for the Phase II Amendment to the Black Hills National Forest 1997 Land and Resource Management Plan. Other participants in this project will cite their areas of expertise in separate white paper reports. A composite of each of the individual papers will be synthesized into the final Appendix B document for the Draft Environmental Impact Statement.

A secondary objective of this report was to benchmark current technologies used in developing yield files for forest planning projects. Existing documentation pertaining to vegetative yield table construction pre-dates the mid-1990's. The computer processing aspects have changed dramatically from the first round of forest planning on National Forests. The primary platform has shifted from mainframe processing to personal desktop computers. Inventory data is now readily available from the internet and corporate databases. Inferences related to forest structure, forest health, and forest disturbance are primal in driving vegetative objectives. New computer programs have been developed to keep pace with the ever increasing sophistication of the analysis process. It is the intent of this report to provide a template of working tools available to forest plan analysts.

The principle tool used in the development of yield files for the Phase II Amendment was the Forest Vegetation Simulator (FVS). This white paper assumes a basic knowledge of FVS. For a more in-depth description of the FVS model, refer to the "Essential FVS: A User's Guide to the Forest Vegetation Simulator" and the "Keyword Reference Guide for the Forest Vegetation Simulator". Both documents were prepared by the Vegetation Simulation Staff, Forest Management Service Center (FMSC), Fort Collins, Colorado. These manuscripts are available from the FMSC, FVS Web Page (http://www.fs.fed.us/fmsc/fvs).

The Forest Vegetation Simulator is not simply one computer program but rather a suite of computer applications tied together into a processing system. Pre-processors, a graphical user interface, geographic variants, and post processing programs comprise the available tools. Each of these proved invaluable in addressing the vegetative resource issues postulated by the Phase II project.

This report is organized in six chapters as follows:

I. *Forest Stratification*
- This section lays the foundation in the development of stand types used in vegetative yield profiles. The derivation of the forestland classification template is extremely important insofar as it defines the basic building blocks for the analysis. Associated stand types comprise forest land units that have the same combination of physical, vegetative, and development characteristics to stratify as homogenous entities.

II. *Data Sources*
- This section cites the base inventory data sets used in the analysis. Data sources provide a reference regarding the measurement date and intensity. Permanent and temporary plot inventories were used for the Phase II project. A discussion of the Pre-Suppose program used to query the data sets into various stand types is also presented.

III. *Model Calibration*
- This section describes steps needed to fashion modeled data runs to replicate measured inventory data. This is a highly critical phase of the analysis process. To simply accept estimates from unconstrained simulations could lead to erroneous results. Establishing baselines from measurement data is the initial step in the calibration process. FVS has several features to assist in calibrating the projections.

IV. *Natural Growth Runs*
- This section discusses the development of benchmark 'let grow' simulation runs. Two aspects that need addressing are regeneration impulses and mortality components. Regeneration aspects are generally left to the discretion of the analysts. The Repute program assists this task. Nature giveth and taketh away. Mortality aspects need to mimic observed rates.

V. *Treatment Prescriptions*

This section presents the management activities prescribed for the Phase II Amendment. FVS keyword sets were developed to simulate the various types of silvicultural activities used on the Black Hills National Forest. Several classification keyword file sets were produced to track forest structure, Mountain Pine Beetle, and fire hazard.

VI. *Yield Profiles*

This section displays the end product of the analysis. Accounting variables form the columns and stand age or projection cycle comprise the rows in the output yield tables. Aggregation of continuous variables results in mean estimates. Compilation of classification data results in mode values. The Spray program aided in pulling together all aspects of the processing sequence. The YEP and YIP programs were develop to extend the stand age ranges within the yield profiles.

I. FOREST STRATIFICATION

Strategic forest planning covers large areas. The Land and Resource Management Plan for the Black Hills National Forest addresses the needs and concerns of a land base in excess of 1.5 million acres. To represent such a large area, ten of thousands of stand polygons have been created. Keeping track of individual polygons, temporally and spatially, is beyond the scope of strategic planning. Traditionally, land classification for forest planning uses the approach of grouping stands of like attributes into stand types or land classes. This is also referred to as "strata-based" planning and the individual land classes are often called "a stratum" or "an analysis area".

A. Stand Types within the Forest Base

The primary unit of a forest at the project level is a "stand". Question is: "What is a stand?". Let's begin with the definition of a forest and progress to a stand.

Forest: A set of land parcels which has or could have tree vegetation and is managed as a whole to achieve the objectives of the owner.

Physical Characteristics: The set of attributes used to characterize the permanent, physical nature of forestlands, including topography, soils, geology, hydrology, and climate.
Vegetative Characteristics: The set of attributes used to characterize the vegetation currently growing on forestland, including cover type species, age, size, density, and volume.
Developmental Characteristics: The set of attributes used to characterize the organizational aspects of forestlands, including land ownerships, transportation networks, and administrative boundaries.

Stand Type: Forestland that has the same combination of physical, vegetative, and developmental characteristics chosen to classify the forest into homogeneous types.

Stand: A geographically continuous parcel of forestland, all of the same stand type and larger that some minimum size.

A stand type is an aggregation of the physical, vegetative, and developmental characteristics used to identify homogeneous forest strata. Physical and developmental attributes are initially addressed by following a land classification scheme. For example, *suitable lands*, according to USDA Forest Service protocols, constitute the land base for determining the allowable sale quantity and the vegetation management practices associated with timber production. Suitable lands must be available, capable, and technically favorable under current management techniques. Figures I-1a-b served as a preliminary flow chart for assigning stand acreage and inventory data to various land classes/stand types.

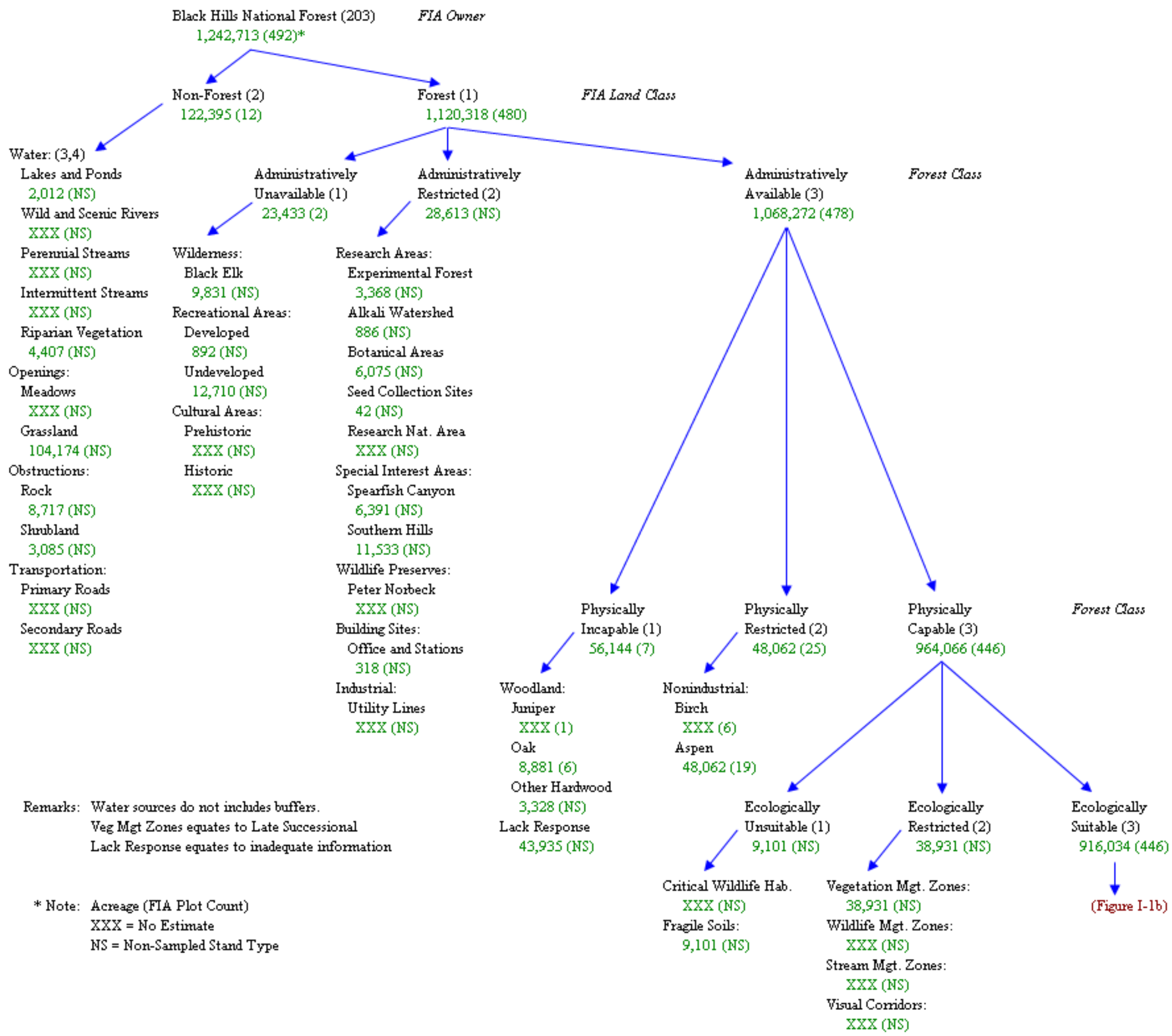


Figure I-1a – Forestland classification template

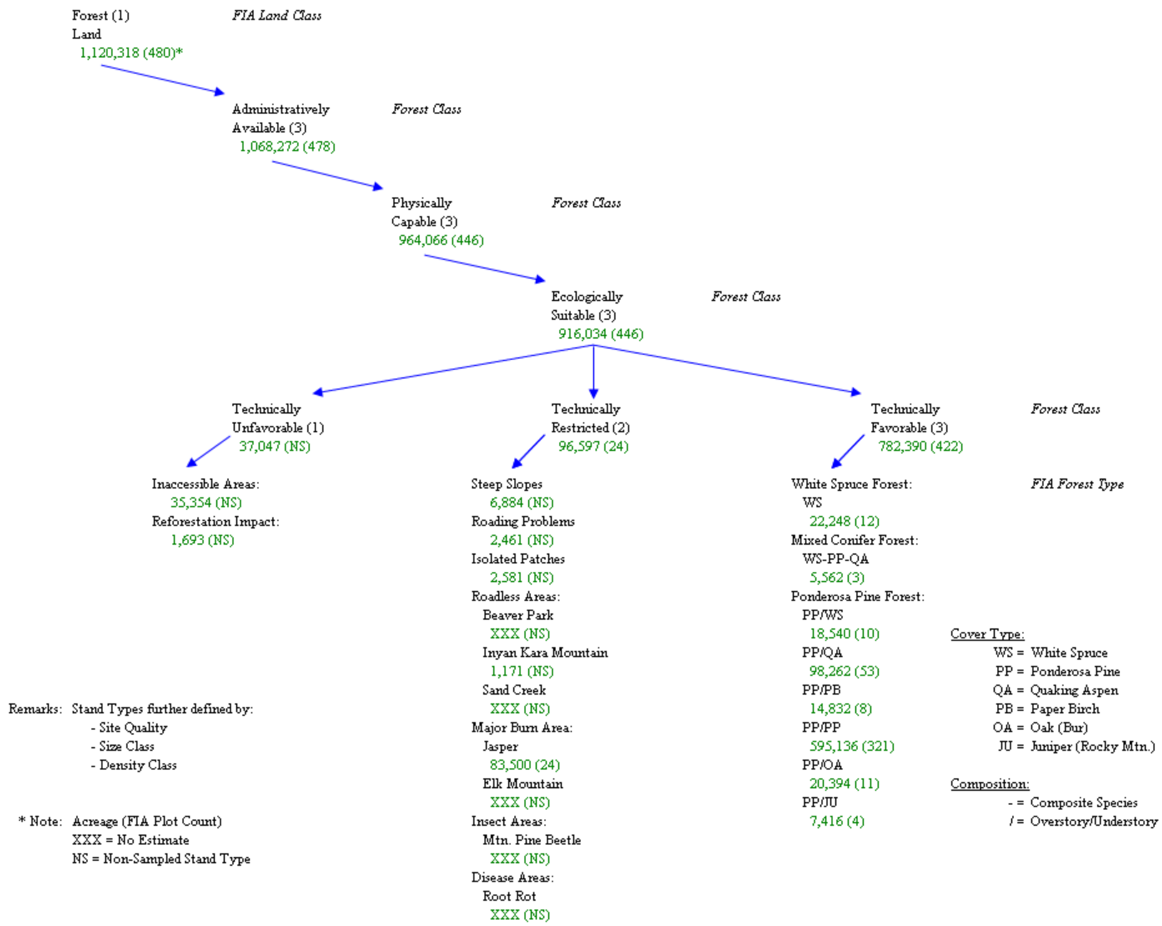


Figure I-1b – Stand type delineation

Figure I-2 provides the prescribed hierarchical approach for identifying lands suitable for timber production as referenced in Forest Service Handbook, FSH 2409.13, Exhibit 01. Figure I-3 displays the resultant land classes for the Phase II Amendment of the Black Hills plan.

Exhibit 01

Process for Identification of Lands Suitable for Timber Production

Is land forested (FSH 2409.13-21.1) YES	NO Unsuitable (nonforest)
Is land withdrawn from timber production (FSH 2409.13-21.2) NO	YES Unsuitable (withdrawn)
Is land capable of producing crops of industrial wood (FSH 2409.13-21.3) YES	NO Unsuitable (nonindustrial wood)
Is irreversible damage likely to occur (FSH 2409.13-21.41) NO	YES Unsuitable (irreversible damage)
Can area be restocked within 5 years (FSH 2409.13-21.42) YES	NO Unsuitable (restocked)
Is adequate response information available (FSH 2409.13-21.5) YES	NO Unsuitable (no information)
Then land is tentatively suitable for timber production (FSH 2409.13-21.6)	
Is land selected in an alternative for timber production (FSH 2409.13-23) YES	NO Not appropriate (unsuitable in preferred alternative and Forest plan)

Then land is suitable for timber production (FSH 2409.13-24)

Figure I-2 – Exhibit 01, FSH 2409.13

CATEGORY	SUBCATEGORY	DESCRIPTION	CODES	FIA PLOTS	GIS ACRES
Non-National Forest	Private	Other Ownership	MA=PVT_	8	284,446
Lands Not Capable of Timber Production	Legislatively Withdrawn	Black Elk Wilderness	MA=1.1A_	3	9,777
Lands Not Capable of Timber Production	Non-Forested	Improved Roads	N/A	0	13,463
Lands Not Capable of Timber Production	Non-Forested	Powerlines	N/A	0	6,263
Lands Not Capable of Timber Production	Non-Forested	Water	CT=W	0	2,067
Lands Not Capable of Timber Production	Non-Forested	Grassland/Forbs	CT=G/F	21	107,827
Lands Not Capable of Timber Production	Non-Forested	Non-Vegetated	CT=N	1	4,676
Lands Not Capable of Timber Production	Non-Forested	Shrublands	CT=S	0	5,237
Lands Not Capable of Timber Production	Non-Forested	Administrative Sites	TC=850	0	280
	Total Non-Forested				139,813
Lands Not Capable of Timber Production	Non-Commercial	Aspen	CT=TAA	15	46,394
Lands Not Capable of Timber Production	Non-Commercial	Birch	CT=TPB	2	3,977
Lands Not Capable of Timber Production	Non-Commercial	Oak	CT=TBO	3	10,419
Lands Not Capable of Timber Production	Non-Commercial	Juniper	CT=TRJ	0	252
Lands Not Capable of Timber Production	Non-Commercial	Other Hardwoods	CT=TOH/TAE	0	1,140
	Total Non-Commercial				62,182
Lands Not Capable of Timber Production	Physically Unsuitable	Unstable Soils	TC=720/722	4	8,645
Lands Not Capable of Timber Production	Physically Unsuitable	Restocking Within 5 Yrs Not Assured	TC=701/702/710	3	15,934
	Total Physically Unsuitable				24,579
Total Lands Not Capable of Timber Production				60	236,351
Tentatively Suited Timber Lands	Not Appropriate	Norbeck Wildlife Preserve	MA=5.4A_	2	12,668
Tentatively Suited Timber Lands	Not Appropriate	Norbeck Scenic Byway	MA=4.2B_	0	1,447
Tentatively Suited Timber Lands	Not Appropriate	Experimental Forest	MA=5.3A_	2	3,164
Tentatively Suited Timber Lands	Not Appropriate	Research Watersheds	MA=5.3B_/5.2A_	1	4,058
Tentatively Suited Timber Lands	Not Appropriate	Inyan Kara	MA=3.2A_	0	1,120
Tentatively Suited Timber Lands	Not Appropriate	Botanical Areas	MA=3.1_	1	6,817
Tentatively Suited Timber Lands	Not Appropriate	Spearfish Canyon	MA=4.2A_	3	7,447
Tentatively Suited Timber Lands	Not Appropriate	Southern Hills	MA=5.1A_	25	49,208
Tentatively Suited Timber Lands	Not Appropriate	Backcountry, Motorized	MA=3.31_	1	7,871
Tentatively Suited Timber Lands	Not Appropriate	Backcountry, Non-Motorized	MA=3.32_	2	7,143
Tentatively Suited Timber Lands	Not Appropriate	Sand Creek	N/A	2	5,669
Tentatively Suited Timber Lands	Not Appropriate	Beaver Park	N/A	0	2,318
Tentatively Suited Timber Lands	Not Appropriate	Low Productivity	TC=740/741	3	5,519
Tentatively Suited Timber Lands	Not Appropriate	Developed Recreation Sites	TC=825	1	1,272
Tentatively Suited Timber Lands	Not Appropriate	Other - Seed Collection Sites, etc	TC=860	0	25
Tentatively Suited Timber Lands	Not Appropriate	Late Successional Areas	TC=802	7	16,548
Tentatively Suited Timber Lands	Not Appropriate	Roading Difficulties	TC=823	0	5,608
Tentatively Suited Timber Lands	Not Appropriate	Steep Slopes	TC=821	3	2,368
Tentatively Suited Timber Lands	Not Appropriate	Isolated Areas	TC=824	3	8,338
Total Tentatively Suited Timber Lands Not Appropriate				56	148,608
Suitable Timber Lands		Suitable Timber Lands		374	862,181
Grand Total					1,531,586
		Management Area	MA		
		Timber Component	TC		
		Cover Type	CT		
		Not Available	N/A		

Figure I-3 – Black Hills Timber Suitability, Phase II Amendment

These charts aid in addressing the physical and development attributes of the land base. Vegetative characteristics need further detail. Once the forestland has been classified, management prescriptions are formulated. Management prescriptions provide an activity schedule that describes the conditions by which vegetation will be treated to obtain desired outcomes. For example, 'no treatment' is a popular contemporary management option. Similar vegetation types often respond in a predictable manner. Thus, vegetative characteristics are often defined by common overstory species, of similar size and density. Understory components are increasingly important and add a dimension of plant association or community type.

Typically, major forest cover types are derived from life zones, plant biomes, or ecological geography. They depict the base vegetation.

For this analysis, *overstory cover type*, *size class*, *crown density*, *site index*, and *understory cover type* were used to describe the vegetative characteristics. Four overstory types are recognized on the Black Hills, two residing within the suitable timberland base and two within the unsuitable lands. Ponderosa Pine is the dominant forest cover type at 85 percent of the total forest land area. White Spruce is a distant second at 5 percent. These two types comprise the suitable timber land base. Quaking Aspen/Paper Birch and Bur Oak occupy the remaining forest land and are considered unsuitable cover types for timber production.

Size class qualifiers were based on Region 2, RMRIS coding specifications. Five size classes are recognized: non-stocked, small, medium, large, and very large. Non-stocked forest sites are currently not vegetated but potentially could grow seedlings. These sites are generally quantified as having less than ten percent canopy cover. The remaining size classes are defined by respective tree diameter ranges. For this analysis, the 'very large' size class was combined into the 'large' size class.

An additional feature was added to the base size class definition. Forest stands on the Black Hills have two tendencies. That is, they can either arise in single-storied structures or they may contain several canopy layers. To aid in classifying single-storied stands from multi-storied stands, an examination of the quadratic-mean-diameter (QMD, trees 1.0" and greater) was used. To clarify by way of an example, the large size class is defined as containing the *majority* of the basal area stocking in trees 9-inches and greater. However, the majority could be just slightly so. It was inferred that if the QMD for the large size class was greater than or equal to 9-inches, then the specific stand was single-storied. If the QMD was less than 9-inches, then it was concluded that an abundant seedling/sapling (small size class) and/or poletimber (medium size class) component was also present. These stands were deemed to be multi-storied. An indicator variable was added to the base size class code to identify storied-ness.

Crown density, also referred to as canopy cover, is the summation of the ground surface that is covered by downward vertical extension of individual tree crowns. In a two-dimensional context, crown density does not exceed 100 percent. However, in multi-storied stands, crown coverage of the different canopy layers is an important consideration, especially for wildlife. In this three-dimensional view, crown density can exceed 100 percent. For this analysis, crown density indicators included overlap of tree crowns between the various stories.

Site productivity is often used to differentiate vegetative stand types. This attribute plays an important role in determining yield capacity. Measures of site index were used as the proxy qualifier for site productivity. Two ranges in site index were chosen. Lower sites equated to site index values of 63 or less. Higher sites included those site indices of 64 and greater. Site index values were derived based on reference curves from Meyer (1961). There was an error in the citation of Hornibrook as the basis for site index in the 1996 Final Environmental Impact Statement, Appendix B, page 15. Carl Edminster, the original developer of the GENGYM growth and yield model, recalls switching to Meyer because of the asymptotic nature of the Hornibrook curves. Fortunately, these site index curves are very similar for trees less than 150 years of age. This age range covers the majority of stands on the Black Hills. A word of caution, the FIA uses a third set of equations for calculating site index for the Black Hills (Lynch 1958). When combing inventory data from differing sources, it is important to insure that each is converted to the site index required by the growth projection model.

Given that Ponderosa Pine overstory occurs on 9 out of 10 acres on the Black Hills, further methods were needed to refine the vegetative component. Understory attributes play an important role in determining potential silvicultural treatments. For example, Ponderosa Pine stands that contain an understory of Bur Oak require different methods to encourage or dissuade existing species composition. Identification of the understory can also provide an indication of the moisture availability on a site. As the elevation increases, more moisture is available. With the increase in precipitation, different tree species inhabit a site. Examination of Rocky Mountain Juniper, Bur Oak, Ponderosa Pine, Aspen/Birch, and White Spruce seedling-saplings tallies allowed for classification of the understory component. Figure I-4 displays the layout of overstory/understory compositions on the Black Hills.

A template was developed to pull together the vegetative qualifiers. Refer to Figure I-5. This guide provided the framework for describing the vegetation characteristics of the resident stand types on the Black Hills.

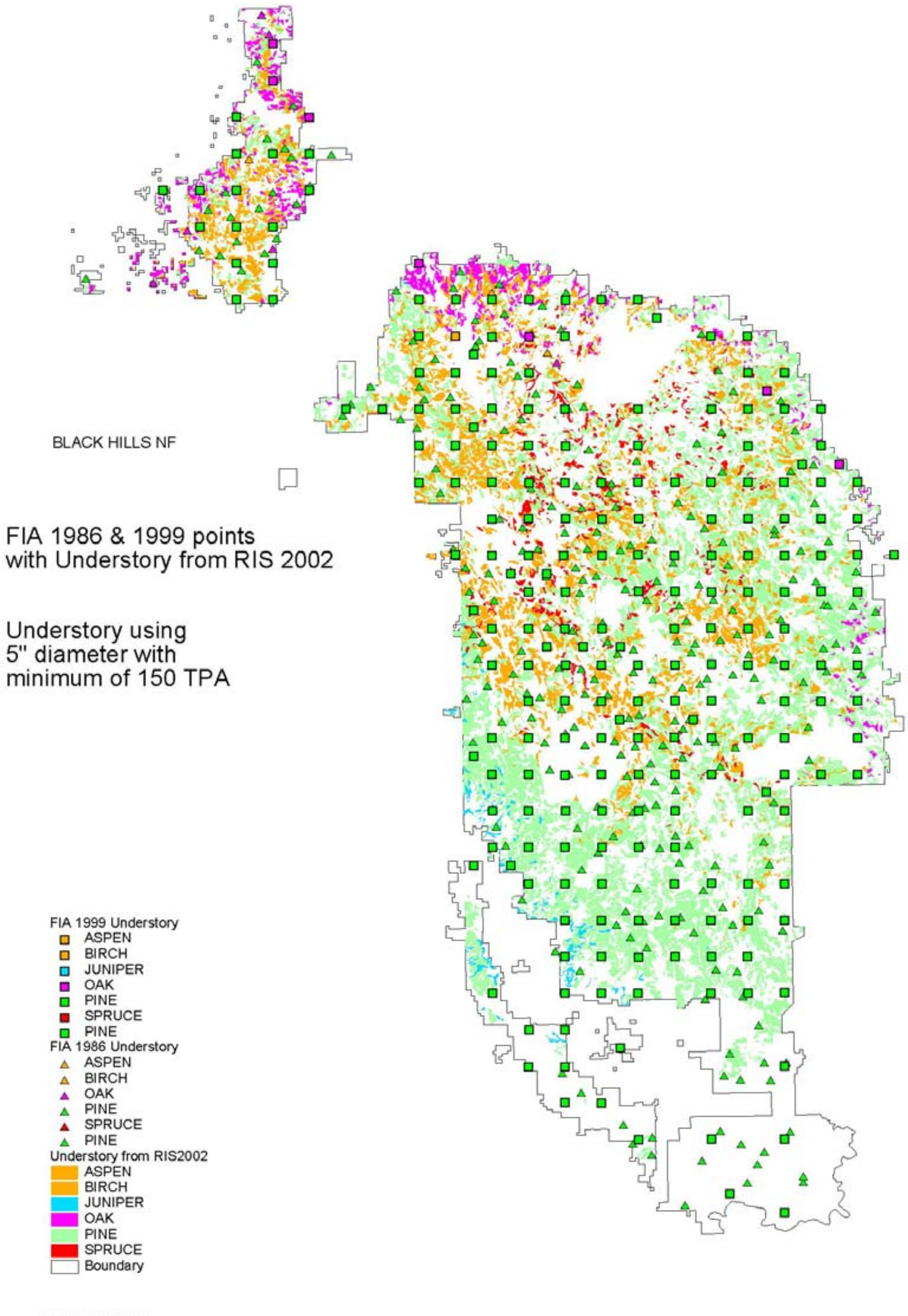
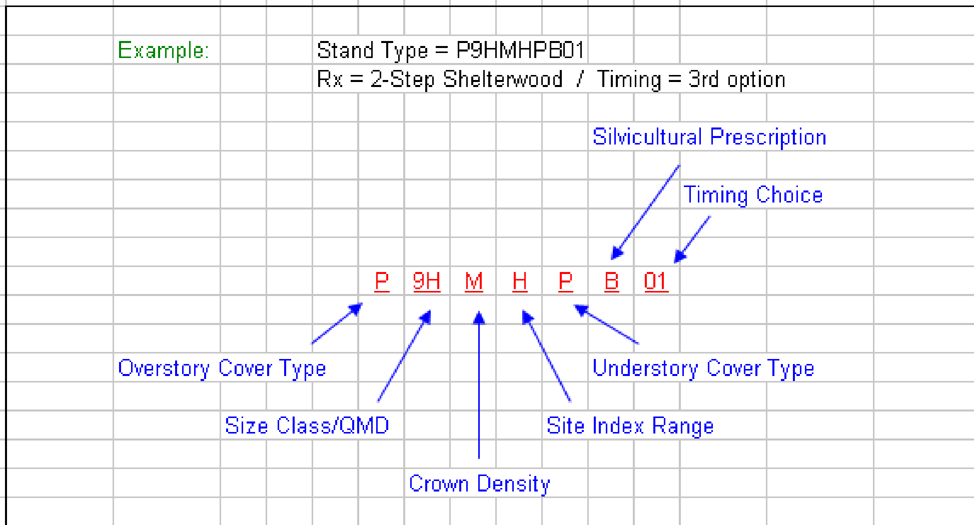


Figure I-4 – Depiction of Overstory/Understory Stand Types



Definitions:

Overstory Cover Type:

P	=	Ponderosa Pine
S	=	White Spruce

	Size Class:				*QMD Range:*
	6L	=	Nonstocked		No Overstory <5" QMD
	6H	=	Nonstocked		Remnant Overstory (RO) 5"+ QMD
0.0"-4.9" diameter	7L	=	Small	-->	Seedlings/Saplings w/o RO <5" QMD
	7H	=	Small	-->	Seedlings/Saplings w/ RO 5"+ QMD
5.0"-8.9" diameter	8L	=	Medium	-->	Poletimber <7" QMD
	8H	=	Medium	-->	Poletimber 7"+ QMD
9.0"+ diameter	9L	=	Large	-->	Sawtimber <9" QMD
	9H	=	Large	-->	Sawtimber 9"+ QMD

Crown Density:

L	=	10-40%	Low Cover
M	=	41-70%	Moderate Cover
H	=	71-100%	High Cover
A	=	0-100%	All Cover Classes

Site Index Range:

L	=	0-62	Lower SI
H	=	63-100	Higher SI
A	=	0-100	All SI

Understory Cover Type:

J	=	Rocky Mtn Juniper
O	=	Bur Oak
P	=	Ponderosa Pine
A	=	Aspen/Birch
S	=	White Spruce
C	=	Ponderosa Pine or White Spruce
U	=	Woodland or Deciduous or Nonstocked
X	=	No Understory Qualifier

Figure I-5 – Nomenclature of Stand Types

II. DATA SOURCES

Forestry data comes in two types: temporal and spatial. Temporal data is usually gathered during a structured field inventory. The collected data provides an estimate of the existing stand conditions at the time of the inventory. Values provided are generally referenced to a per acre basis. Spatial data is usually compiled from remote sensed information. Ground verification methods often are integrated with stand level inventories. Acreage compilations for various land classes are derived from spatial analysis methods. Temporal data, when multiplied by spatial data, renders total strata estimates.

Permanent plot inventories and temporary plot inventories provided the temporal data sets for the Phase II Amendment. This information became the building blocks for the yield projections. Further discussion in this report will focus primarily on this aspect. The Black Hills National Forest has an extensive Geographic Information System (GIS). It provided the acreage summary for the proposed stand types. This effort is documented in a separate report.

A. Permanent Plot Data Sets

During the 1970's and 80's, permanent plot inventories conducted on National Forests were referred to as 'Stage I Inventory'. From the 1990's to the present, the Forest Inventory and Analysis (FIA) Unit within the U.S. Forest Service Research Branch has conducted the permanent plot inventories. Beginning in the year 2000, the FIA transitioned its sampling method from a periodic measurement interval (generally 10 years) to an annualized inventory system. For the Black Hills National Forest, there was a Stage I measurement conducted in 1986; a periodic FIA measurement gathered in 1999; and, an annual inventory installation in 2001. Data from each of these inventories was used for the yield analysis.

In the continuing evolution of the FIA sampling method, the plot grid was enhanced during the 1999 measurement. The primary spacing between sample locations for periodic inventories in the Intermountain West was a 5,000 meter grid (5M). With the eminent implementation of the annual inventory, a new sampling grid was proposed based on a hexagon placement (HX). There is a 'Base U.S. Hexagon' that covers the entire lower 48 States. Within this, 367,794 FIA hexagons that encompass slightly less than 6,000 acres are identified. In most cases, existing FIA plot locations based on the 5M grid are used for the hexagon sample. However, there are situations where hexagon plots are needed to complete the hexagon grid. The additional HX plots were identified separate from the 5M plots for this project for reference purposes only.

B. Temporary Plot Data Sets

Stand examination inventories are commonly established using temporary plots. The time and dollar expense associated with permanent plot inventories is not justified for this level of information. As such, the collected data is often not as extensive and rigorous post inventory quality control may be lacking. Credence associated with temporary plots samples is somewhat less than that associated with permanent plots. However, there is a need to use information gathered from temporary plot inventories in forest planning. There are special situations involving minor components that may need to be addressed. There is a chance that these minor strata may not be adequately sampled solely using permanent plots to provide reliable estimates. Thus, data is taken from temporary plot inventories to augment the permanent plot sample. This was the case for the Black Hills analysis. Data needed to be assembled to represent important stand types that comprise small acreages. To do so, the Rocky Mountain Resource Information System (RMRIS) that stores the stand examination information was queried to supplement the plot samples for minor stand types. The RMRIS system was 'frozen' for the 1997 Land and Resource Management Plan in early 1995. In an effort to duplicate the prior analysis process, the stand examination inventory data used previously was incorporated into the overall data set for the Phase II analysis.

C. Pre-Suppose Application

The Pre-Suppose program was developed to assist forest analysts in producing stand types for management planning (Figure II-1). This program leads users through a series of three input forms (parameter, plot, and key screens; Figures II-2b-c). Upon conclusion, a statistical report is presented to aid evaluation of a proposed data group (Figure II-3). Refer to the article 'Pre-Suppose: Preprocessor for Suppose' in the Second Forest Vegetation Simulator Conference (RMRS-P-25) for a more in-depth description of the Pre-Suppose program. Additional documentation for the Pre-Suppose program can be viewed on the World Wide Web at http://www.fs.fed.us/fmsc/fvs/documents/gtrs_select-topics.php. Select Topic I.

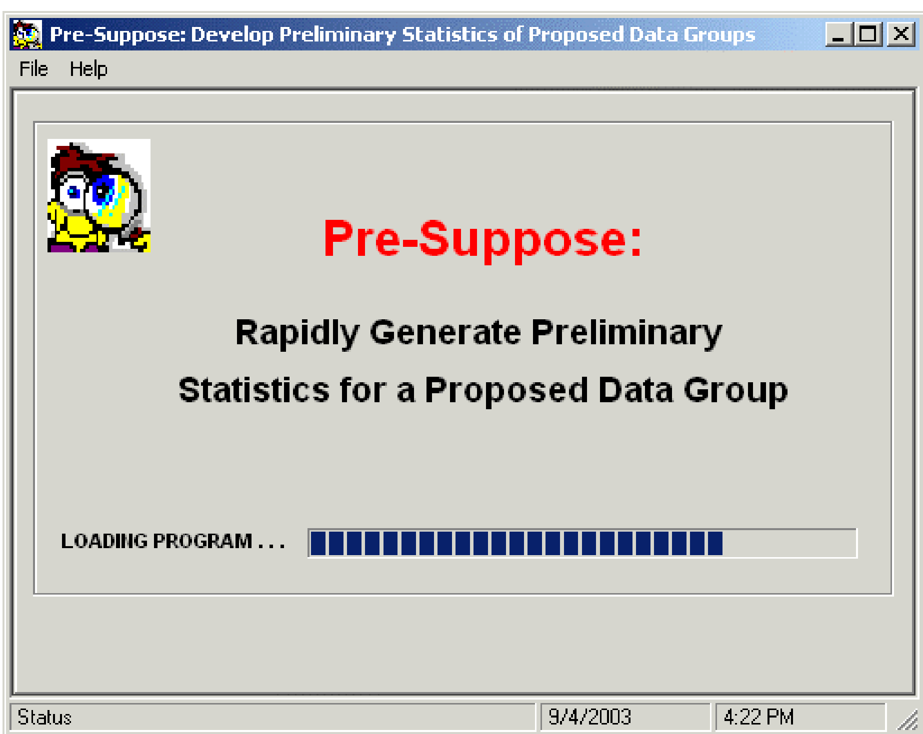


Figure II-1 – Pre-Suppose Splash Screen

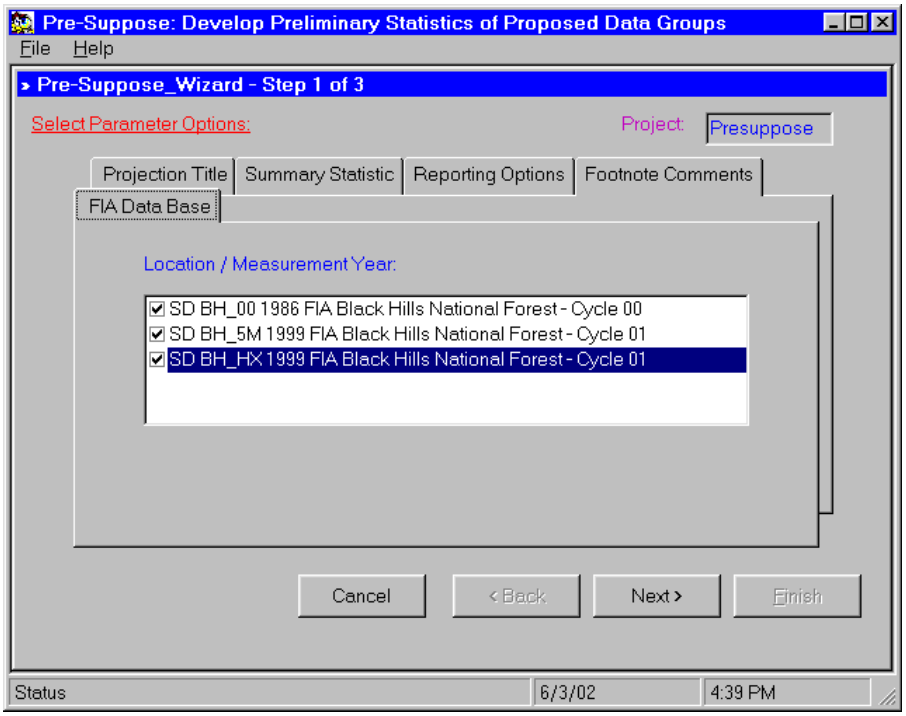


Figure II-2a – Pre-Suppose Parameter Screen

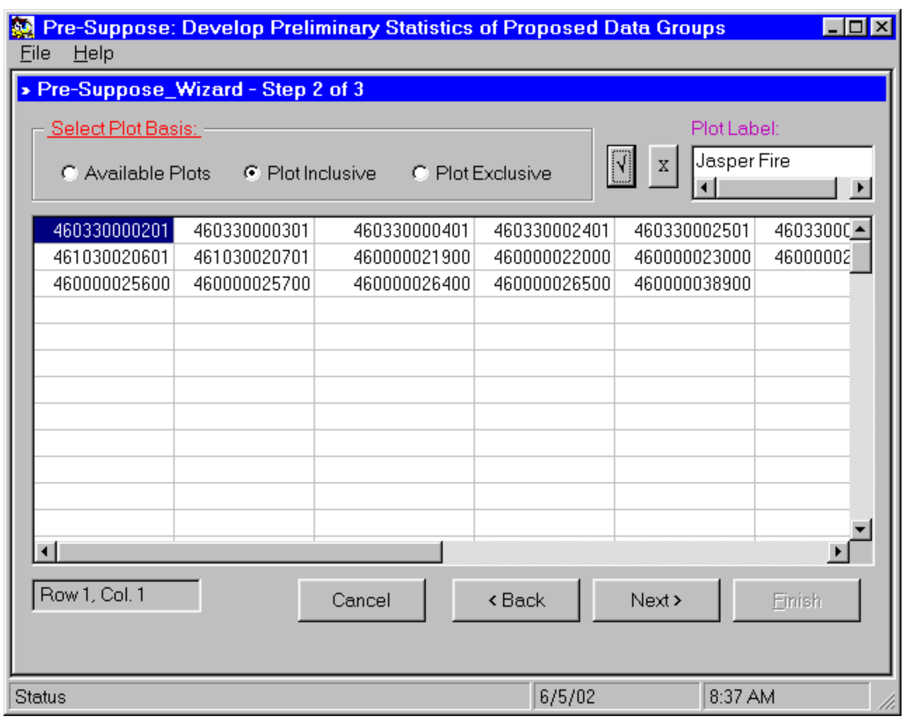


Figure II-2b – Pre-Suppose Plot Screen

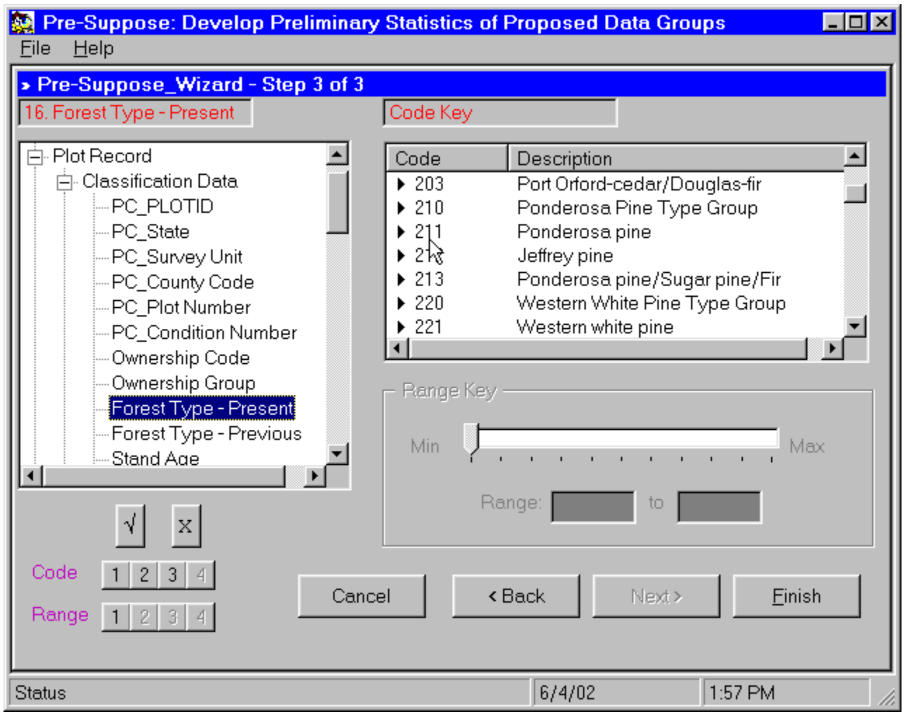


Figure II-2c – Pre-Suppose Key Screen

The value of the Pre-Suppose program for building stand types is tremendous. As a benefit of its rapid processing of plot summary records, resultant data groups could be quickly generated. Output from trial runs could be evaluated based on statistical merits to determine if an adequate plot count had been obtained with the input criteria. The Pre-Suppose program was used to query the data tables to assemble plots sets for the various stand types.

D. Plot Status Report

The data set used to develop yield profiles for the Phase II Amendment of the 1997 Black Hills Land and Resource Management Plan was comprised from several sources. They were:

1. 1986 Stage I Permanent Plot Inventory
2. 1995 Stage II Temporary Plot Inventory (RMRIS – Stand Exams)
3. 1999 FIA Permanent Plot Inventory (Periodic measurement, 5M and Hex grids)
4. 2001 FIA Permanent Plot Inventory (Annual measurement)

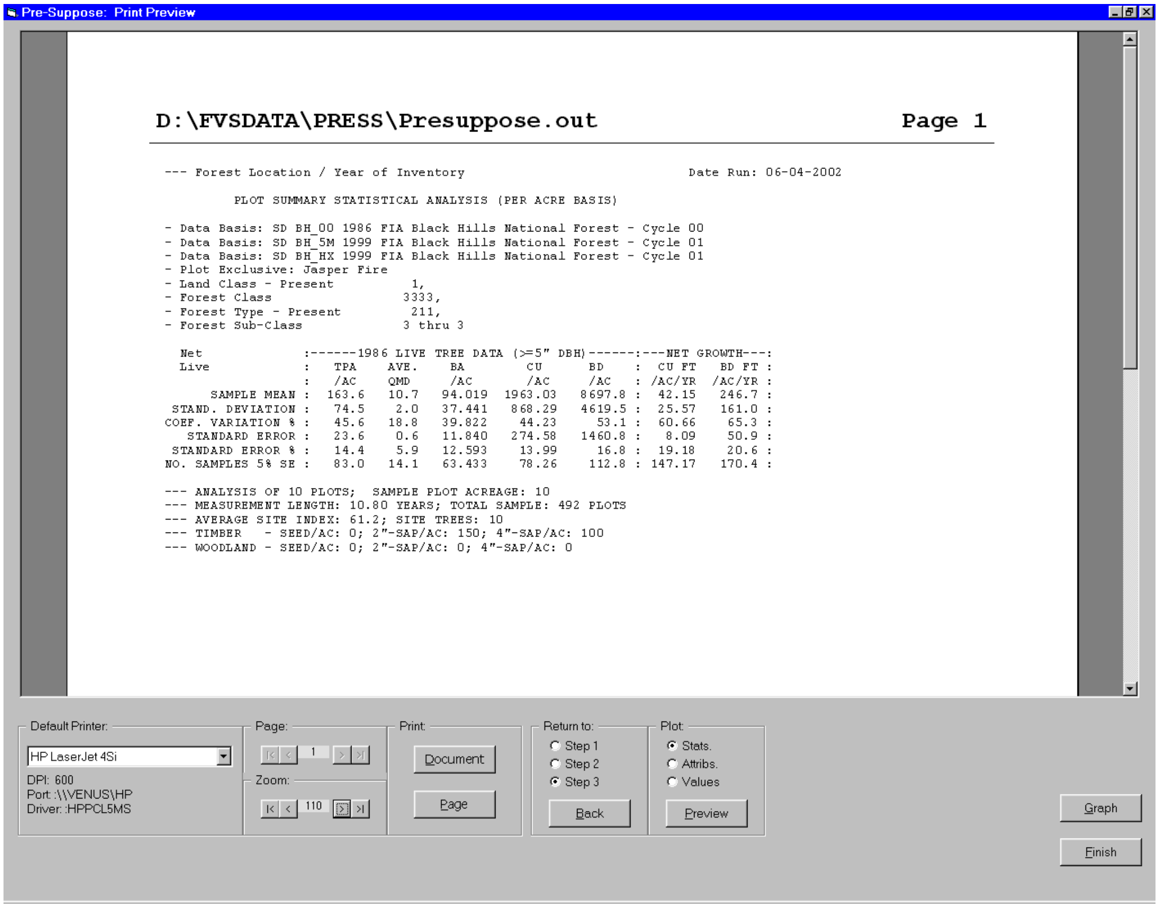


Figure II-3 – Pre-Suppose Plot Summary Statistical Analysis Screen

Each sample stood on its own merits as a representative of a stand type condition class. The data was not grown forward to a common year. If a plot condition was of a specific stand type, it was inferred that it was not relevant as to its measurement date. In other words, a Ponderosa Pine stand of a given size class, crown density, site index range, and understory component should be similar at any point in time.

Using the Pre-Suppose program, the data sets were sorted into their appropriate stand types. Figure II-4 presents the final distribution of plot samples per stand type. An effort was made to cover the full range stand conditions throughout the forest. Identification of the understory component is most relevant for older, larger size class stands. Regeneration treatments will vary depending on the existing understory conditions. Identifying older stands by their understory composition allowed linking the appropriate regeneration treatment. Appendix I contains a complete listing of plot breakouts by stand type for each of the inventories.

Collapsed Sample

	Understory Cover Type									
	Juniper (J)	Oak (O)	Pine (P)	Aspen (A)	Spruce (S)	P-S (C)	J-O-A (U)	N Qual. (X)	Sub	
P6LAL								7	7	
P6LAH								2	2	
P6HAL								7	7	
P6HAH								5	5	21
P7LAL								18	18	
P7LAH								11	11	
P7HAL								10	10	
P7HAH								10	10	49
P8LLL						8			8	
P8LLH						6			6	
P8LML						25			25	
P8LMH						21			21	
P8LHL						12			12	
P8LHH						19			19	
P8LAL							10		10	
P8LAH							16		16	
P8HLL						6			6	
P8HLH						4			4	
P8HML						17			17	
P8HMH						17			17	
P8HHL						3			3	
P8HHH						4			4	
P8HAL							2		2	
P8HAH							12		12	182
P9LLL			15						15	
P9LLH			16						16	
P9LML		10	65	18	10				103	
P9LMH			44	20					64	
P9LHL			11						11	
P9LHH			8						8	
P9HLL			18						18	
P9HLH			21						21	
P9HML		5	27	14	4				50	
P9HMH			41	19					60	
P9HHL			3						3	
P9HHH			3						3	372
S7AAA								2	2	
S8AAA								11	11	
S9AAA								10	10	23
Total	0	15	272	71	14	142	40	93	647	

1. Merge Juniper understory with Ponderosa Pine
2. Collapse Oak in L/H QMD, M Crown Density, L Site Index Range
3. Collapse Aspen in L/H QMD, M Crown Density, L/H Site Index Range
4. Collapse Spruce in L/H QMD, M Crown Density, L Site Index Range

Figure II-4 – Sample Plot Distribution by Stand Type

III. MODEL CALIBRATION

An essential step in using the Forest Vegetation Simulator is calibration of the model. The FVS geographic variants are comprised of numerous mathematical relationships. In the biological sciences, regression equations at best achieve an r-squared correlation value of 70 to the fitted data. If the results of one regression function provide the input to another, then the resultant error is compounded. Thus, it behooves the user to validate the virtual world estimates generated by FVS versus the real world values obtained from the inventory sample.

A. Establishing Baselines

The primary reason for calibrating the FVS variant is to keep model estimates within the realm of reasonableness. FVS does not contain a senescence algorithm. Without this constraint, FVS tends to produce stands with few trees that are very old and very large. Disturbance ecology is not its forte. The best way to establish baseline growth trends is to produce scatter plot diagrams of the raw inventory data. That is, use non-modeled inventory data as a cross-check. A simple two-dimensional graph with a plot summary value represented by the y-axis and stand age on the x-axis should suffice.

1. Measurement Data

One of the end targets for calibrating the FVS model is the creation of the ReadCorD (Readjust Correction for Diameter) keyword. Input of this keyword alters the baseline estimate for the large-tree diameter growth submodel. For a particular species, the original baseline estimate is multiplied by the value of this keyword, and the result becomes the new baseline estimate. These adjustments are done prior to the model's self calibrating routines. Calculated scale factors derived from FVS self calibrating feature attenuate toward a value midway between the calculated scale factor and the new baseline estimate at twenty-five year intervals.

With this in mind, eleven grouping of stand types were chosen for the Black Hills Phase II Amendment. These calibration classes span the range of overstory cover type, size class, site productivity, and understory characteristics for the Black Hills forest. They were:

1. P6AAAX: Ponderosa Pine/Nonstocked/Single & Multi-Storied/All Sites/ No Understory Qualifier
2. P7AAAX: Ponderosa Pine/Small Size Class/Single & Multi-Storied/All Sites/ No Understory Qualifier
3. P8LAAC: Ponderosa Pine/Medium Size Class/Single & Multi-Storied/Low Site/ Conifer Understory
4. P8LAAU: Ponderosa Pine/Medium Size Class/Single & Multi-Storied/Low Site/ Woodland Understory
5. P8HAAC: Ponderosa Pine/Medium Size Class/Single & Multi-Storied/High Site/ Conifer Understory
6. P8HAAU: Ponderosa Pine/Medium Size Class/Single & Multi-Storied/Low Site/ Woodland Understory

7. P9LALA: Ponderosa Pine/Large Size Class/Multi-Storied/Low Site/ All Understories
8. P9LAHA: Ponderosa Pine/Large Size Class/Multi-Storied/High Site/ All Understories
9. P9HALA: Ponderosa Pine/Large Size Class/Single Storied/Low Site/ All Understories
10. P9HAHA: Ponderosa Pine/Large Size Class/Single Storied/High Site/ All Understories
11. SAAAAA: White Spruce/All Size Classes/Single & Multi-Storied/All Sites/ All Understories

Four plot summary values were chosen to examine their stand age relationship. These were "Trees per Acre", "Basal Area per Acre", "Cubic Foot Volume per Acre", and "Board Foot Volume per Acre". The Pre-Suppose program was used to isolate the calibration class stand types and to generate the 'Presuppose.val' report. This text file lists the aforementioned plot summary values. Inputting this file into a MS-Excel spreadsheet allowed for easy tabulation and graphing.

Stand age as reported by FIA appeared to be inconsistent. Many plots indicated young ages for larger size class stands. The opposite situation held true as well. Given the mosaic structure of the Black Hills forests where a stand can be comprised of many small groups of trees, this inference was not surprising. In an effort to provide consistent trends, stand age was computed by the FVS model. The age of each tree record is estimated by FVS. Using the embedded forest typing algorithm, an associated stand size class is also determined. By summing up the tree ages in the dominant size class and dividing by the tree count, an average stand age was computed. This value was used in conjunction with the plot summary values.

2. Upper Trend Line

The objective of the calibration exercise is to establish a ceiling for the FVS projection estimates. So as not to get overly encumbered in regression analysis, it was decided to establish a simple natural logarithmic function through the measured data. Once computed, the y-intercept would be augmented by two positive deviations of standard error. In most cases, this procedure seemed to represent the upper echelon of the data. A trend line was added to the scatter of the plot summary value versus the computed stand age. This analysis was performed within the MS-Excel spreadsheet.

3. FVS Projection Line

Once the basic scatter of measurement data was displayed and the augmented natural log trend line added, the final step was to incorporate the FVS projection values per stand age. FIA plots that resided within the stand type calibration class were selected for simulation by FVS. These stands were grown forward with FVS self-calibration mechanisms in full use. FVS will develop large tree diameter scale factors for a tree species if diameter increment (paired measurements of diameter or diameter growth) values are input for five or more trees. These scale factors will adjust the diameter growth rate directly by multiplying the regionally developed regression baseline estimate thus providing a localized approximation. Plot sets were aggregated into age-based yield trends using the FVSSTAND Alone post processor. These values were into the MS-Excel spreadsheet and included on the scatter plots. As a demonstration template, the P9HAHA (Ponderosa Pine/Large Size Class/Single Storied/High Site/All Understories) are displayed in Figure III-1a-d. Measurement data is displayed as the smaller (blue – color printer) tilted squares; Augmented computed stand age is depicted by the solid (black – all printers) upper trend line; and, the FVS projected values are shown as the larger (yellow – color printer) triangles.

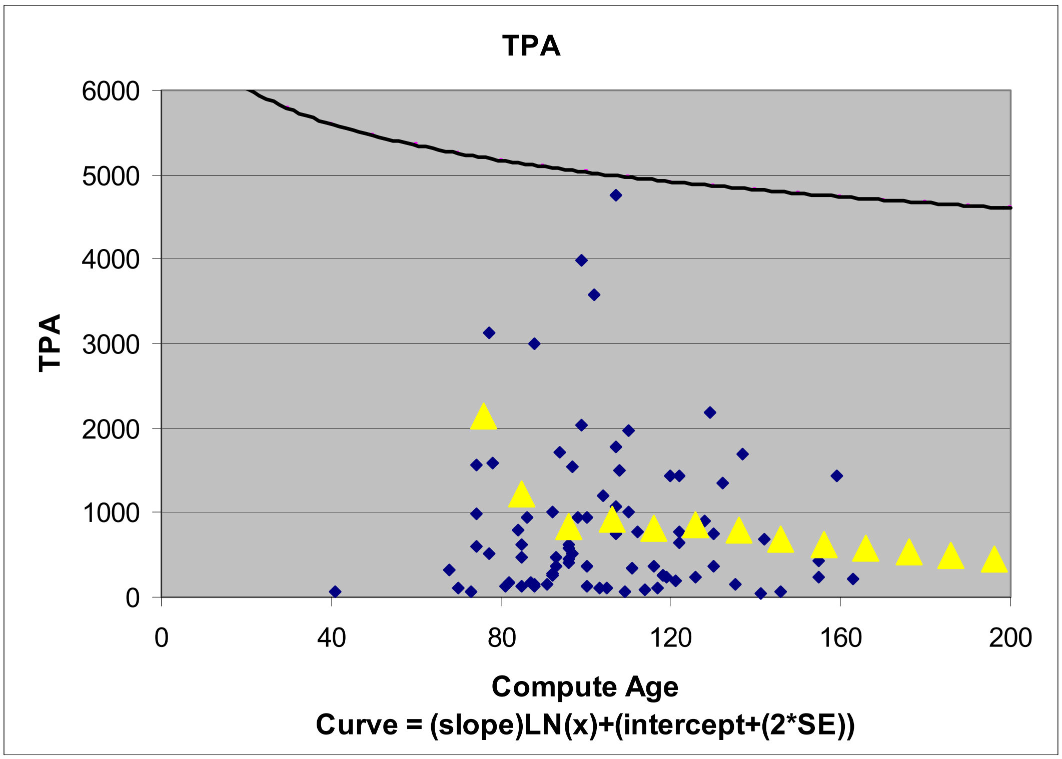


Figure III-1a – P9HAHA Trees per Acre versus Augmented Computed Stand Age

The value of the "Trees per Acre" versus "Augmented Computed Stand Age" graph is limited. Regeneration on the Black Hills can be prolific at any stand age. Thus, the number of trees present at any given time has a tremendous range. If a woodland component exist within a stand (i.e. Bur Oak), numerous seedling/sapling counts may be encountered. The basal area and volume plot summary values lent themselves better to trend analysis.

As a stand becomes fully stocked, there is a limiting carrying capacity for growing stock. Basal area displays this trend well. At relatively young ages, stands tend to obtain the upper bound. Basal area was computed for all trees greater than four and one-half feet tall. The greater the diameter of a given tree the greater its contribution is to basal area per area. It takes many more small trees to obtain a level of basal area render by far fewer large trees. Of note is the upper trend in the FVS projection line.

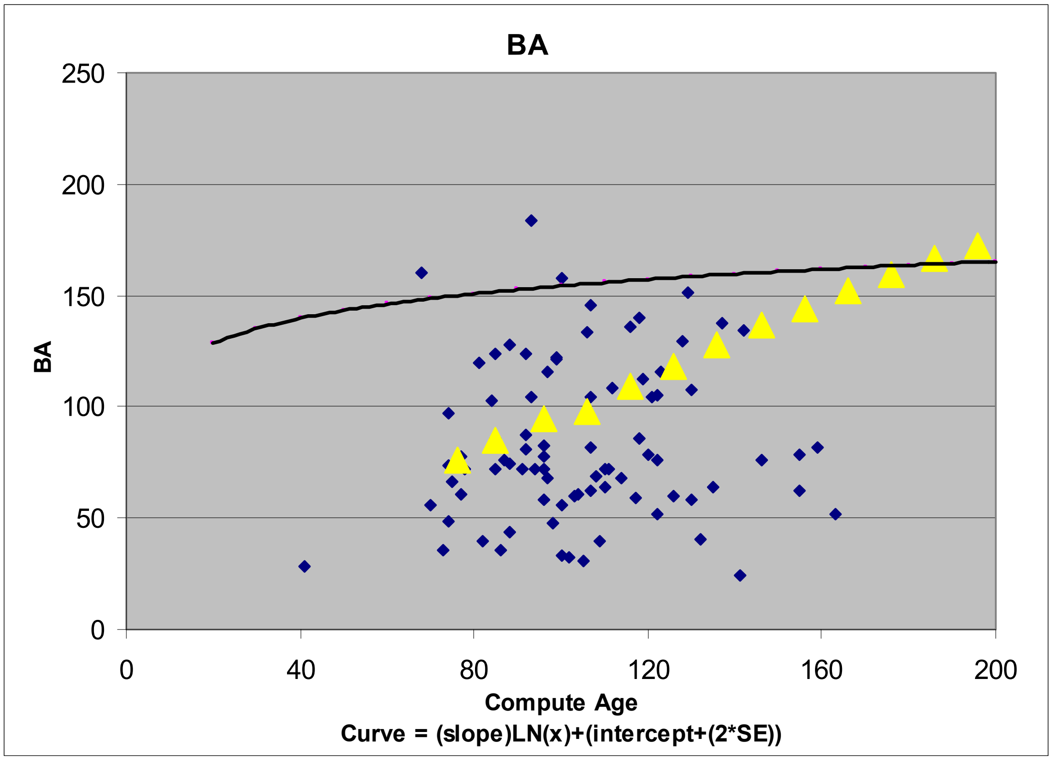


Figure III-1b – P9HAHA Basal Area per Acre versus Augmented Computed Stand Age

The cubic and board foot volume per acre charts offer some insight into the need for tempering FVS projections. These figures reveal a pronounced upward trend. It is necessary for the analyst to know the upper echelon of reasonableness. Out performance of the natural seems suspect. A fair assumption would be ascertaining the values within the observed range.

What is missing in this analysis? We have trees; we have growth; and, we have mortality agents. However, we have not accounted for regeneration impulses into stand development. Frequent rain showers engulf the Black Hills throughout the growing season, which lasts from early March to August. This contributes to the prolific establishment and growth of ponderosa pine. Examination of each of the designated stand types indicates significant seedling/sapling tree count, even in older stands. The mortality submodel for the Central Rockies variant of FVS that was used for the Black Hills analysis is based on "stand density index" (SDI) inferences. SDI is a relative measure of stand stocking as a function of trees per acre at a "quadratic mean diameter" (QMD) of 10-inches. By ignoring the ingrowth of seedlings to saplings and their associated contribution to SDI values, mortality components are under estimated. Thus, basal area and volume attainment are overstated. The next section of this report will detail efforts used to grapple with regeneration influences.

Similar trends in trees, basal area, and volume were denoted by each of the other ten stand type calibration classes. Retained MS-Excel spreadsheets are available from the Forest Management Service Center (FMSC) in Fort Collins, Colorado.

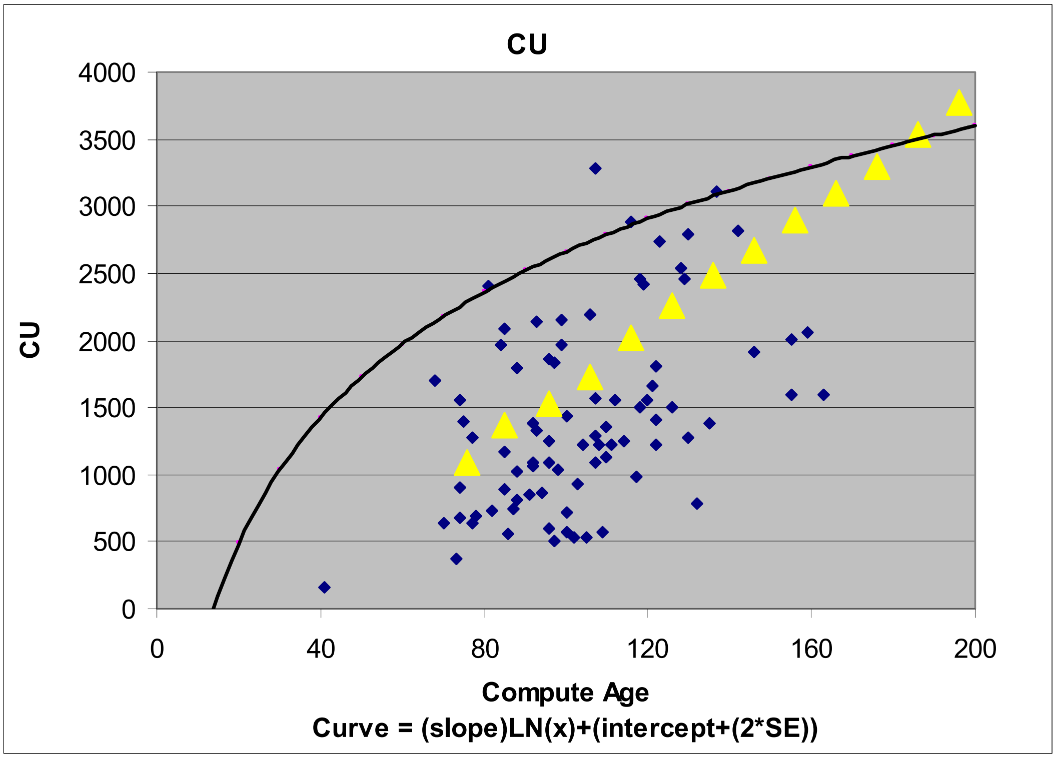


Figure III-1c – P9HAHA Cubic Foot Volume per Acre versus Augmented Computed Stand Age

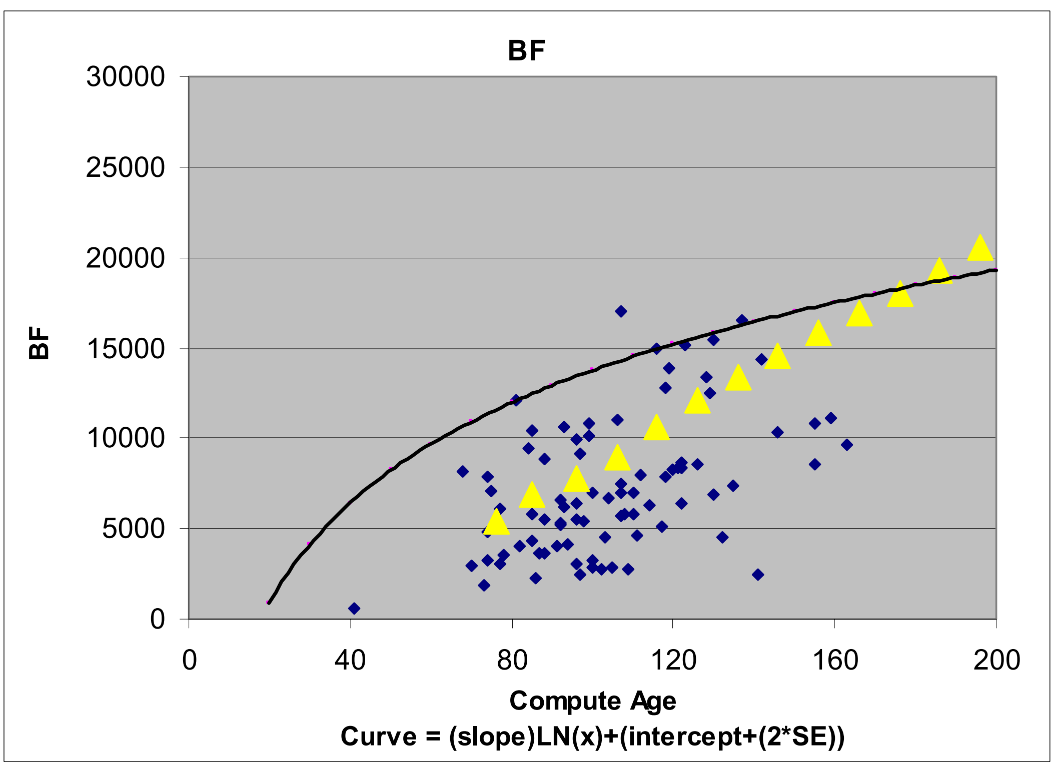


Figure III-1d – P9HAHA Board Foot Volume per Acre versus Augmented Computed Stand Age

B. FVS Self-Calibration

The Forest Vegetation Simulator has the ability to adjust the internal growth models to match the increment rates presented in the input data. This process is called self-calibration and occurs prior to any growth simulation. The effect of self-calibration is to validate and correct the core individual tree growth models for prediction bias before stand projection. Growth models that self-calibrate include the large-tree diameter increment model and the small-tree height increment model. Self-calibration of these models will affect the other growth models in FVS, such as the large-tree height increment model and the small tree diameter increment model, since these models use diameter increment and height increment directly or indirectly in their predictions, respectively.

The self-calibration process computes a scale factor that is used as a multiplier to the base growth equations. This scaling procedure is really quite simple. The affected models are linear with logarithmically scaled dependent variables. Therefore, the model intercepts are in effect growth multipliers. FVS predicts a growth increment to match each observed increment for a species and sorts the differences. The median difference is then added to the model for that species, on the logarithmic scale, as an additional intercept term, thus becoming a growth multiplier.

In order to compute scale factors for either the large-tree diameter increment model or the small-tree height increment model, there must be five or more increment observations per tree species. For the Central Rockies geographic variant, diameter increment observations are accepted only from trees that were larger than three inches diameter at the beginning of the growth measurement period. Height increment observations are accepted only from trees that were less than five inches diameter the end of the period. The number of records reported as available for scaling in the 'Calibration Statistics' table of the FVS Main Output Report includes only those records that have measured increments and meet the diameter restrictions.

The height increment scale factor is used as a direct multiplier of predicted height growth. However, the diameter increment scale factor is used as a multiplier of periodic change in diameter squared *(DDS)* and is in effect a multiplier of basal area increment. The rate of conversion of *DDS* to diameter increment is dependent on the relative size of tree diameter.

For the Black Hills Phase II Amendment, individual inventory plots comprised the base unit for stand structure projection. Each plot was processed through FVS based on its specific site productivity and stand density values. If the individual plot contained five or more growth sample trees per tree species, then FVS self-calibration feature automatically adjusted the embedded growth functions prior to stand projection.

C. Mean Scale Factors

If the individual plot sample did not contain five or more growth sample trees for a given tree species, the FVS self-calibration feature can not be called upon. The embedded geographically based growth functions alone dictate stand projection. However, there is a means to capture the model scaling from other plots within a forest strata or stand type to better represent local conditions. By averaging the individual scale factors for qualifying plot samples within a stand type, a 'mean scale factor' can be determined and used by FVS via the 'ReadCorD' (large tree diameter increment) and 'ReadCorR' (small tree height increment) multiplier keywords. In effect, the mean scale factor becomes a new estimate of the model intercept. Stands with increment data will still calibrate, but will calibrate and attenuate in response to the new model intercept (based on the mean scale factor).

A simple way to look at FVS model calibration is to consider 'self-calibration' as a means of honing in on the growth rates in your backyard. Developing 'mean scale factors' is a method of focusing growth for trees in your neighborhood. And lastly, defaulting to the 'regional growth equations' is falling back to a larger county or township area. Certainly, it is best if the local growth conditions can be captured and utilized directly by FVS.

The Forest Vegetation Simulator contains helpful features to calculate suitable mean scale factors. Generally, this is a six-step process. Prior to using this process, it is necessary to define the strata where the multipliers will be applied (i.e. for Black Hills Phase II: stand types). Once the strata are identified, the first step is to insert the 'CalbStat' keyword and the 'Calibration Summary Statistics' (CSS) post processor into the simulation and process all plots. This will generate an auxiliary file that is read and displayed in a user-friendly format by the CSS post processor. Second, examine the values in the CSS output and determine the source of any values that seem extremely high or low (normally between 2.0 and 0.5). Errors in the data input records or the keyword parameters could be the cause scale factors to exceed these ranges. Third, for any plot with unresolved sources of error or with calibration values that are not reflective of the strata, insert the 'NoCalib' keyword for the particular plot and species. Fourth, rerun the set of plots. Fifth, look at the CSS output to determine the 'mean large-tree diameter growth scale factor' and the 'mean small-tree height growth scale factor' for the strata. Sixth, if the mean scale factor values are different from 1.0, create 'ReadCorD' and 'ReadCorR' keywords respectively and save these keywords to a FVS keyword addfile. Repeat these steps for each stratum that has been identified. The addfiles are then inserted into the FVS runs.

Figure III-2 contains the 'ReadCorD' FVS keyword component addfile for the P9HAHA (Ponderosa Pine/Large Size Class/Single Storied/High Site/All Understories) stand type. The ReadCorD readjusts the baseline estimate for the large tree diameter growth model. Supplemental records consist of eight 10-character fields, each of which contains a multiplier value for a tree species based on mean scale factors. The fields are in the order of the species sequence number specified for the FVS variant. The "1.147" mean scale factor in supplemental record two is listed for Ponderosa Pine. The "1.320" mean scale factor in supplemental record three is recorded for White Spruce.

```
********************************************************************************
* Rcd_P9haha.kcp -- ReadCorD Adjustment for P9haha Strata
********************************************************************************
ReadCorD
        1.        1.        1.        1.        1.        1.        1.        1.
        1.        1.        1.        1.     1.147        1.        1.        1.
        1.        1.     1.320        1.        1.        1.        1.        1.
```

Figure III-2 – P9HAHA ReadCorD FVS Keyword Component Addfile

Mean scale factors are relative to a base value of “1.0”. Values greater than 1.0 increase growth rates. Values less than 1.0 decrease growth rates. The scale is logarithmic so a value of 2.0 represents two-fold increase whereas a value of 0.5 represents one-half rate. For the P9HAHA stand type, both Ponderosa Pine and White Spruce diameter growth increment is increased from the regionally based rates.

Similar ‘ReadCorD’ FVS keyword component addfiles were created for the remainder of the ten stand type calibration classes. These text files are available from the Forest Management Service Center (FMSC) in Fort Collins, Colorado. The inventory data set did not lend itself to creation of addfiles for the ‘ReadCorR’ keyword.

IV. NATURAL GROWTH RUNS

What is being asked of forest planners today are estimates of stand development well beyond the existing pool of stand ages. In many situations, simulations of old growth structures are needed. The age range of these stand profiles far exceed inventoried stands. It is tenuous at best to assume exact knowledge of long-term physiological processes. A reasonable assumption would be a 'steady-state' condition extending for some time into the future. As individual trees attain their morphological age, mortality agents will take their toll and the stand will transition back to earlier serial stages. Forests are very dynamic, they are not static.

Two of the most difficult aspects to forecast in stand development are regeneration and mortality components. One adds trees to the system, the other subtracts. Both are stochastic (random) events. Normal inventory sampling procedures render high variability regarding seedling recruitment and tree decline. Finding reliable predictor variables from collected data is not easy. Regeneration and mortality responses are weak links in the chain of growth and yield prediction. Methods employed for the Black Hills Phase II Amendment to wrestle with natural regeneration and mortality agents will be discussed in the following sections. The context will be in reference to the construction of 'natural growth' runs.

A. Regeneration Imputation

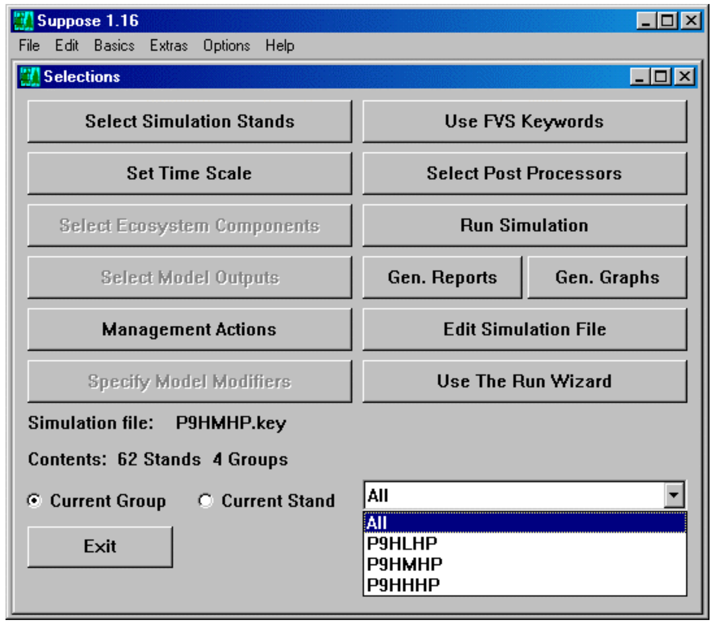
To impute implies the assignment of something to another. With respect to regeneration inferences, imputation procedures examine existing conditions to predict potential conditions in future stands. Basically, the process calls for querying existing data sets for representative *stand types* (stands of similar administrative, vegetative, and developmental characteristics) and tabulating the seedling/sapling component.

1. REPUTE the Program

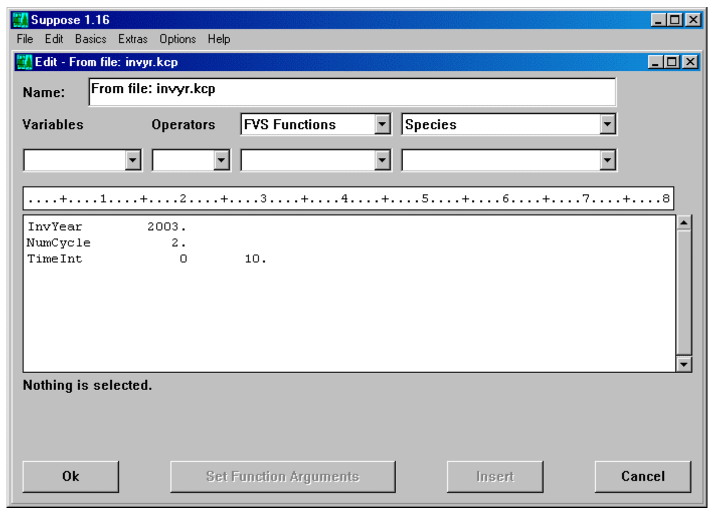
REPUTE, a *post* post-processing program, has been written that embodies the concept of Regeneration Imputation. This program reads 'Stand Table' output files from the FVSSTAND Alone post processing program to develop regeneration keyword component files. REPUTE will cycle through the FVSSTAND Alone Stand Table picking out the diameter classes less than the maximum diameter specified on the initial REPUTE screen. Separate lines in the regeneration add-file will be created per species, per diameter, given that there are trees per acre values listed. The final step includes naming the newly created regeneration Keyword Component File. Additional documentation for the FVSSTAND Alone and REPUTE post processing programs can be viewed on the World Wide Web at http://www.fs.fed.us/fmsc/fvs/documents/gtrs_select-topics.php. Select Topics III and V.

Regeneration addfiles were built for 27 stand types for the Black Hills Phase II Amendment. Stand Type P9HMHP (Ponderosa Pine/Large Size Class/Single Storied/Moderate Crown Density/High Site/Ponderosa Pine Understory) will be used as an example of the methodology used to construct the regeneration addfile. The process involved the following steps:

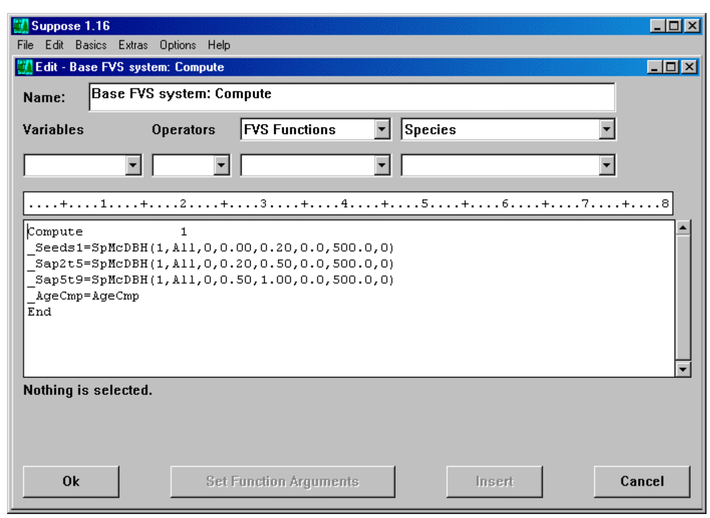
1. Using the Suppose interface to FVS, selected a stand type grouping of plots (P9HMHP). Crown densities were merged in the construction of regeneration addfiles.



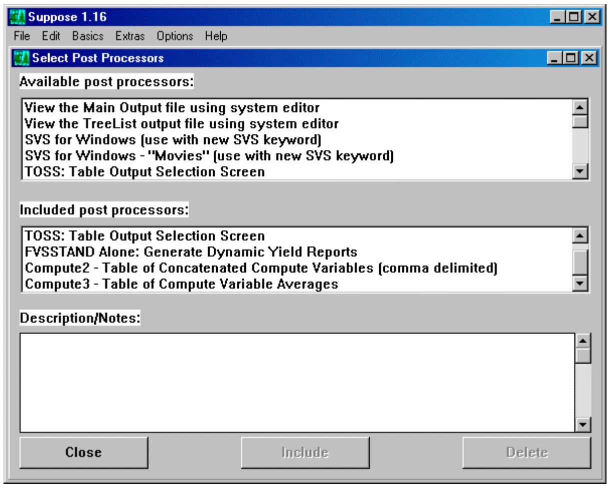
2. Constructed an FVS addfile to set inventory year, number of cycles, and projection time interval to a common basis for all plots.



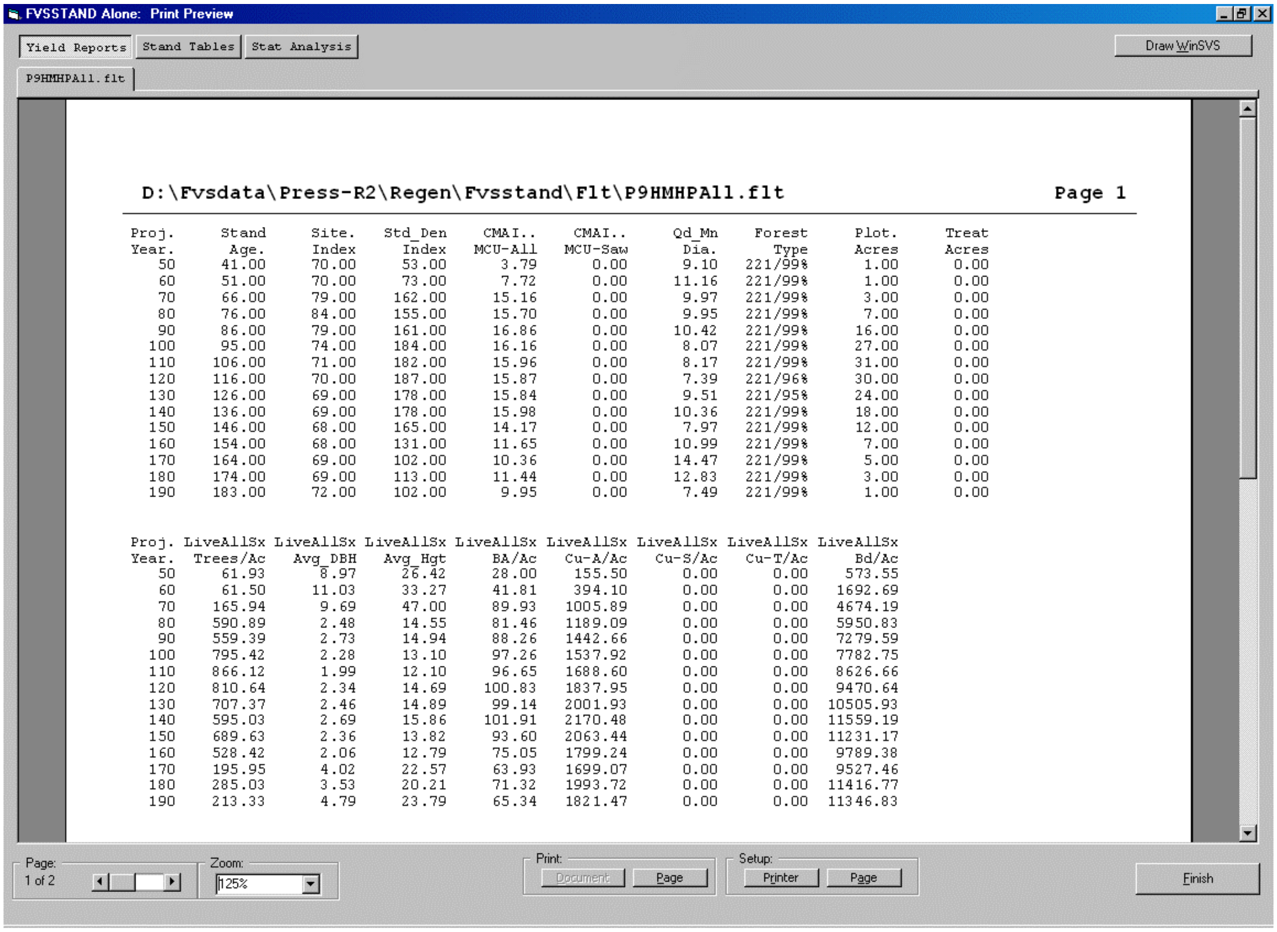
3. Constructed an FVS addfile to compute existing seedling and small sapling counts (diameter 0.2” to less than 1.0”).



4. Selected TOSS (to enable examination of inconsistencies in stand size class and tree counts per individual plot), FVSSTAND Alone (to generate age-based yield files and stand tables), Compute2 (to inspect seedling and small sapling values per plot), and Compute3 (to produce average report of seedlings, small saplings, and computer stand age) post processors. Ran simulation to generate output tables.



5. Reviewed age-based yield table from the FVSSTAND Alone post processor to determine dominant age classes (i.e. age classes with most plot counts). Recall that the number of projection cycles was set to two (20-years). The objective was to stay as close to the measurement data as possible. Examined live trees per acre trend (LiveAllSx Trees/Ac column).

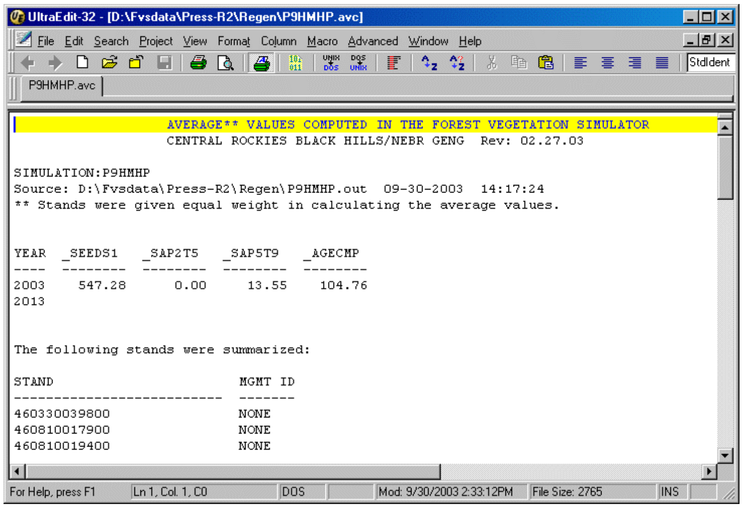


D:\Fvsdata\Press-R2\Regen\Fvsstand\Flt\P9HMHPAll.flt Page 1

Proj. Year.	Stand Age.	Site. Index	Std_Den Index	CMAI.. MCU-All	CMAI.. MCU-Saw	Qd_Mn Dia.	Forest Type	Plot. Acres	Treat Acres
50	41.00	70.00	53.00	3.79	0.00	9.10	221/99%	1.00	0.00
60	51.00	70.00	73.00	7.72	0.00	11.16	221/99%	1.00	0.00
70	66.00	79.00	162.00	15.16	0.00	9.97	221/99%	3.00	0.00
80	76.00	84.00	155.00	15.70	0.00	9.95	221/99%	7.00	0.00
90	86.00	79.00	161.00	16.86	0.00	10.42	221/99%	16.00	0.00
100	95.00	74.00	184.00	16.16	0.00	8.07	221/99%	27.00	0.00
110	106.00	71.00	182.00	15.96	0.00	8.17	221/99%	31.00	0.00
120	116.00	70.00	187.00	15.87	0.00	7.39	221/96%	30.00	0.00
130	126.00	69.00	178.00	15.84	0.00	9.51	221/95%	24.00	0.00
140	136.00	69.00	178.00	15.98	0.00	10.36	221/99%	18.00	0.00
150	146.00	68.00	165.00	14.17	0.00	7.97	221/99%	12.00	0.00
160	154.00	68.00	131.00	11.65	0.00	10.99	221/99%	7.00	0.00
170	164.00	69.00	102.00	10.36	0.00	14.47	221/99%	5.00	0.00
180	174.00	69.00	113.00	11.44	0.00	12.83	221/99%	3.00	0.00
190	183.00	72.00	102.00	9.95	0.00	7.49	221/99%	1.00	0.00

Proj. Year.	LiveAllSx Trees/Ac	LiveAllSx Avg_DBH	LiveAllSx Avg_Hgt	LiveAllSx BA/Ac	LiveAllSx Cu-A/Ac	LiveAllSx Cu-S/Ac	LiveAllSx Cu-T/Ac	LiveAllSx Bd/Ac
50	61.93	8.97	26.42	28.00	155.50	0.00	0.00	573.55
60	61.50	11.03	33.27	41.81	394.10	0.00	0.00	1692.69
70	165.94	9.69	47.00	89.93	1005.89	0.00	0.00	4674.19
80	590.89	2.48	14.55	81.46	1189.09	0.00	0.00	5950.83
90	559.39	2.73	14.94	88.26	1442.66	0.00	0.00	7279.59
100	795.42	2.28	13.10	97.26	1537.92	0.00	0.00	7782.75
110	866.12	1.99	12.10	96.65	1688.60	0.00	0.00	8626.66
120	810.64	2.34	14.69	100.83	1837.95	0.00	0.00	9470.64
130	707.37	2.46	14.89	99.14	2001.93	0.00	0.00	10505.93
140	595.03	2.69	15.86	101.91	2170.48	0.00	0.00	11559.19
150	689.63	2.36	13.82	93.60	2063.44	0.00	0.00	11231.17
160	528.42	2.06	12.79	75.05	1799.24	0.00	0.00	9789.38
170	195.95	4.02	22.57	63.93	1699.07	0.00	0.00	9527.46
180	285.03	3.53	20.21	71.32	1993.72	0.00	0.00	11416.77
190	213.33	4.79	23.79	65.34	1821.47	0.00	0.00	11346.83

6. Reviewed *.avc file from the Compute 3 post processor and constructed spreadsheet of seedling and small sapling counts and computed stand age. _SEEDS1 are seedlings counts. _SAP2t5 represent saplings 0.2” to less than 0.5”. _SAP5t9 are saplings 0.5” to less than 1.0”



UltraEdit-32 - [D:\Fvsdata\Press-R2\Regen\P9HMHP.avc]

```
AVERAGE** VALUES COMPUTED IN THE FOREST VEGETATION SIMULATOR
CENTRAL ROCKIES BLACK HILLS/NEBR GENG  Rev: 02.27.03

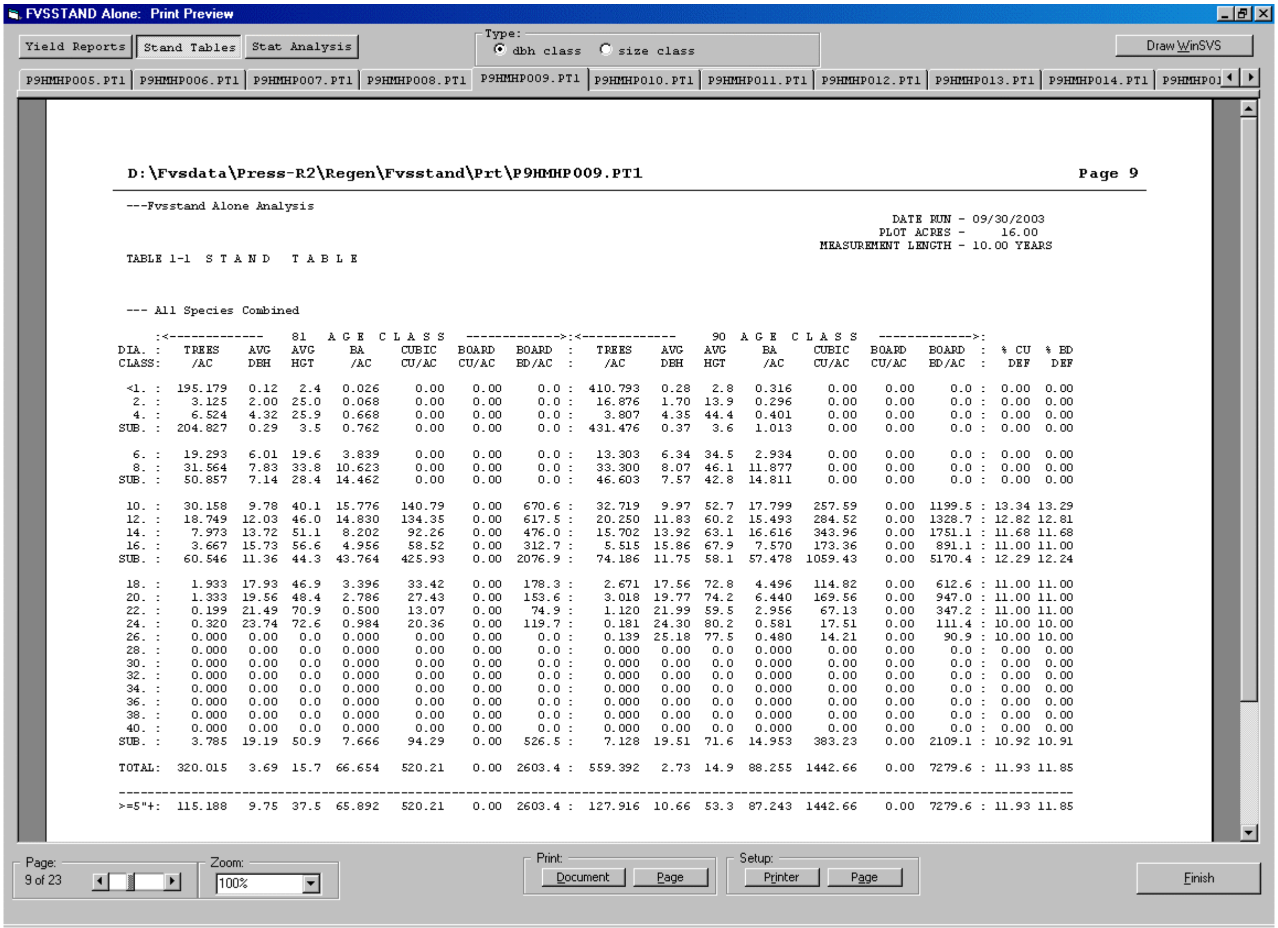
SIMULATION:P9HMHP
Source: D:\Fvsdata\Press-R2\Regen\P9HMHP.out  09-30-2003  14:17:24
** Stands were given equal weight in calculating the average values.

YEAR  _SEEDS1   _SAP2T5   _SAP5T9   _AGECMP
----  --------  --------  --------  --------
2003    547.28      0.00     13.55    104.76
2013

The following stands were summarized:

STAND                        MGMT ID
---------------------------  -------
460330039800                 NONE
460810017900                 NONE
460810019400                 NONE
```

7. Perused the age-based stand tables from the FVSSTAND Alone post processor in the vicinity of the dominant age class to select report that closely matched seedling/sapling count from the *.avc file from the Compute 3 post processor.



FVSSTAND Alone: Print Preview

D:\Fvsdata\Press-R2\Regen\Fvsstand\Prt\P9HMHP009.PT1 Page 9

---Fvsstand Alone Analysis

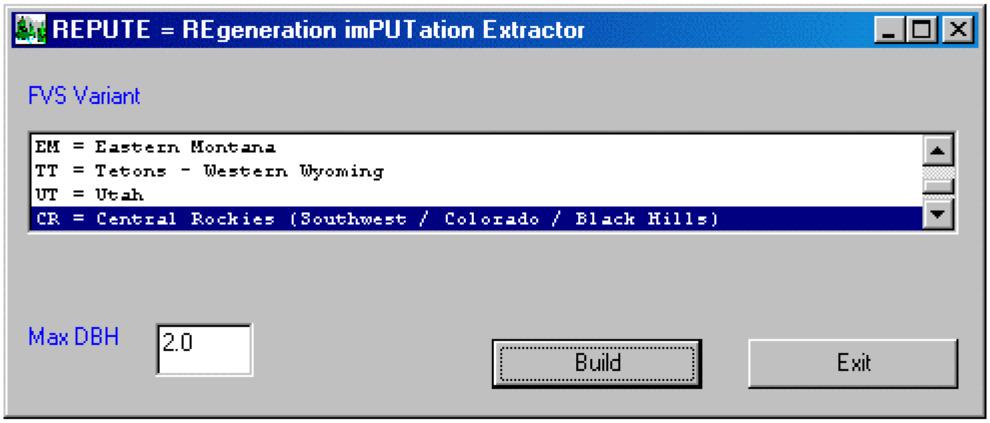
DATE RUN - 09/30/2003
PLOT ACRES - 16.00
MEASUREMENT LENGTH - 10.00 YEARS

TABLE 1-1 S T A N D T A B L E

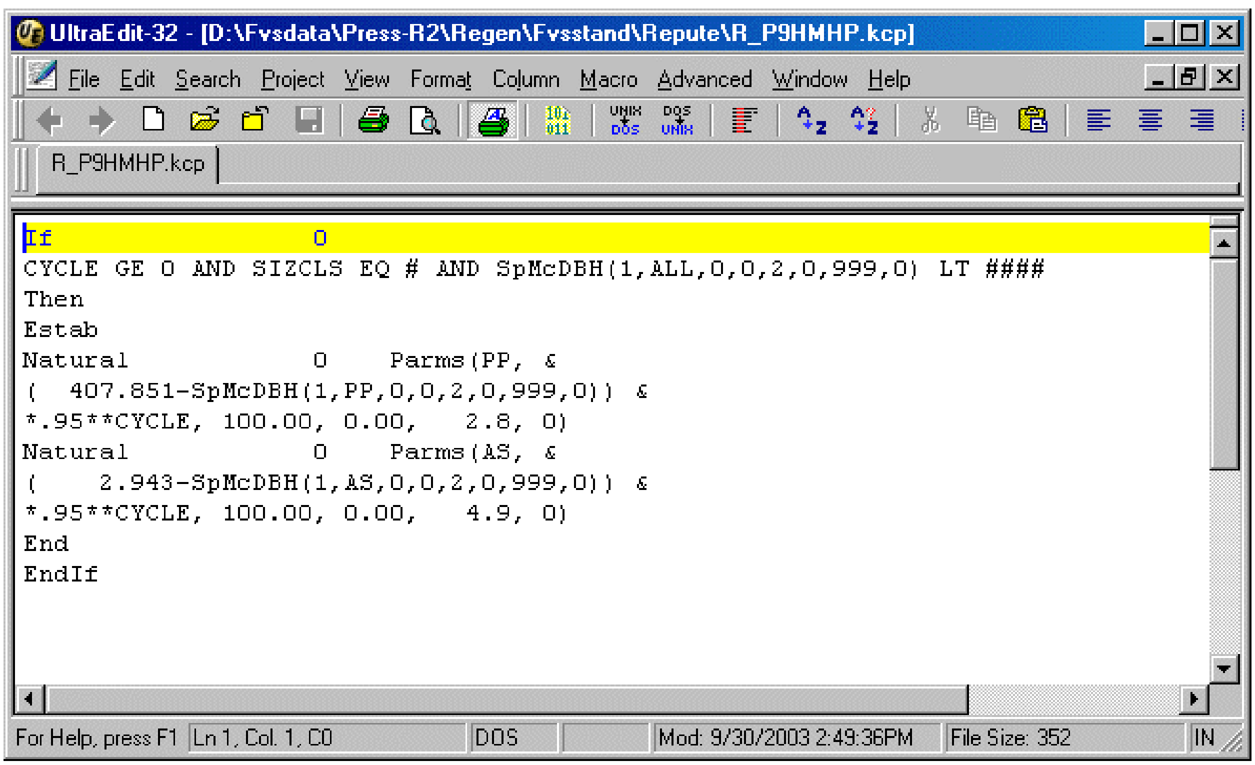
--- All Species Combined

DIA. CLASS	81 AGE CLASS TREES /AC	AVG DBH	AVG HGT	BA /AC	CUBIC CU/AC	BOARD CU/AC	BOARD BD/AC	90 AGE CLASS TREES /AC	AVG DBH	AVG HGT	BA /AC	CUBIC CU/AC	BOARD CU/AC	BOARD BD/AC	% CU DEF	% BD DEF
<1.	195.179	0.12	2.4	0.026	0.00	0.00	0.0	410.793	0.28	2.8	0.316	0.00	0.00	0.0	0.00	0.00
2.	3.125	2.00	25.0	0.068	0.00	0.00	0.0	16.876	1.70	13.9	0.296	0.00	0.00	0.0	0.00	0.00
4.	6.524	4.32	25.9	0.668	0.00	0.00	0.0	3.807	4.35	44.4	0.401	0.00	0.00	0.0	0.00	0.00
SUB.	204.827	0.29	3.5	0.762	0.00	0.00	0.0	431.476	0.37	3.6	1.013	0.00	0.00	0.0	0.00	0.00
6.	19.293	6.01	19.6	3.839	0.00	0.00	0.0	13.303	6.34	34.5	2.934	0.00	0.00	0.0	0.00	0.00
8.	31.564	7.83	33.8	10.623	0.00	0.00	0.0	33.300	8.07	46.1	11.877	0.00	0.00	0.0	0.00	0.00
SUB.	50.857	7.14	28.4	14.462	0.00	0.00	0.0	46.603	7.57	42.8	14.811	0.00	0.00	0.0	0.00	0.00
10.	30.158	9.78	40.1	15.776	140.79	0.00	670.6	32.719	9.97	52.7	17.799	257.59	0.00	1199.5	13.34	13.29
12.	18.749	12.03	46.0	14.830	134.35	0.00	617.5	20.250	11.83	60.2	15.493	284.52	0.00	1328.7	12.82	12.81
14.	7.973	13.72	51.1	8.202	92.26	0.00	476.0	15.702	13.92	63.1	16.616	343.96	0.00	1751.1	11.68	11.68
16.	3.667	15.73	56.6	4.956	58.52	0.00	312.7	5.515	15.86	67.9	7.570	173.36	0.00	891.1	11.00	11.00
SUB.	60.546	11.36	44.3	43.764	425.93	0.00	2076.9	74.186	11.75	58.1	57.478	1059.43	0.00	5170.4	12.29	12.24
18.	1.933	17.93	46.9	3.396	33.42	0.00	178.3	2.671	17.56	72.8	4.496	114.82	0.00	612.6	11.00	11.00
20.	1.333	19.56	48.4	2.786	27.43	0.00	153.6	3.018	19.77	74.2	6.440	169.56	0.00	947.0	11.00	11.00
22.	0.199	21.49	70.9	0.500	13.07	0.00	74.9	1.120	21.99	59.5	2.956	67.13	0.00	347.2	11.00	11.00
24.	0.320	23.74	72.6	0.984	20.36	0.00	119.7	0.181	24.30	80.2	0.581	17.51	0.00	111.4	10.00	10.00
26.	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.139	25.18	77.5	0.480	14.21	0.00	90.9	10.00	10.00
28.	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.00	0.00
30.	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.00	0.00
32.	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.00	0.00
34.	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.00	0.00
36.	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.00	0.00
38.	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.00	0.00
40.	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.000	0.00	0.0	0.000	0.00	0.00	0.0	0.00	0.00
SUB.	3.785	19.19	50.9	7.666	94.29	0.00	526.5	7.128	19.51	71.6	14.953	383.23	0.00	2109.1	10.92	10.91
TOTAL	320.015	3.69	15.7	66.654	520.21	0.00	2603.4	559.392	2.73	14.9	88.255	1442.66	0.00	7279.6	11.93	11.85
>=5"+	115.188	9.75	37.5	65.892	520.21	0.00	2603.4	127.916	10.66	53.3	87.243	1442.66	0.00	7279.6	11.93	11.85

8. Ran REPUTE program against age-based stand table from FVSSTAND Alone post processor that is most similar to the Compute 3 *.avc table. Renamed newly created REPUTE regeneration addfile to the stand type name (i.e. R_P9HMHP.kcp).



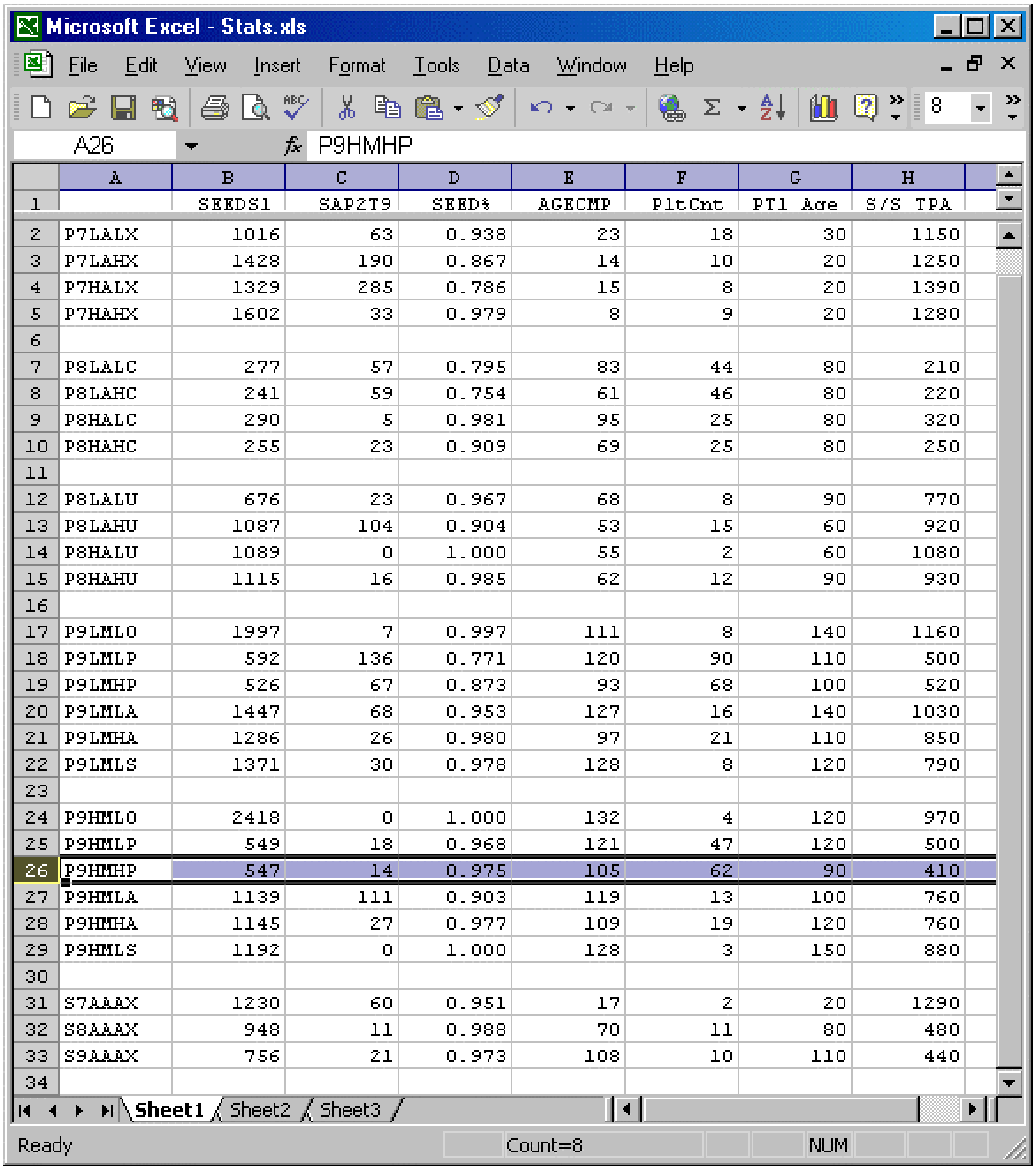
9. Edited regeneration addfile to update size class seedling tally to match stand type and FVSSTAND stand table values.



Line two of the addfile was updated to:

```
CYCLE GE 0 AND SIZCLS EQ 1 AND SpMcDBH(1,ALL,0,0,2,0,999,0) LT 410
```

Construction of a spreadsheet to track the developing factors relative to regeneration aspects per stand type is highly recommended. A total of 27 stand type regeneration addfiles were developed for the Black Hills Phase II Amendment. Refer to Figure IV-1 for a listing of the vital statistics associated with the regeneration imputation process. Similar addfiles were created for the remainder of the 26 regeneration stand types. These text files are available from the Forest Management Service Center (FMSC) in Fort Collins, Colorado.



	A	B	C	D	E	F	G	H
1		SEEDS1	SAPZT9	SEED%	AGECMP	PltCnt	PT1 Age	S/S TPA
2	P7LALX	1016	63	0.938	23	18	30	1150
3	P7LAHX	1428	190	0.867	14	10	20	1250
4	P7HALX	1329	285	0.786	15	8	20	1390
5	P7HAHX	1602	33	0.979	8	9	20	1280
6								
7	P8LALC	277	57	0.795	83	44	80	210
8	P8LAHC	241	59	0.754	61	46	80	220
9	P8HALC	290	5	0.981	95	25	80	320
10	P8HAHC	255	23	0.909	69	25	80	250
11								
12	P8LALU	676	23	0.967	68	8	90	770
13	P8LAHU	1087	104	0.904	53	15	60	920
14	P8HALU	1089	0	1.000	55	2	60	1080
15	P8HAHU	1115	16	0.985	62	12	90	930
16								
17	P9LMLO	1997	7	0.997	111	8	140	1160
18	P9LMLP	592	136	0.771	120	90	110	500
19	P9LMHP	526	67	0.873	93	68	100	520
20	P9LMLA	1447	68	0.953	127	16	140	1030
21	P9LMHA	1286	26	0.980	97	21	110	850
22	P9LMLS	1371	30	0.978	128	8	120	790
23								
24	P9HMLO	2418	0	1.000	132	4	120	970
25	P9HMLP	549	18	0.968	121	47	120	500
26	P9HMHP	547	14	0.975	105	62	90	410
27	P9HMLA	1139	111	0.903	119	13	100	760
28	P9HMHA	1145	27	0.977	109	19	120	760
29	P9HMLS	1192	0	1.000	128	3	150	880
30								
31	S7AAAX	1230	60	0.951	17	2	20	1290
32	S8AAAX	948	11	0.988	70	11	80	480
33	S9AAAX	756	21	0.973	108	10	110	440
34								

Figure IV-1 – Evaluation Criteria for Developing Regeneration Keyword Component Addfile

B. Mortality Matters

The mortality model used in the Central Rockies variant is based on Stand Density Index. It is a theoretical model with origins back to the 1930's. Reineke postulated in 1933 that any pure, fully stocked, even-aged stand of a given average stand diameter contained approximately the same number of trees per acre as any other pure, fully stocked, even-aged stand of the same species that had the same average stand diameter. Thus, the most important factor in estimating stand density is the average stand diameter (D_R). Reineke proposed that the number of trees per acre (TPA) in a normal density stand could be expressed as:

$$TPA = a*(D_R)^b$$

The coefficient "b" has been found to be very close to "-1.605". (Note: this concept approximates the maximum size-density relationship of plant biology known as the -3/2 power law). Reineke defined 'Stand Density Index' (SDI) as the number of trees corresponding to D_R equal to 10 inches. From this, SDI is computed:

$$SDI = TPA*(D_R/10.0)^{1.605}$$

Using SDI, it is possible to compare stands at different stages of development. Regarding FVS mortality theory, density related mortality starts to occur when a stand reaches 55 percent of maximum SDI. Mortality increases as the stand's SDI increases and once a stand reaches 85 percent of maximum SDI, supposedly it stays there.

1. Maximum SDI

To control the mortality submodel within FVS, the SDI maximum value must be determined. An obvious source to quantify maximum SDI would be research literature pertaining to the desired forest cover type. Edminster, in his publication "Stand Density and Stocking in Even-Aged Ponderosa Pine Stands" that appeared in the 1987 Symposium Proceedings for "Ponderosa Pine: The Species and Its Management", cited a mean stand density index of 419. Natural stand data was assembled from throughout the Central and Southwest Rocky Mountain region. A screening process was invoked to qualify stands that used the following criteria: (1) Ponderosa Pine must have been the tree species used for site index determination; (2) the forest type must have been Ponderosa Pine; (3) at least 80 percent of the species composition, in terms of basal area, must have been Ponderosa Pine; (4) 90 percent of the sampled points in a stand must have been tallied trees and the quadratic-mean-diameter (QMD) for each point must be 1.0 inches or larger; (5) stands must have been relatively even-aged to permit computation of a meaningful QMD.

From a forest modeling standpoint, there is a problem with these sideboards to the analysis. That is that the maximum SDI that was derived is not truly operationally based. The selected stands are very homogeneous. The forest at-large is very heterogeneous with regard to stocking and structure. Normally, SDI maximum values derived from research tend to over estimate the carrying capacity of general forest sites.

A proxy for the maximum SDI can be derived from the inventory data sets that are used for the planning effort. Simply compute the SDI for each stand in the inventory. Select the upper 3 percent of the per stand SDI values. Compute the statistical mean for this subset. This value is often termed the "Average Maximum Density" (AMD). Following this procedure, the AMD for the Black Hills Phase II Amendment, based on the previously described inventory data set, was determine to be 400. This appears to represent the average upper echelon of stand density that can be achieved by stands within the Black Hills National Forest. To configure FVS to conform to this stand development pattern, through experience, the AMD value needs to be multiplied by 0.85 to properly parameterize the SDIMax keyword. The end result is that the mortality submodel will only then behaves in a manner similar to that observed in the empirical data. The maximum stand density index value entered on the SDIMax keyword was 340 for the Phase II analysis.

2. Morphological Cap

The FVS model does not automatically kill trees at a given tree age. In essence, trees can live forever. Only recently has tree age been incorporated into the program. However, there is a pending need to refine and validate this calculation. Thus, tree senescence and death must be handled by the user. Without full implementation of tree age tracking, tree size needs to be used as a surrogate. Examination of the inventory data set provides information on the expected largest size attainable. For the Black Hills Phase II project, inspection of stand tables generated by the FVSSTAND Alone post processor revealed that no trees were inventoried on the Forest larger than 30" in diameter. Inserting a FixMort keyword into the simulation and specifying 100 percent kill of trees greater than a specified diameter insures 100 percent morality of trees of a particular size. Refer to Figures IV-2a-b, inspect diameter range greater than or equal to 25-inches.

3. Senescence Filter

A reasonable assumption would be that trees start to falter prior to their morphological cap size. Beginning at some relative tree size, more and more trees will die as they get larger. This senescence pattern is different for single versus multi-storied stands. Trial and error is the best method of finding reasonable results to set up FixMort keywords to represent stand development. Refer to Figures IV-2a-b, examine diameter range less than 25 inches. Attributes from existing stands provided a perspective of expected future structures.

```
******************************************************************************
* FixMort_H.kcp --- Mortality Adjustment Keywords for Single Storied Stand
*                   _H = High Range QMD Size Class Qualifier
*  - Seeds/Saps diameter classes --> Shade induced mortality
*  - Mature diameter classes     --> Senescence filter
*  - Overmature diameter class   --> Morphological cap
******************************************************************************
FixMort           0       All    0.9000        .0        .2         1         0
FixMort           0       All    0.4500        .2         1         1         0
FixMort           0       All    0.1500        25        27         1         0
FixMort           0       All    0.7500        27        29         1         0
FixMort           0       All    1.0000        29        99         1         0
```

Figure IV-2a – FixMort Keyword Mortality Adjustments for Single Storied Stands

```
****************************************************************************
* FixMort_L.kcp --- Mortality Adjustment Keywords for Multi-Storied Stands
*                  _L = Low Range QMD Size Class Qualifier
*  - Seeds/Saps diameter classes --> Step-down distribution
*  - Young diameter classes      --> Additive constant
*  - Mature diameter classes     --> Senescence filter
*  - Overmature diameter class   --> Morphological cap
****************************************************************************
FixMort          0       All    0.7500        .0        .2         1         0
FixMort          0       All    0.4500        .2         3         1         0
FixMort          0       All    0.1500         3         5         1         0
FixMort          0       All    0.0500         5         9         1         0
FixMort          0       All    0.0500         9        15         1         0
FixMort          0       All    0.0500        15        19         1         0
FixMort          0       All    0.1500        19        25         1         0
FixMort          0       All    0.4500        25        27         1         0
FixMort          0       All    0.7500        27        29         1         0
FixMort          0       All    1.0000        29        99         1         0
```

Figure IV-2b – FixMort Keyword Mortality Adjustments for Multi- Storied Stands

C. Let Grow

Natural growth runs are a common starting point in the development of yield files for forest planning. It is quite possible in this day of limited human intervention in forest management that many stands will simply be left to let grow through the planning horizon. From a yield modeling standpoint, this scenario may appear to be the most simplest to construct. However, due to our limited knowledge of older stand structures, this runstream may require the most time and imagination. Cultured stands are fairly straightforward with regard to stocking density at various stand ages. Also, the regeneration response may be highly regulated. Natural stands that are left to grow are definitely more complicated to model. Forests are not static and in some cases are very dynamic over short time periods.

When charged with developing yield profiles for stands that receive no treatment throughout the planning horizon, two forest structures had to be considered. Both have to do with forest layering. Single storied stands that originate from forest disturbance, either human or natural, will evolve differently from multi-storied stands. Competition dynamics for light and moisture are drastically different. With this in mind, separate runs were produced for single-storied stands and multi-storied stands. The size class qualifier based on quadratic mean diameter of the stand type designation allows for differentiation of the stand stories. An "L" attribute meant a stand type met the minimum requirements to be classified within a specified size domain but had significant minor components to draw down the QMD within the class. An "H" denoted that the stand type clearly met the size class requirement and that the majority of the stand resided within the diameter breaks for the class.

1. Ponderosa Pine – Single-Storied – High Site

A comparison was conducted between measured stand data versus modeled stand data for: the Ponderosa Pine overstory cover type; predominantly single-storied stands; residing on higher productivity sites. A subjective development path was postulated by combining the stand types for the various size classes into a composite yield stream as follows:

P6HAHX → P7HAHX → P8HMHC → P9HMHP

Nonstocked → Seeds/Saps → Poletimber → Sawtimber

The inventory plot sample per stand type was:

P6HAHX	=	5 plots	
P7HAHX	=	9 plots	(one plot dropped with inordinate number of seedlings)
P8HMHC	=	17 plots	
P9HMHP	=	40 plots	(one plot dropped with inordinate number of seedlings)

Figure IV-3a contains the yield table generated by the FVSSTAND Alone post processor for the measured stand data. Inventory plots were projected for two decades to provide minimal overlap of stand ages. Note the column for 'Forest Type'. A code of 999 indicates a nonstocked stand. A code of 221 indicates a Ponderosa Pine forest type. A code of 901 indicates a Quaking Aspen forest type. The percentage value following the forest type code represents the proportion of plots comprising the dominant forest type call (99% equates to 100%). The inventory plot displayed for the 40 year old age class was principally aspen.

Figure IV-3b contains the yield table for the modeled stand data. Inventory plots were projected for sixteen decades to provide maximum overlap of stand ages. Note that the forest type stays consistently in Ponderosa Pine. Compare and contrast columns for live tree numbers per acre, basal area, and volume. Finding the right mix of regeneration and mortality components is challenging. The 'art' of the craft of forest modeling comes into part. However, staying true to the measured data as possible renders a degree of credibility.

During the last round of forest planning, emphasis was placed on commodity production and extraction. During this round of forest plan revision, the emphasis is on forest structure. Thus, it is extremely important that the distribution of trees per size class match measured trends. Getting the board foot volume yield correct is still important. However, if the board foot volume is rendered by a few large trees rather than on several smaller trees, this is an overstatement of the stand structure. Non-commodity resources such as wildlife habitat may not be accurately represented. Extreme care needs to be taken to properly portray stand development within the realm of known reality (measured trends).

Figures IV-4a-e are graphical comparisons of the P#HH strata using the Stand Visualization System (SVS) software. Thirty-year age intervals were selected to show stand progression. Also, these age brackets appeared to have adequate measured plot samples. Notice similarities and discrepancies between measured and modeled age classes. The goal of the analysts is to maximize the positives and minimize the negative components between measured versus modeled data.

Figures IV-5a-e are graphical depictions of the P#HH stand type using the SVS program for the 180-300 year age classes. These slides go beyond the realm of measured data. The senescence filter and morphological cap should induce mortality to larger trees. Regeneration imputation should fill in the gap left by the old dead trees. It is postulated that a steady-state dynamic should characterize the long-term stand development.

Proj. Year.	Stand Age.	Site. Index	Std_Den Index	Forest Type	Plot. Acres	Live Trees/Ac	Live Avg_DBH	Live Avg_Hgt	Live BA/Ac	Live Cu-A/Ac	Live Bd/Ac
0	0.00	69.00	22.00	999/99%	4.00	44.95	5.18	25.24	12.00	130.07	729.15
10	9.00	68.00	53.00	221/57%	14.00	1116.13	0.36	3.00	14.76	180.34	949.47
20	19.00	68.00	69.00	221/57%	14.00	1073.79	1.22	8.58	25.67	295.30	1526.45
30	28.00	69.00	151.00	221/54%	11.00	1105.38	2.62	14.17	59.49	404.99	2053.79
40	40.00	79.00	221.00	901/99%	1.00	375.80	6.26	36.29	121.18	1786.16	8551.65
50	50.00	79.00	228.00	221/50%	2.00	835.20	2.93	17.07	116.97	1428.85	6925.77
60	55.00	80.00	172.00	221/99%	5.00	478.84	4.52	23.54	83.96	502.40	2316.87
70	66.00	76.00	202.00	221/99%	9.00	442.94	5.23	28.03	102.53	782.73	3722.26
80	75.00	76.00	211.00	221/99%	15.00	594.68	3.68	20.56	108.35	1111.71	5452.58
90	85.00	74.00	206.00	221/99%	19.00	640.08	3.22	18.34	108.96	1431.50	7096.64
100	95.00	73.00	210.00	221/99%	26.00	880.13	2.38	14.00	109.47	1638.64	8209.42
110	106.00	72.00	200.00	221/99%	26.00	1015.69	1.88	11.68	104.97	1782.68	8999.56
120	116.00	70.00	197.00	221/99%	25.00	930.63	2.19	13.77	106.16	1925.36	9804.67
130	126.00	70.00	203.00	221/94%	17.00	1186.77	1.64	10.71	108.55	2239.16	11569.39
140	135.00	70.00	215.00	221/90%	11.00	1101.84	1.95	12.21	118.90	2526.30	13337.31
150	145.00	70.00	226.00	221/99%	6.00	1204.39	2.24	12.67	125.45	2781.21	15021.11
160	156.00	70.00	190.00	221/99%	4.00	508.61	3.06	18.53	113.28	2787.57	15048.47
170	165.00	71.00	168.00	221/99%	3.00	151.17	8.96	50.05	105.88	2744.57	15011.70
180	175.00	73.00	135.00	221/99%	1.00	219.44	5.15	30.40	85.61	2337.36	12993.52

Figure IV-3a – Yield Table for P#HH Measured Stand Data

Proj. Year.	Stand Age.	Site. Index	Std_Den Index	Forest Type	Plot. Acres	Live Trees/Ac	Live Avg_DBH	Live Avg_Hgt	Live BA/Ac	Live Cu-A/Ac	Live Bd/Ac
0	0.00	69.00	22.00	999/99%	4.00	44.95	5.18	25.24	12.00	130.07	729.15
10	9.00	68.00	65.00	221/71%	14.00	1459.74	0.50	3.89	16.99	180.34	949.47
20	19.00	68.00	91.00	221/85%	14.00	1204.32	1.46	8.95	33.14	285.64	1489.81
30	29.00	69.00	168.00	221/80%	15.00	1708.71	1.83	10.61	63.07	433.55	2237.83
40	39.00	69.00	224.00	221/80%	15.00	1822.89	2.18	12.37	87.58	560.04	2940.99
50	49.00	70.00	232.00	221/81%	16.00	1604.45	2.39	13.68	95.22	600.78	3141.22
60	58.00	72.00	215.00	221/85%	20.00	1039.50	3.11	17.46	95.44	637.16	3306.85
70	68.00	72.00	229.00	221/83%	24.00	833.54	3.73	21.05	107.77	781.63	4046.12
80	77.00	72.00	232.00	221/87%	31.00	812.19	3.54	20.27	112.17	966.38	4934.47
90	87.00	73.00	221.00	221/89%	39.00	672.07	3.78	21.77	112.07	1263.44	6438.73
100	96.00	72.00	219.00	221/92%	50.00	766.98	3.10	18.34	113.00	1536.60	7846.16
110	106.00	72.00	207.00	221/91%	57.00	689.79	3.17	18.70	109.97	1737.81	8979.43
120	116.00	72.00	201.00	221/92%	64.00	528.31	3.91	22.80	110.72	1959.62	10258.78
130	126.00	72.00	204.00	221/92%	67.00	665.57	3.07	18.31	112.56	2169.21	11490.15
140	136.00	72.00	200.00	221/91%	68.00	565.35	3.55	20.64	112.97	2299.02	12285.19
150	146.00	72.00	198.00	221/92%	70.00	524.67	3.76	21.48	113.68	2433.71	13131.42
160	156.00	72.00	197.00	221/91%	71.00	526.97	3.70	20.97	113.93	2495.07	13577.49
170	166.00	72.00	194.00	221/92%	67.00	523.34	3.65	20.37	113.85	2583.86	14213.46
180	176.00	72.00	183.00	221/96%	57.00	516.72	3.47	19.10	108.86	2593.54	14507.79
190	186.00	72.00	184.00	221/96%	57.00	522.29	3.49	19.04	109.46	2588.31	14548.02
200	195.00	72.00	186.00	221/96%	56.00	522.54	3.56	19.25	110.72	2597.21	14630.17
210	205.00	72.00	185.00	221/96%	56.00	512.31	3.62	19.42	110.37	2568.42	14519.61
220	215.00	72.00	186.00	221/96%	55.00	510.82	3.68	19.56	110.78	2525.23	14273.54
230	225.00	72.00	191.00	221/96%	51.00	508.32	3.78	20.00	113.59	2555.13	14398.14
240	235.00	72.00	191.00	221/95%	47.00	509.59	3.79	19.90	113.29	2488.84	14044.88
250	246.00	71.00	191.00	221/97%	40.00	504.53	3.83	20.13	113.66	2466.96	13912.11
260	256.00	70.00	196.00	221/96%	32.00	489.52	3.97	20.88	117.81	2576.73	14332.45
270	266.00	70.00	195.00	221/95%	21.00	491.62	3.91	20.36	118.72	2638.78	14757.12
280	275.00	70.00	190.00	221/92%	14.00	490.31	3.85	20.38	114.52	2564.79	14400.97
290	285.00	70.00	196.00	221/99%	7.00	505.49	3.86	20.39	119.32	2736.94	16088.58
300	296.00	70.00	175.00	221/99%	4.00	481.71	3.68	19.27	104.76	2366.22	13842.34
310	305.00	71.00	182.00	221/99%	3.00	485.06	3.81	19.98	107.98	2378.13	13769.70
320	315.00	73.00	169.00	221/99%	1.00	479.20	3.75	19.13	96.90	1807.37	10828.34

Figure IV-3b – Yield Table for P#HH Modeled Stand Data

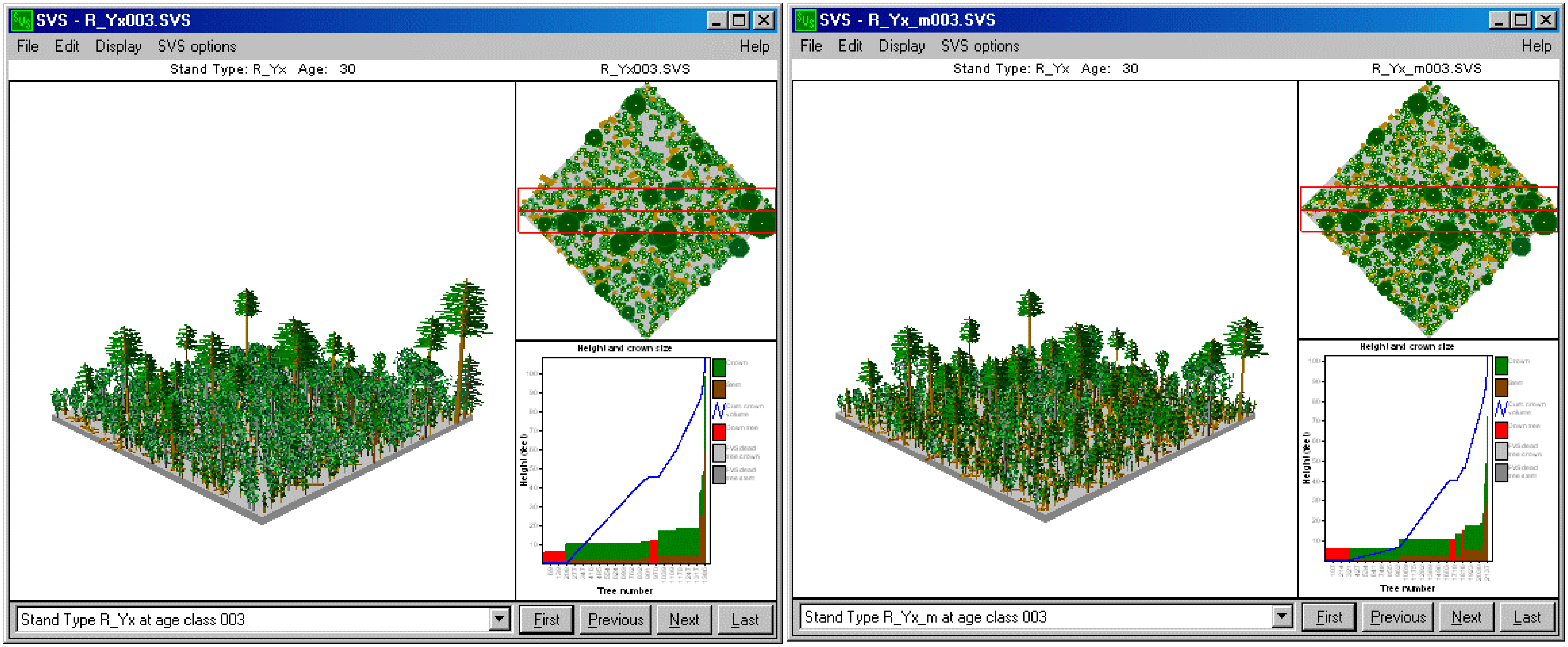


Figure IV-4a -- P#HH Measured versus Modeled Stand Data, Year-30 old Age Class

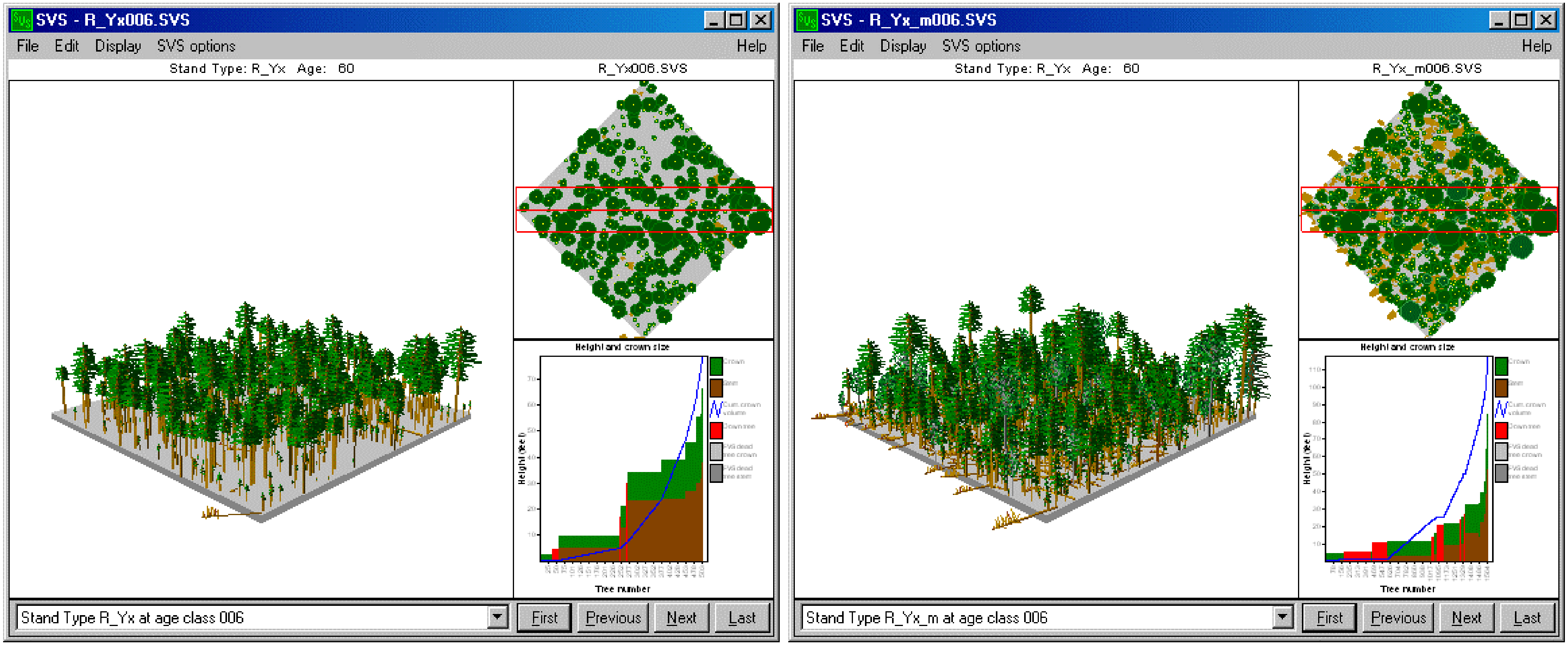


Figure IV-4b -- P#HH Measured versus Modeled Stand Data, Year-60 old Age Class

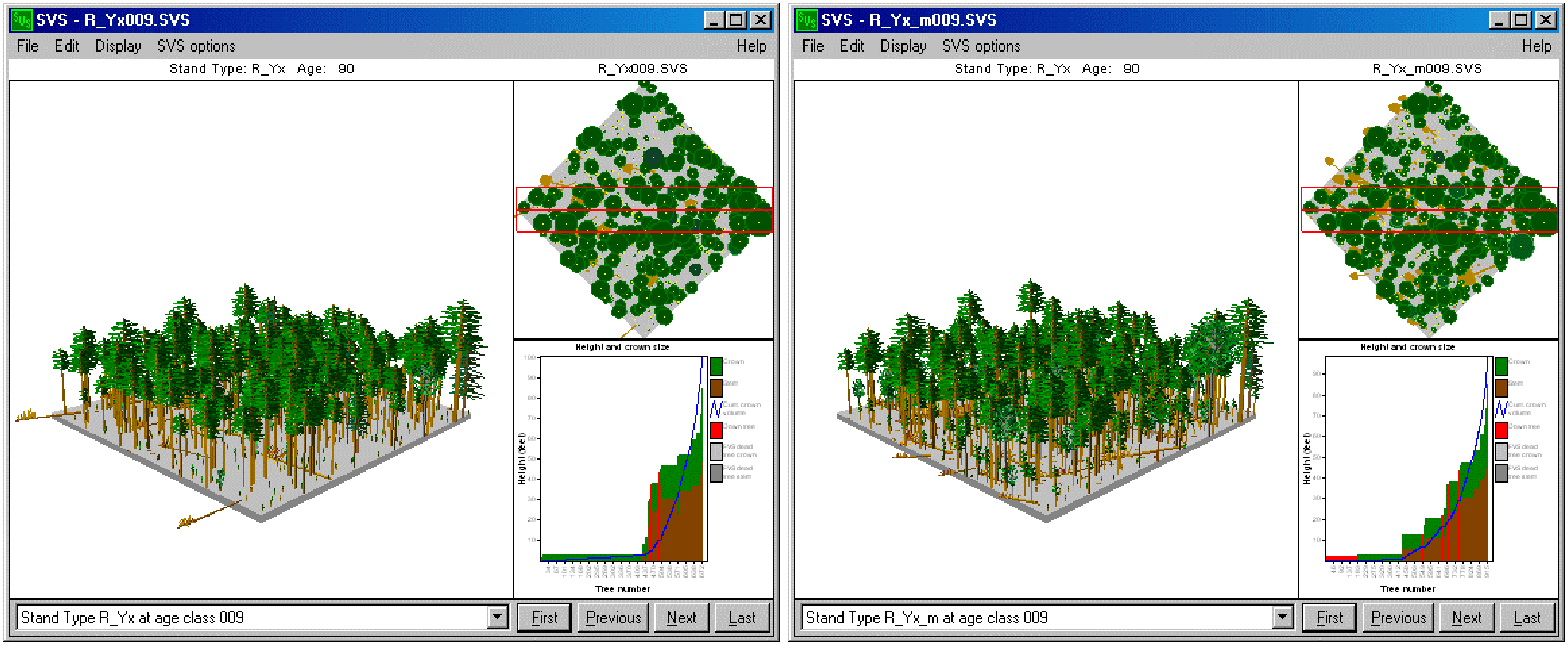


Figure IV-4c -- P#HH Measured versus Modeled Stand Data, Year-90 old Age Class

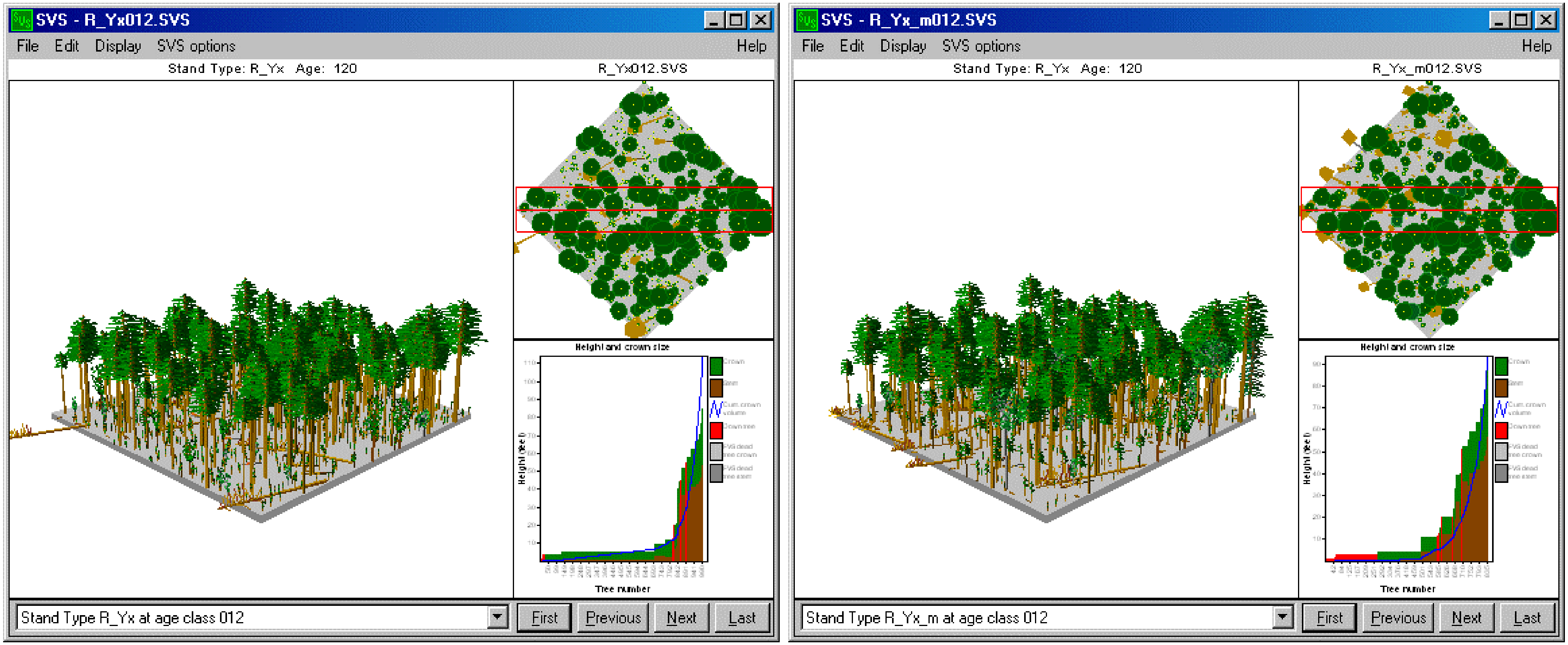


Figure IV-4d -- P#HH Measured versus Modeled Stand Data, Year-120 old Age Class

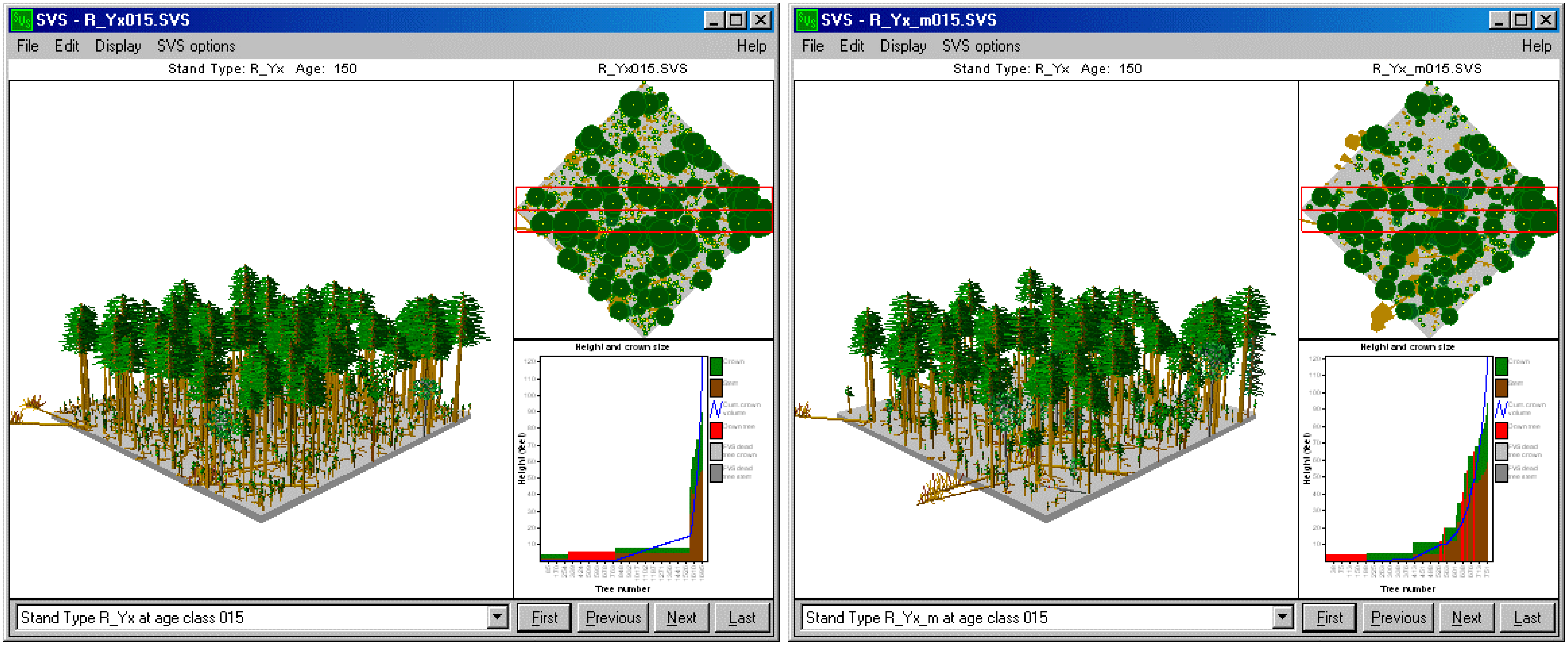


Figure IV-4e -- P#HH Measured versus Modeled Stand Data, Year-150 old Age Class

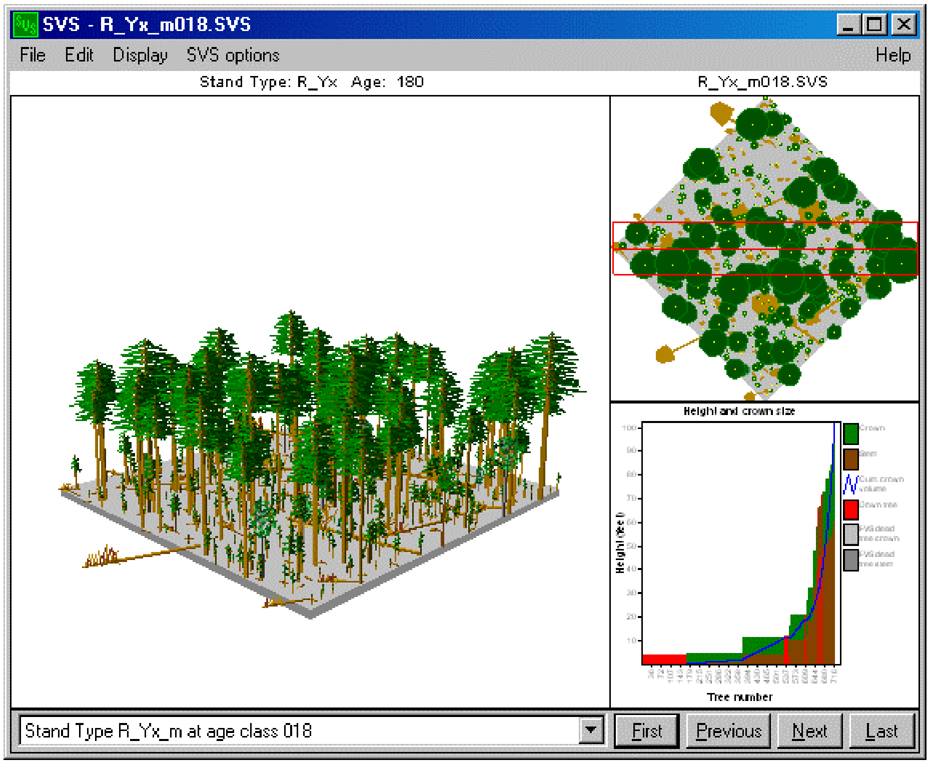


Figure IV-5a -- P#HH Modeled Stand Data, Year-180 old Age Class

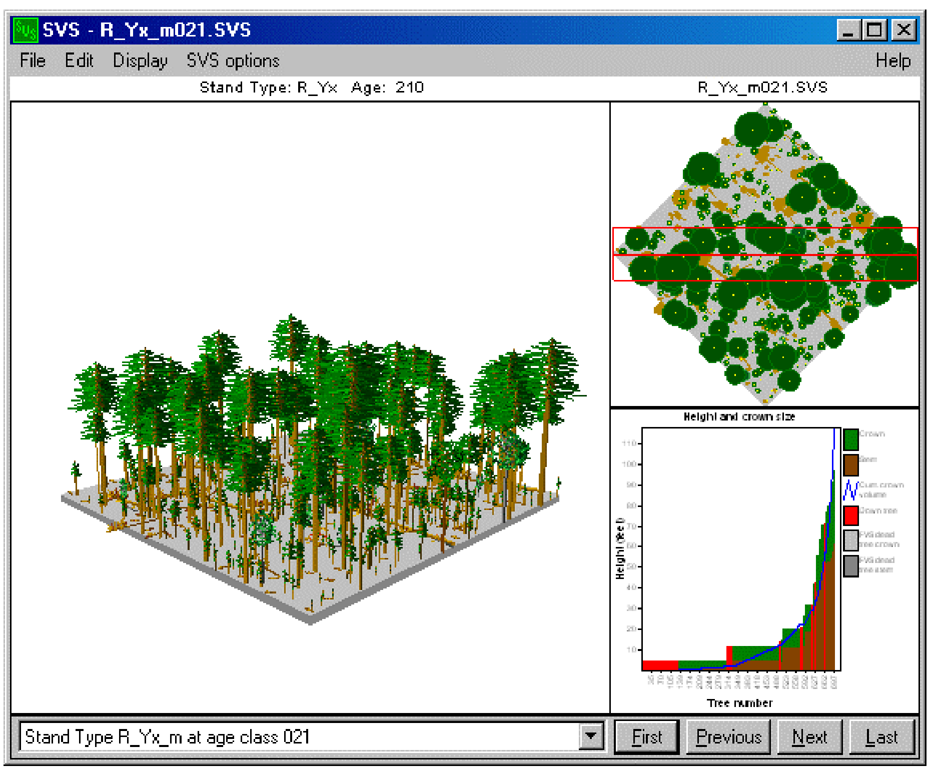


Figure IV-5b -- P#HH Modeled Stand Data, Year-210 old Age Class

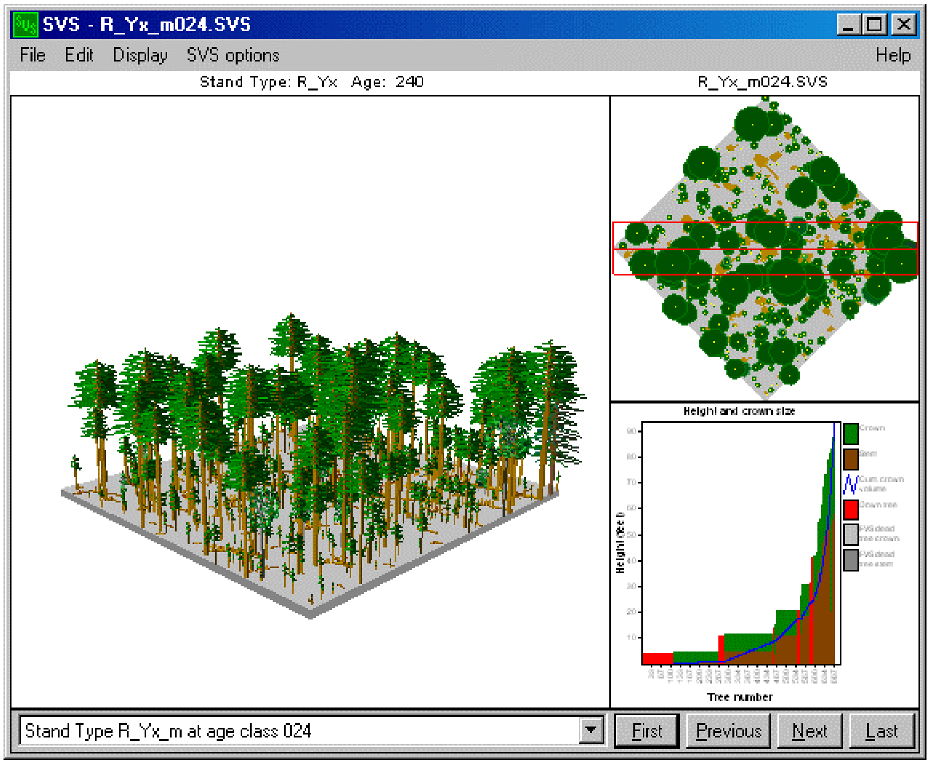


Figure IV-5c -- P#HH Modeled Stand Data, Year-240 old Age Class

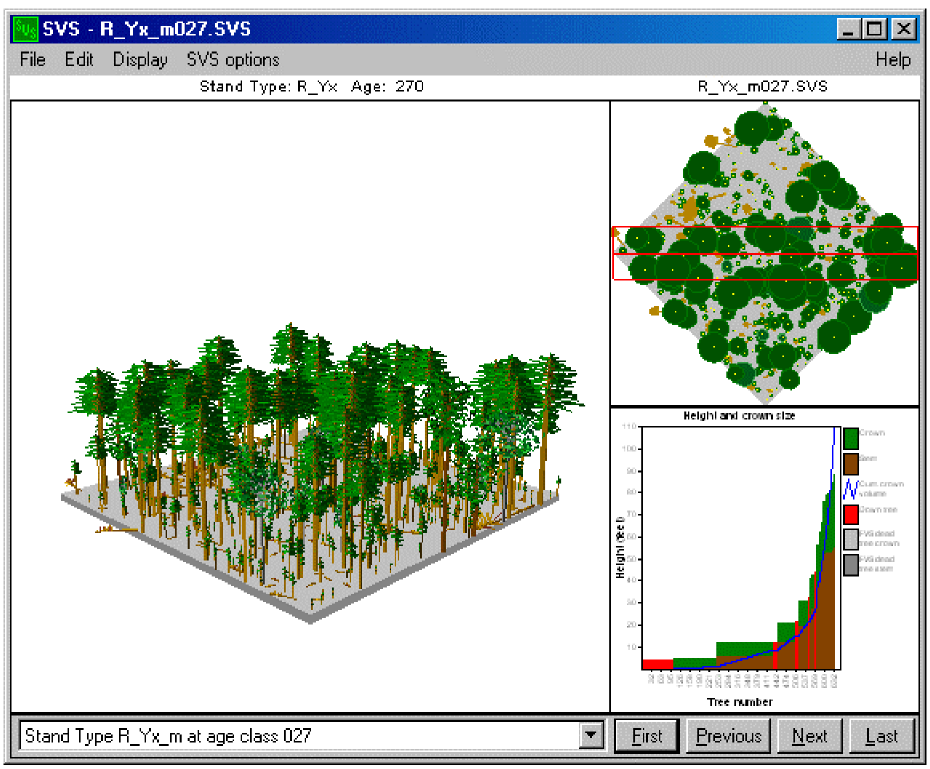


Figure IV-5d -- P#HH Modeled Stand Data, Year-270 old Age Class

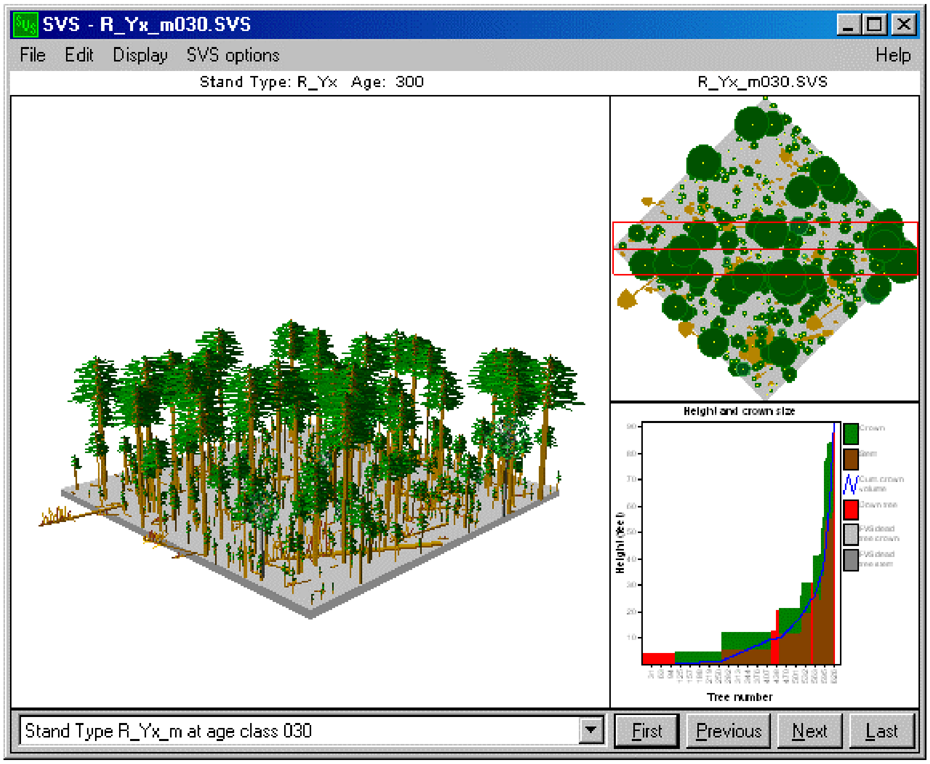


Figure IV-5e -- P#HH Modeled Stand Data, Year-300 old Age Class

2. Ponderosa Pine – Multi-Storied – High Site

An effort was made to differentiate single-storied stands from multi-storied stands for the Black Hills Phase II analysis. To do so, the relationship between the dominant size class and the respective quadratic mean diameter (QMD -- trees 1" diameter and greater) was examined. If the QMD was less than the lower diameter break for a size class, it was surmised that the stand was comprised of additional minor size classes and thus multi-storied. For example, if a size class 9 stand (sawtimber – diameter range 9" and greater) had a QMD of 9" and greater, it was considered to be single-storied. However, if it had a QMD of less than 9", then it was considered to be multi-storied. It was concluded that trees from the sapling and poletimber size classes were reducing the QMD for the sawtimber stand.

Most stands on the Black Hills National Forest are comprised of a mosaic of size classes. Groups of trees reside in close proximity. Size class designations are generally borderline calls. A tree or two within an inventory plot could swing the size class from one class to another. It is a very subtle difference. However, single storied stands vary fundamentally from multi-storied stands. They differ in growth, structure, and volume. These differences were deemed important.

A comparison was conducted between measured stand data versus modeled stand data for: the Ponderosa Pine overstory cover type; predominantly multi-storied stands; residing on higher productivity sites. A subjective development path was postulated by combining the stand types for the various size classes into a composite yield stream as follows:

P6LAHX → P7LAHX → P8LMHC → P9LMHP

Nonstocked → Seeds/Saps → Poletimber → Sawtimber

The inventory plot sample per stand type was:

P6LAHX	=	2 plots
P7LAHX	=	11 plots
P8LMHC	=	21 plots
P9LMHP	=	44 plots

Figure IV-6a contains the yield table generated by the FVSSTAND Alone post processor for the measured stand data. Inventory plots were projected for two decades to provide minimal overlap of stand ages. Figure IV-6b contains the yield table for the modeled stand data. Inventory plots were projected for sixteen decades to provide maximum overlap of stand ages. Compare columns for live tree numbers per acre, basal area, and volume.

Figures IV-7a-e are graphical comparisons of the P#LH strata using the Stand Visualization System (SVS) software. Thirty-year age intervals were selected to show stand progression. Also, these age brackets had adequate measured plot samples. Notice similarities and discrepancies between measured and modeled age classes.

Figures IV-8a-e are graphical depictions of the P#LH stand type using the SVS program for the 180-300 year age classes. These slides go beyond the realm of measured data. The senescence filter and morphological cap should induce mortality to larger trees. Regeneration imputation should fill in the gap left by the old dead trees. It is postulated that a steady-state dynamic should characterize the long-term stand development.

A quick review of the FixMort keywords in Figures IV-2a and 2b would reveal an application difference between single and multi-storied stands. A concerted effort was made to mimic understory shading. For the single-storied stands, the mortality rate for the seedling/sapling class was higher than that used for multi-storied stands. Multi-storied stands should have had more trees scattered through all diameter classes.

Stand and stock tables are available from the Forest Management Service Center in Fort Collins, Colorado. These tables display values by 2-inch diameter class and size class breaks. Trees per acre, basal area, cubic foot volume, and board foot volume attributes comprise the tables.

Proj. Year.	Stand Age.	Site. Index	Std_Den Index	Forest Type	Plot. Acres	LiveAllSx Trees/Ac	LiveAllSx Avg_DBH	LiveAllSx Avg_Hgt	LiveAllSx BA/Ac	LiveAllSx Cu-A/Ac	LiveAllSx Bd/Ac
0	0.00	64.00	0.00	999/99%	1.00	0.00	0.00	0.00	0.00	0.00	0.00
10	9.00	71.00	126.00	901/42%	7.00	2945.95	0.48	3.75	27.70	193.13	1023.76
20	16.00	72.00	111.00	221/50%	12.00	1382.81	1.29	7.93	37.26	191.65	994.60
30	25.00	73.00	118.00	221/58%	12.00	971.65	1.86	11.91	47.50	295.15	1533.82
40	34.00	78.00	151.00	221/87%	8.00	911.00	2.31	13.20	65.89	303.06	1426.64
50	46.00	81.00	174.00	221/99%	6.00	751.85	3.15	17.68	80.36	434.81	1954.15
60	56.00	79.00	194.00	221/92%	14.00	797.70	3.10	17.47	90.88	572.25	2720.44
70	65.00	76.00	208.00	221/95%	21.00	839.62	3.02	18.18	98.71	698.41	3335.88
80	76.00	75.00	215.00	221/96%	27.00	718.54	3.54	21.61	106.25	934.49	4566.21
90	85.00	72.00	206.00	221/99%	29.00	666.27	3.52	21.49	104.01	1060.96	5231.22
100	96.00	69.00	194.00	221/99%	31.00	845.45	2.53	15.20	96.59	1136.55	5623.20
110	105.00	68.00	165.00	221/96%	29.00	692.18	2.65	16.66	83.88	1119.82	5654.61
120	115.00	67.00	168.00	221/94%	19.00	703.59	2.63	15.99	86.53	1190.06	6061.84
130	125.00	69.00	173.00	221/87%	8.00	648.03	3.01	18.99	88.22	1193.46	5949.97
140	136.00	71.00	185.00	221/99%	3.00	765.97	2.89	18.22	98.30	1854.96	10240.80
150	148.00	67.00	124.00	221/99%	3.00	501.52	2.79	17.66	67.34	1443.02	8079.38
160	158.00	67.00	126.00	221/99%	3.00	685.76	1.99	13.08	66.46	1388.27	7822.00
170	168.00	63.00	85.00	221/99%	1.00	563.61	1.76	10.10	42.65	655.82	3499.65

Figure IV-6a – Yield Table for P#LH Measured Stand Data

Proj. Year.	Stand Age.	Site. Index	Std_Den Index	Forest Type	Plot. Acres	LiveAllSx Trees/Ac	LiveAllSx Avg_DBH	LiveAllSx Avg_Hgt	LiveAllSx BA/Ac	LiveAllSx Cu-A/Ac	LiveAllSx Bd/Ac
0	0.00	64.00	0.00	999/99%	1.00	0.00	0.00	0.00	0.00	0.00	0.00
10	9.00	71.00	126.00	901/42%	7.00	2945.95	0.48	3.75	27.70	193.13	1023.76
20	16.00	72.00	111.00	221/50%	12.00	1382.81	1.29	7.93	37.26	191.65	994.60
30	26.00	72.00	118.00	221/61%	13.00	1021.30	1.81	11.49	46.59	272.44	1415.83
40	36.00	75.00	146.00	221/66%	15.00	1013.64	2.15	12.79	62.33	351.98	1754.77
50	46.00	75.00	168.00	221/72%	18.00	937.75	2.53	14.81	75.30	478.48	2326.61
60	56.00	76.00	187.00	221/77%	27.00	925.11	2.68	15.80	86.31	610.73	3013.18
70	66.00	76.00	195.00	221/83%	36.00	854.16	2.87	17.32	93.26	756.44	3700.69
80	76.00	75.00	202.00	221/88%	45.00	725.55	3.35	20.33	100.24	942.09	4693.41
90	86.00	74.00	199.00	221/92%	56.00	649.95	3.51	21.17	101.28	1120.17	5643.79
100	96.00	73.00	196.00	221/94%	67.00	734.20	2.94	17.74	100.52	1306.09	6629.50
110	106.00	72.00	186.00	221/93%	74.00	654.83	3.09	19.06	97.45	1414.40	7267.78
120	116.00	72.00	184.00	221/93%	75.00	637.46	3.07	18.70	98.47	1581.22	8191.64
130	126.00	72.00	183.00	221/93%	75.00	605.37	3.14	18.91	99.77	1753.05	9166.16
140	136.00	72.00	182.00	221/93%	77.00	598.70	3.11	18.63	100.60	1903.51	10036.75
150	146.00	72.00	180.00	221/93%	78.00	572.31	3.16	18.66	100.94	2006.31	10644.39
160	156.00	72.00	179.00	221/93%	78.00	556.71	3.17	18.53	101.56	2089.36	11120.69
170	166.00	72.00	177.00	221/93%	77.00	537.84	3.22	18.53	101.74	2160.15	11516.95
180	175.00	72.00	174.00	221/95%	71.00	527.31	3.20	18.21	100.56	2193.84	11739.62
190	186.00	72.00	171.00	221/96%	66.00	514.29	3.20	18.06	99.39	2187.18	11712.85
200	196.00	72.00	169.00	221/96%	65.00	498.59	3.23	17.97	98.97	2186.28	11746.52
210	206.00	71.00	168.00	221/96%	63.00	484.03	3.26	17.88	99.11	2205.05	11862.00
220	215.00	71.00	165.00	221/96%	60.00	469.25	3.29	17.79	98.01	2174.47	11708.61
230	225.00	70.00	160.00	221/98%	51.00	459.99	3.26	17.56	95.12	2072.64	11149.91
240	236.00	69.00	152.00	221/97%	42.00	448.86	3.20	17.30	90.20	1922.03	10241.15
250	245.00	68.00	146.00	221/96%	33.00	440.43	3.15	16.96	86.04	1791.68	9470.37
260	255.00	67.00	145.00	221/95%	22.00	435.53	3.18	16.70	85.50	1710.77	8813.88
270	266.00	68.00	151.00	221/90%	11.00	438.55	3.24	17.68	89.30	1848.09	9173.20
280	276.00	68.00	142.00	221/99%	4.00	460.64	3.04	16.88	82.79	1612.50	8830.62
290	288.00	67.00	130.00	221/99%	3.00	452.01	2.97	17.18	73.47	1321.63	7103.42
300	298.00	67.00	131.00	221/99%	3.00	439.19	3.02	17.26	73.84	1340.64	7258.28
310	308.00	58.00	150.00	221/99%	1.00	441.59	3.33	16.56	86.84	1408.45	7346.02

Figure IV-6b – Yield Table for P#LH Modeled Stand Data

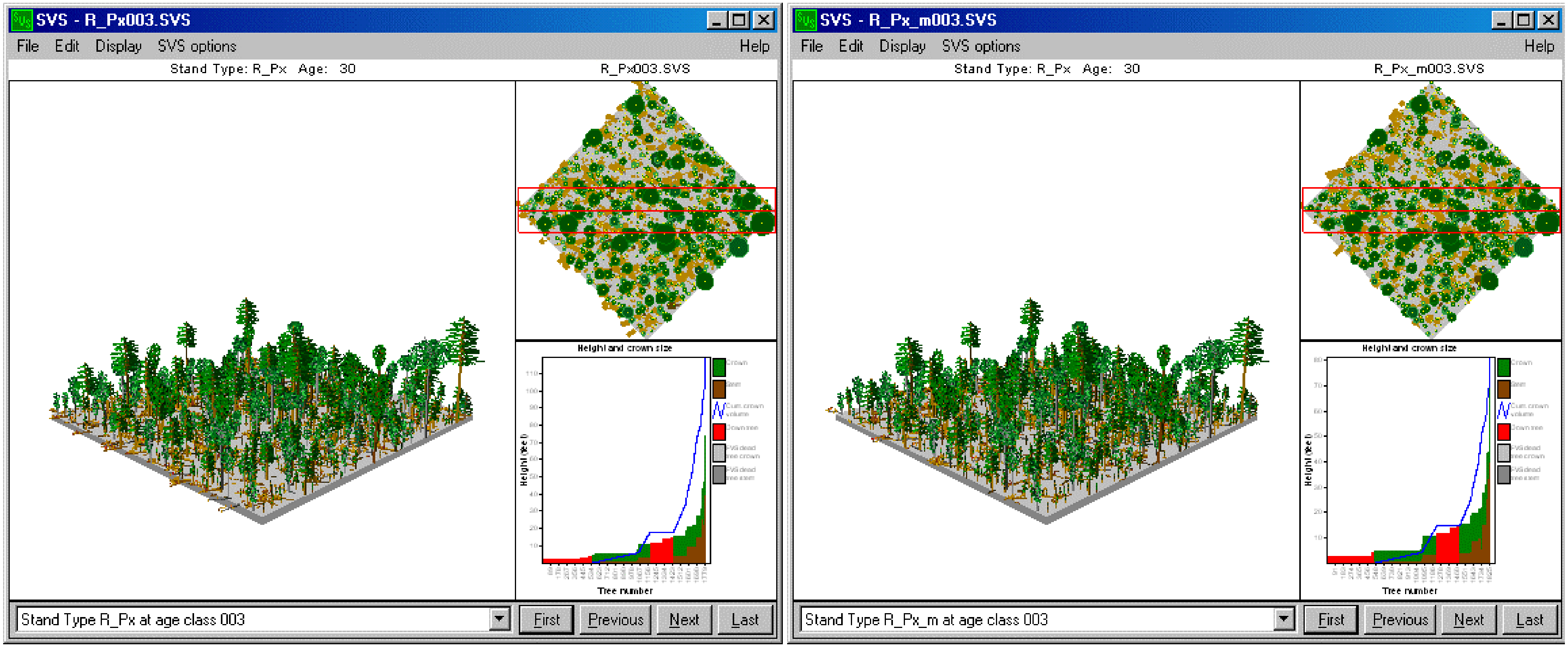


Figure IV-7a -- P#LH Measured versus Modeled Stand Data, Year-30 old Age Class

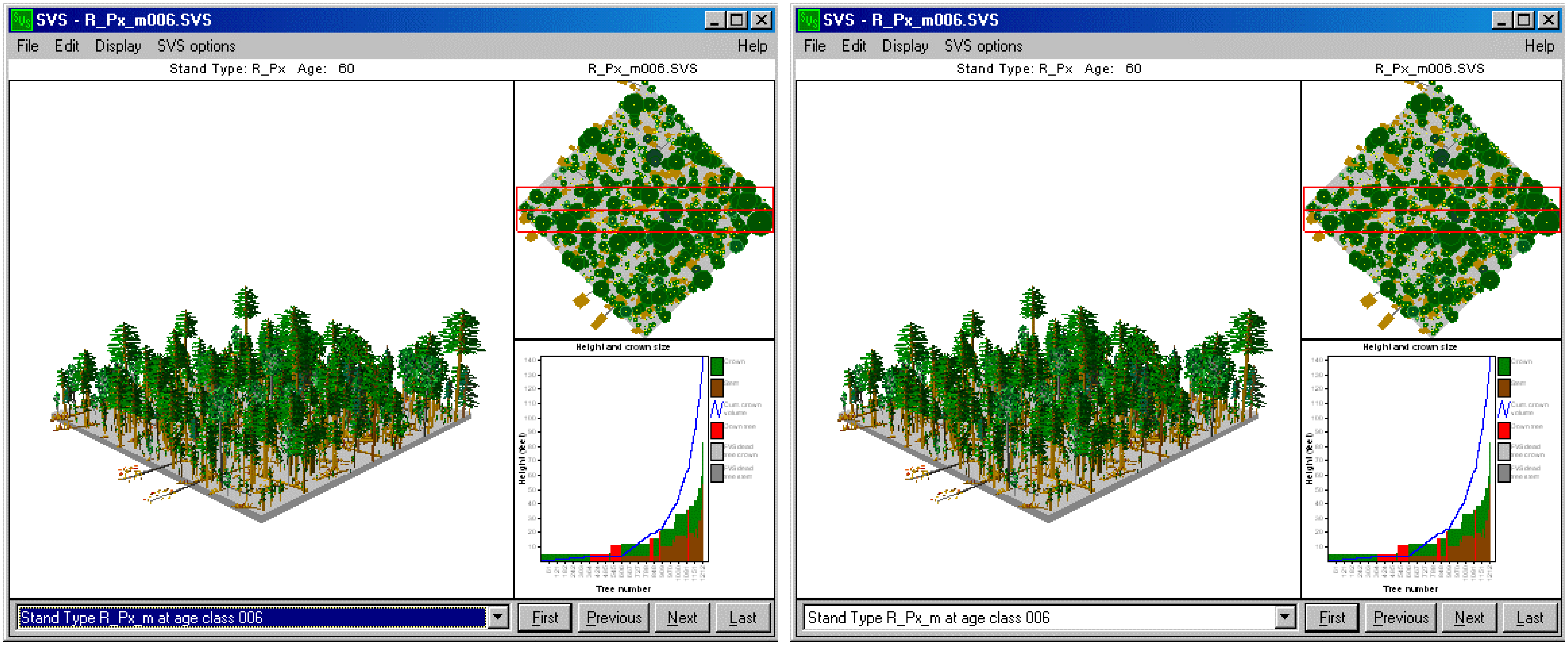


Figure IV-7b -- P#LH Measured versus Modeled Stand Data, Year-60 old Age Class

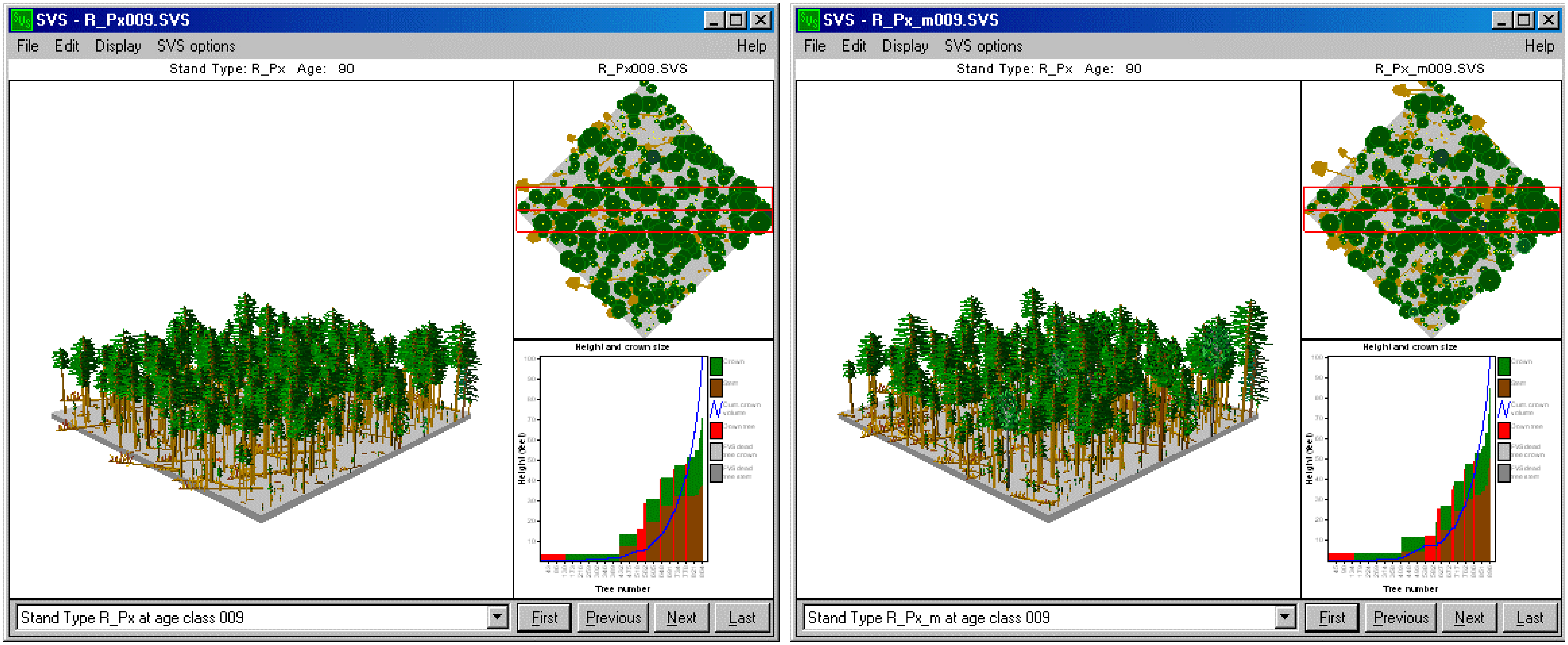


Figure IV-7c -- P#LH Measured versus Modeled Stand Data, Year-90 old Age Class

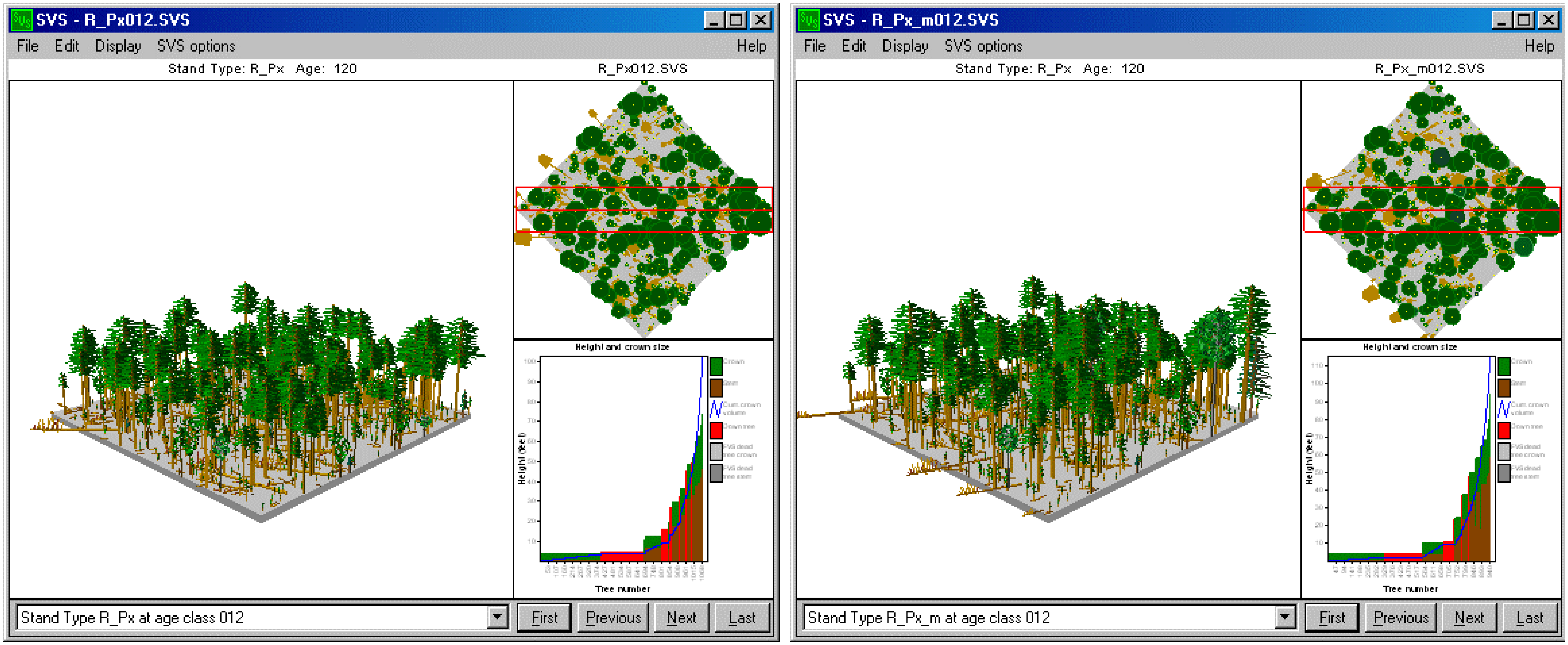


Figure IV-7d -- P#LH Measured versus Modeled Stand Data, Year-120 old Age Class

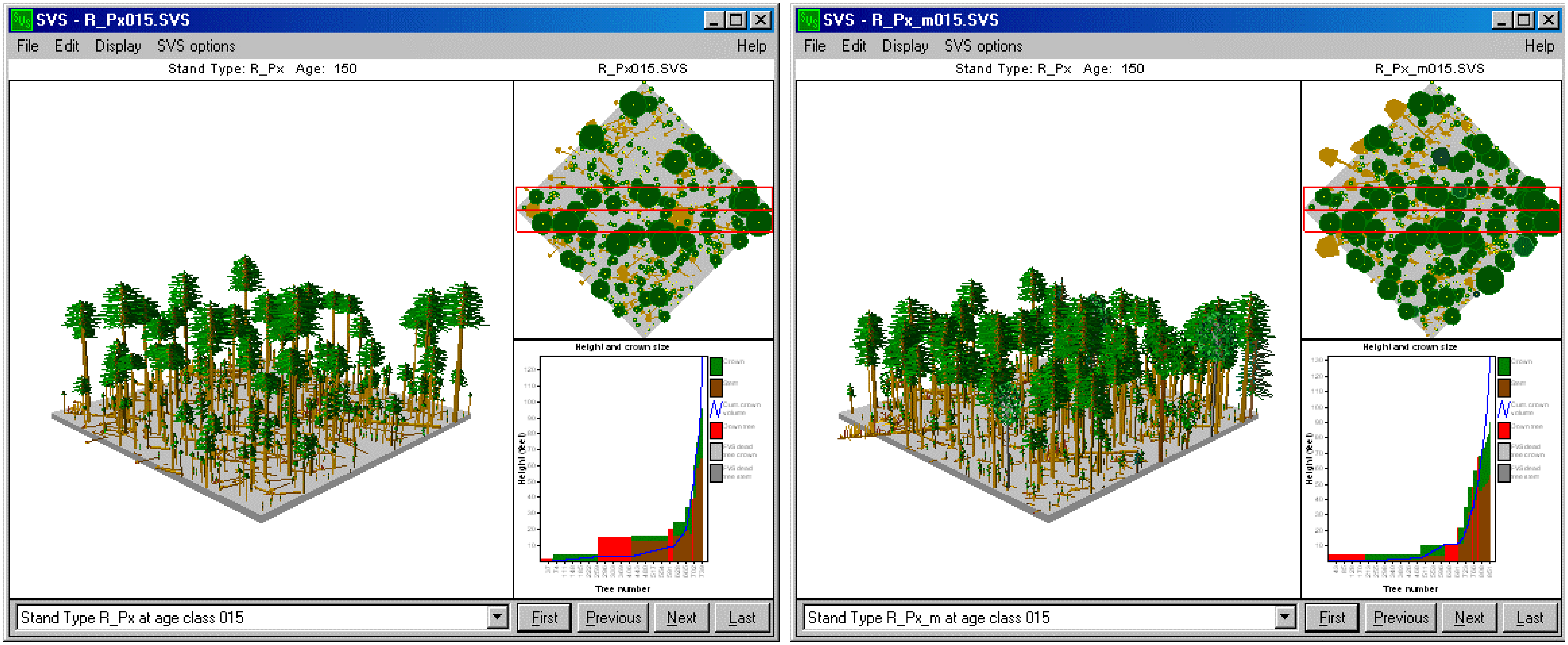


Figure IV-7e -- P#LH Measured versus Modeled Stand Data, Year-150 old Age Class

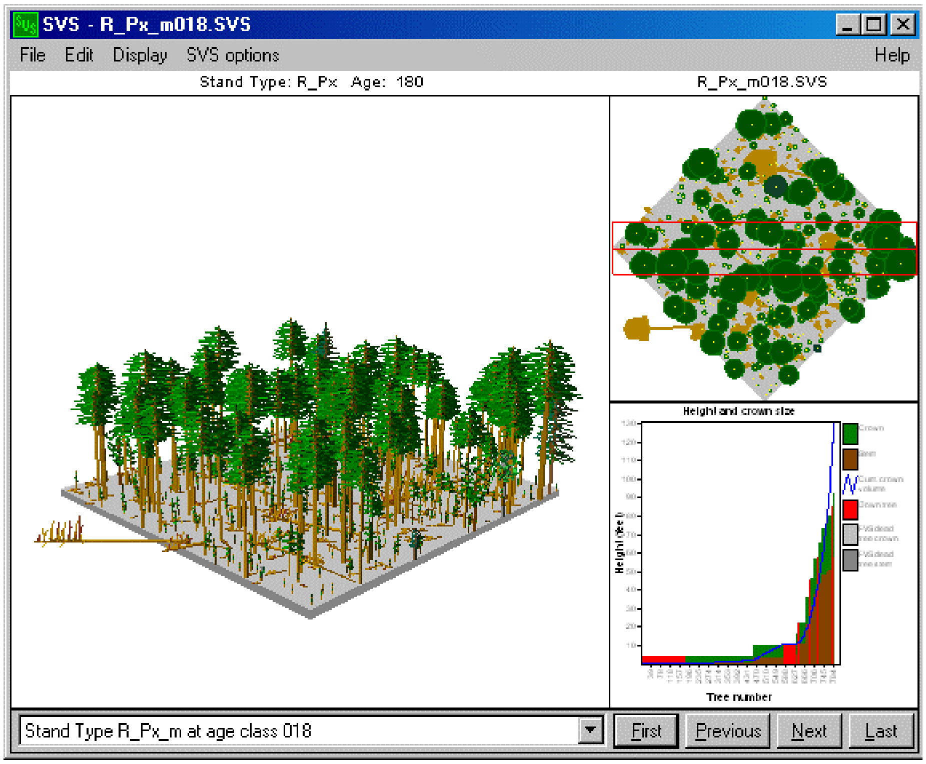


Figure IV-8a -- P#LH Modeled Stand Data, Year-180 old Age Class

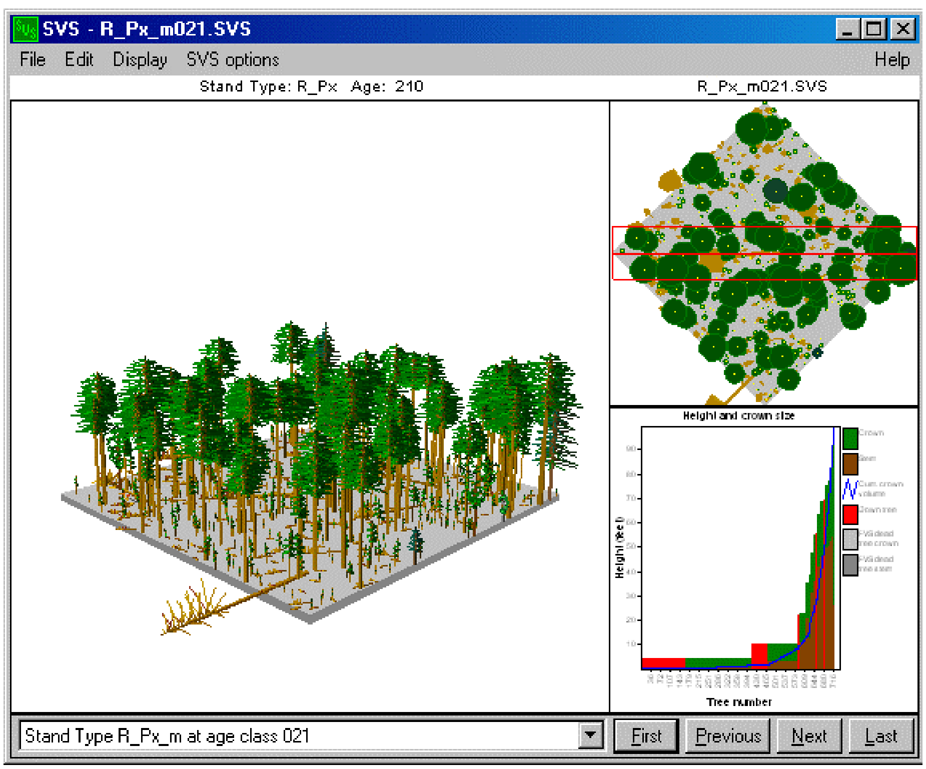


Figure IV-8b -- P#LH Modeled Stand Data, Year-210 old Age Class

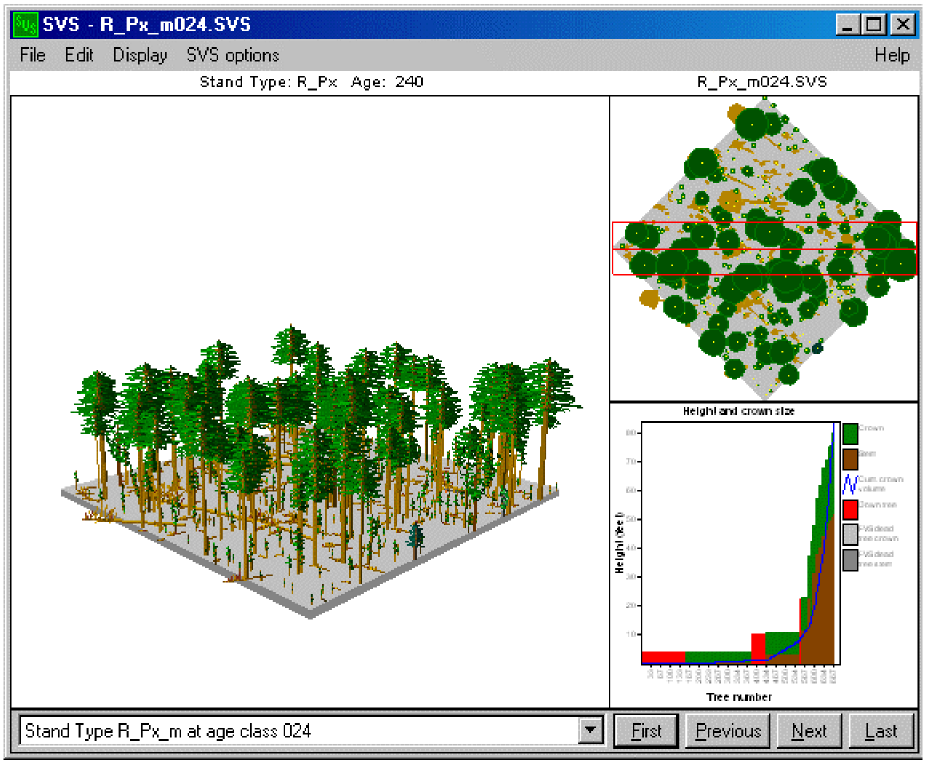


Figure IV-8c -- P#LH Modeled Stand Data, Year-240 old Age Class

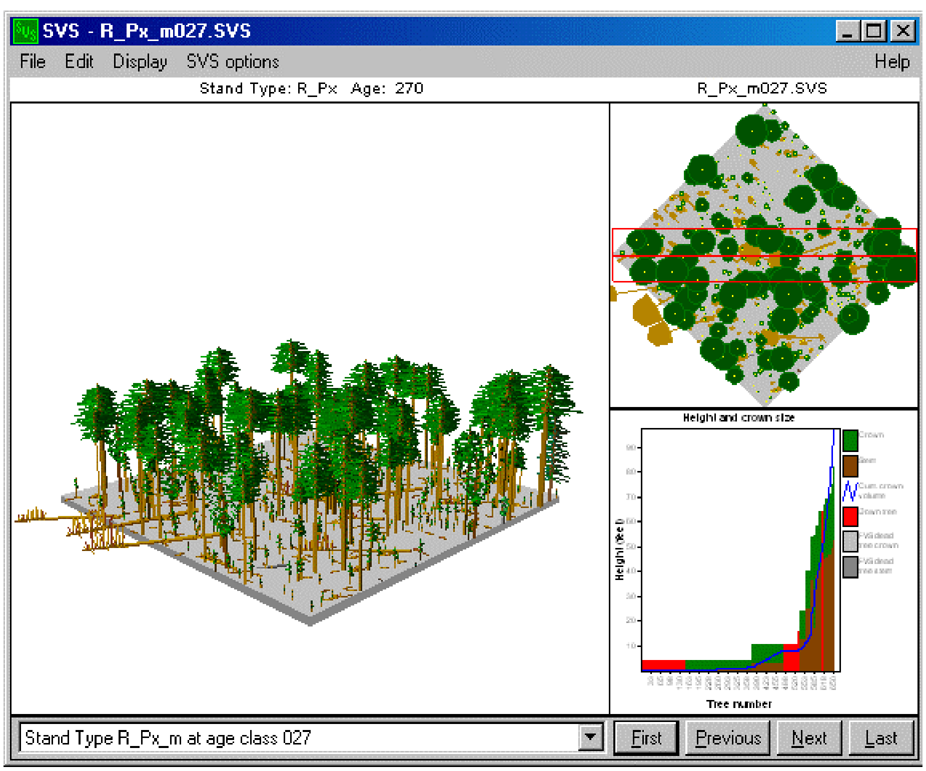


Figure IV-8d -- P#LH Modeled Stand Data, Year-270 old Age Class

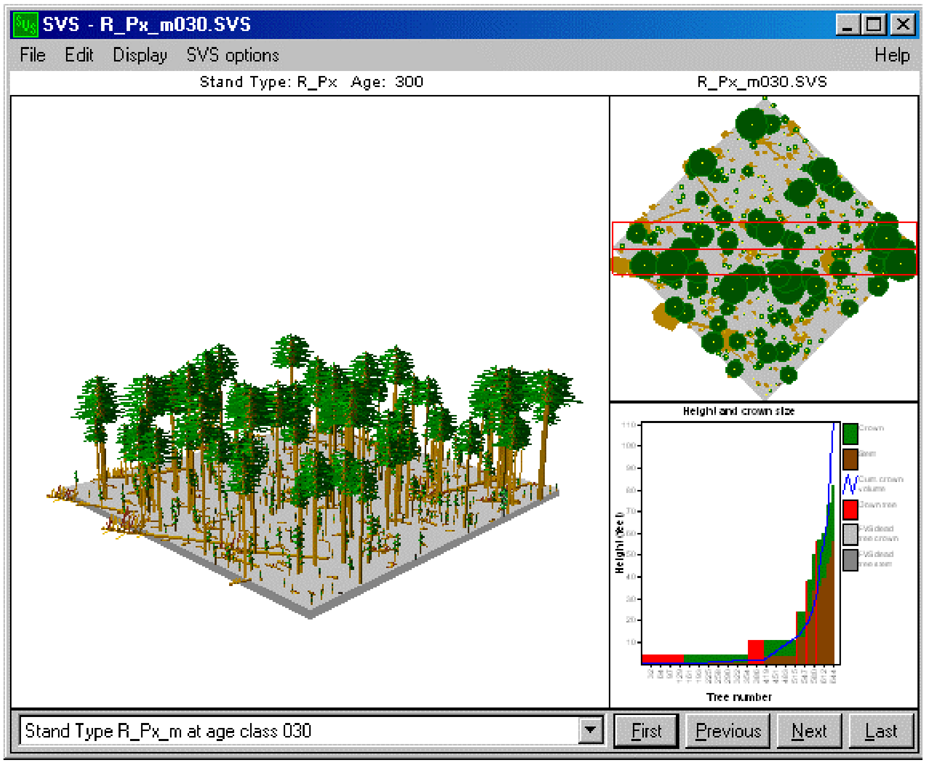


Figure IV-8e -- P#LH Modeled Stand Data, Year-300 old Age Class

V. TREATMENT PRESCRIPTIONS

Management direction suggest action, be it passive or active. In preparation of a land and resource management plan, certain stand level treatments are postulated as potential activities to move the forest toward desired outcomes. For example, it may be proposed to reduce stocking densities to lessen insect impacts. It may also be recommended to provide remedial fuel treatments to minimize wildland fire intensity. It may additionally be advocated to produce a balance of stand size classes throughout the forest to furnish a spectrum of wildlife habitats. For each proposed action, a stand treatment schedule needs to be formulated to achieve the stated goal. The natural growth runs described in the previous section are a de facto prescription option to let stands grow without human intervention.

"Decision Variables" are synonymous with 'supply' and "Accounting Constraints" with 'demand' in resource allocation economics. Decision variables comprise the columns and accounting constraints comprise the rows in most linear programming models. Linear programming techniques have been employed for over two decades to assist solving forest planning problems. A decision variable represents the level of activity that can be undertaken on a given resource. The primary resource of the forest is the land. The primary unit is therefore expressed in terms of acres. The number of acres by stand type that are allocated to each activity renders an efficient solution to the planning problem.

Decision variables are combinations of stand type, silvicultural prescription, and timing option. Stand types identify unique vegetative units within a forest. Basic attributes are used to construct a stand type such as overstory cover, size class, crown density, site productivity, and understory component. The formulation of stand types was presented previously in this text. Associated silvicultural treatments and timing options will be presented in the following section.

A. Silvicultural Regimes

A silvicultural prescription is a 'blueprint' of recommended activities to be applied throughout the life span of a forest stand. Treatments for existing stands can be quite different than those for future stands. Thus, an activity schedule needs to be developed for each condition. Timing options are composed of timing choices and time periods. To provide flexibility in finding a good solution to the forest allocation problem, several timing choices are often presented. Offsetting the standard series of silvicultural events by plus or minus 10 years provides an expanded decision space. The planning horizon dictates the time periods to be represented in the forest planning model. If stand development needs to be tracked for 150 years (usually, one and half times the rotation length of significant tree species will suffice), or 15 10-year decade, then there are 15 time periods to consider per silvicultural treatment per stand type.

Several silvicultural regimes were developed for the Black Hills Phase II Amendment project. Figure V-1 provides a summary of the various prescriptions. Note that the base prescriptions for shelterwood, seed-tree, and clearcut (01) were offset ten years to provide alternative timing choices (02, 03).

Labels	Silvicultural Rx	Timing Choice	Yield Basis	Entry Years	Applicable Stand Types	Remarks:
Rx_A01	Natural Growth	01	Age Dependent		All	
Rx_B01	Shelterwood	01	Age Dependent	30,60,90,120	PP Overstory/PP Understory	60 BA thins
Rx_B02	Shelterwood	02	Age Dependent	20,50,80,110	PP Overstory/PP Understory	60 BA thins
Rx_B03	Shelterwood	03	Age Dependent	40,70,100,130	PP Overstory/PP Understory	60 BA thins
Rx_C01	Seed-Tree	01	Age Dependent	30,60,90,130	PP Overstory/PP Understory	60 BA thins
Rx_C02	Seed-Tree	02	Age Dependent	20,50,80,120	PP Overstory/PP Understory	60 BA thins
Rx_C03	Seed-Tree	03	Age Dependent	40,70,100,140	PP Overstory/PP Understory	60 BA thins
Rx_D01	Clearcut	01	Age Dependent	30,60,90,120	PP Overstory/PP Understory	60 BA thins
Rx_D02	Clearcut	02	Age Dependent	20,50,80,110	PP Overstory/PP Understory	60 BA thins
Rx_D03	Clearcut	03	Age Dependent	40,70,100,130	PP Overstory/PP Understory	60 BA thins
Rx_E01	Group Selection	01	Time Dependent	20-yr Cut Cycle	PP Overstory/PP Understory	60 BA thins
Rx_F01	Aspen/Birch Preference	01	Age Dependent	30,60,90,120	PP Overstory/AS Understory	60 BA thins
Rx_G01	Oak Preference	01	Age Dependent	30,60,90,120	PP Overstory/OA Understory	60 BA thins
Rx_H01	Goshawk	01				Use Natural Growth Runs
Rx_I01	Old Growth	01				Use Natural Growth Runs
Rx_J01	Individual Tree Selection 1/	01	Time Dependent	20-yr Cut Cycle	PP Overstory/PP Understory	50 BA, 1.4 Q, 2"-18", 2 Legacy
Rx_K01	WUI & CARs 2/	01	Age Dependent	30,60,90,120	PP Overstory/PP Understory	Shelterwood, 50 BA thins
Rx_L01	Group Selection	01	Time Dependent	20-yr Cut Cycle	WS Overstory/WS Understory	60 BA thins
Rx_M01	Thin w/o Regen Cut 3/	01	Age Dependent	30,60,90,120	PP Overstory/PP Understory	60 BA thins
Rx_N01	Second Growth Stands 4/	01	Age Dependent	30,60,90,120	PP Overstory/PP Understory	60 BA thins
Rx_O01	Bur Oak Natural Growth	01	Age Dependent		Bur Oak	
Rx_P01	Aspen/Birch Natural Growth	01	Age Dependent		Aspen/Birch	

1/ Scenic Integrity
2/ Wildland/Urban Interface & Communities at Risk
3/ No Regeneration Cuts
4/ Extended Rotations to Cover Second Cuts

Figure V-1 – Silvicultural Prescriptions for Black Hills Phase II Amendment

Even-aged prescriptions require 'age-dependent' yield tables. Uneven-aged prescriptions require 'time-dependent' yield tables. The last year entered for the 'Entry Year' column for even-aged prescriptions generally designates the minimum rotation age for the stand. The base regimens per silvicultural treatment were as follows:

Natural Growth – All Stand Types:

```
*******************************************************************************
* No treatment prescription.                                                  *
*******************************************************************************
```

Shelterwood:

```
*******************************************************************************
* P_PPpp_SW.kcp --- Rx for PP overstory w/ PP understory: Shelterwood         *
*   Age 120+/0: Seed Cut to 40 BA                                             *
*     - Nat. Regen. of 150 TPA of PP 5 yrs after thinning w/ ave. age of 2 yrs *
*     - Nat. Regen. of 300 TPA of PP 10 yrs after thinning w/ ave. age of 2 yrs*
*     - Nat. Regen. of 100 TPA of PP pulse w/ 75% surv. following thins       *
*   Age 20: Overstory Removal                                                 *
*     - Leave 6 of the largest trees for snags                                *
*   Age 30:  Precommerial Thin from below to 302 TPA, 0"=< dbh <5"            *
*   Age 60:  POL Thin from below to 60 BA, 5"=< dbh <9"                       *
*   Age 90:  Commercial Thin PP to 60 BA, 9"=< dbh                            *
*******************************************************************************
```

Seed-Tree:

```
*******************************************************************************
* P_PPpp_ST.kcp --- Rx for PP overstory w/ PP understory: Seed-Tree           *
*   Age 130+/0: Seed-Tree Cut to 10 TPA                                       *
*     - Nat. Regen. of 150 TPA of PP 5 yrs after thinning w/ ave. age of 2 yrs *
*     - Nat. Regen. of 300 TPA of PP 10 yrs after thinning w/ ave. age of 2 yrs*
*     - Nat. Regen. of 100 TPA of PP pulse w/ 75% surv. following thins       *
*   Age 30:  Precommerial Thin from below to 302 TPA, 0"=< dbh <5"            *
*   Age 60:  POL Thin from below to 60 BA, 5"=< dbh <9"                       *
*   Age 90:  Commercial Thin PP to 80 BA, 9"=< dbh                            *
*******************************************************************************
```

Clearcut:

```
*******************************************************************************
* P_PPpp_CC.kcp --- Rx for PP overstory w/ PP understory: Clearcut            *
*   Age 120+/0: Clearcut Cut                                                  *
*     - Nat. Regen. of 150 TPA of PP 5 yrs after thinning w/ ave. age of 2 yrs *
*     - Nat. Regen. of 300 TPA of PP 10 yrs after thinning w/ ave. age of 2 yrs*
*     - Nat. Regen. of 100 TPA of PP pulse w/ 75% surv. following thins       *
*   Age 30:  Precommerial Thin from below to 302 TPA, 0"=< dbh <5"            *
*   Age 60:  POL Thin from below to 60 BA, 5"=< dbh                           *
*   Age 90:  Commercial Thin PP to 60 BA, 9"=< dbh                            *
*******************************************************************************
```

Group Selection – Ponderosa Pine:

```
********************************************************************************
* P_PPpp_GS.kcp --- Rx for PP overstory w/ PP understory: Group Selection      *
*   Opening Size: 0.5 acre                                                     *
*     - Tallest Tree Height of 110 feet                                        *
*     - Height Multiple of 1.5 times                                           *
*     - Calculation: ((((110*1.5)/2)**2)*3.141593)/43,560                      *
*                     {area of a circle}/{area of an acre}                     *
*   Proportional Area: 1/6 or 16.7%                                            *
*     - Harvest Tree Age of 120 years                                          *
*     - Cutting Cycle Length of 20 years                                       *
*     - Calculation: 120/20                                                    *
*                     {cutting cycle length}/{harv tree age}                   *
*   Small Tree Height Growth Multiplier: Additive Scaled Factor                *
*     - ATOPHT: After-thin average of top 40 tree heights                      *
*     - Radius: Opening Size basis                                             *
*     - Calculation: (Radius*2)/ATOPHT=1; Factor=1.0                           *
*                     (Radius*2)/ATOPHT=2; Factor=1.5                          *
*                     (Radius*2)/ATOPHT=3; Factor=2.0                          *
*   Small Tree Mortality Multiplier: Reduction Scaled Factor                   *
*     - ATOPHT: After-thin average of top 40 tree heights                      *
*     - Radius: Opening Size based                                             *
*     - Calculation: (Radius*2)/ATOPHT=1; Factor=1.0                           *
*                     (Radius*2)/ATOPHT=2; Factor=0.3                          *
*                     (Radius*2)/ATOPHT=3; Factor=0.1                          *
*   Group Age 120+/0: Group Select Cut, 9"=< dbh < 99"                         *
*     - Nat. Regen. of 302 TPA of PP 5 yrs after thinning w/ ave. age of 2 yrs *
*   Group Age 30: Precommerial Thin from below to 302 TPA, 0"=< dbh <5"        *
*   Group Age 60: POL Thin from below to 60 BA, 5"=< dbh < 9"                  *
*   Group Age 90: Commercial Thin PP to 60 BA, 9"=< dbh < 99"                  *
********************************************************************************
```

Aspen/Birch Preference:

```
********************************************************************************
* P_PPas_TC.kcp --- Rx for PP overstory w/ AS understory: Type Convert to Aspen*
*   Age 120+/0: Clearcut Cut PP Stand, Convert to Aspen                        *
*     - Nat. Regen. of 1250 TPA of AS 5 yrs after thinning w/ ave. age of 2 yrs*
*   Age 30: Precommerial Thin from below to 302 TPA, 0"=< dbh <5"              *
*   Age 60: POL Thin from below to 60 BA, 5"=< dbh                             *
*   Age 90: Commercial Thin PP to 60 BA, 9"=< dbh                              *
********************************************************************************
```

Bur Oak Preference:

```
********************************************************************************
* P_PPoa_TC.kcp --- Rx for PP overstory w/ OA understory: Type Convert to Oak  *
*   Age 120+/0: Clearcut Cut PP Stand, Convert to Bur Oak                      *
*     - Nat. Regen. of 1250 TPA of OA 5 yrs after thinning w/ ave. age of 2 yrs*
*   Age 30: Precommerial Thin from below to 302 TPA, 0"=< dbh <5"              *
*   Age 60: POL Thin from below to 60 BA, 5"=< dbh                             *
*   Age 90: Commercial Thin PP to 60 BA, 9"=< dbh                              *
********************************************************************************
```

Individual Tree Selection:

```
******************************************************************************
* P_PPpp_IT.kcp --- Rx for PP overstory w/ PP understory: Individual Tree Select
*   - Basal Area Target = 50 Square Feet                                      *
*   - Q-slope to regulate tree frequency per diamter class  = 1.4             *
*   - Diameter of Beginning Class = 2"                                        *
*   - Diameter of Ending Class = 18"                                          *
*   - Diameter Class Increment = 2"                                           *
*   - Number of Legacy Trees = 2                                              *
*   - Average Legacy Tree Diameter = 20"                                      *
*   - Cutting Cycle Length = 20-years                                         *
******************************************************************************
```

Wildland Urban Interface and Communities at Risk:

```
******************************************************************************
* P_PPpp_WC.kcp --- Rx for PP overstory w/ PP understory: WUI/CARs Shelterwood *
*   WUI: Wildland Urban Interface / CAR: Community at Risk (wildland fire)    *
*   Age 120+/0: Seed Cut to 40 BA                                             *
*     - Nat. Regen. of 150 TPA of PP 5 yrs after thinning w/ ave. age of 2 yrs *
*     - Nat. Regen. of 300 TPA of PP 10 yrs after thinning w/ ave. age of 2 yrs*
*     - Nat. Regen. of 100 TPA of PP pulse w/ 75% surv. following thins       *
*   Age 20: Overstory Removal                                                 *
*     - Leave 6 of the largest trees for snags                                *
*   Age 30: Precommerial Thin from below to 302 TPA, 0"=< dbh <5"             *
*   Age 60: POL Thin from below to 50 BA, 5"=< dbh <9"                        *
*   Age 90: Commercial Thin PP to 50 BA, 9"=< dbh                             *
******************************************************************************
```

Group Selection – White Spruce:

```
******************************************************************************
* P_WSws_GS.kcp --- Rx for WS overstory w/ WS understory: Group Selection     *
*   Opening Size: 0.5 acre                                                    *
*     - Tallest Tree Height of 110 feet                                       *
*     - Height Multiple of 1.5 times                                          *
*     - Calculation: ((((110*1.5)/2)**2)*3.141593)/43,560                     *
*                    {area of a circle}/{area of an acre}                     *
*   Proportional Area: 1/6 or 16.7%                                           *
*     - Harvest Tree Age of 120 years                                         *
*     - Cutting Cycle Length of 20 years                                      *
*     - Calculation: 120/20                                                   *
*                    {cutting cycle length}/{harv tree age}                   *
*   Small Tree Height Growth Multiplier: Additive Scaled Factor               *
*     - ATOPHT: After-thin average of top 40 tree heights                     *
*     - Radius: Opening Size basis                                            *
*     - Calculation: (Radius*2)/ATOPHT=1; Factor=1.0                          *
*                    (Radius*2)/ATOPHT=2; Factor=1.5                          *
*                    (Radius*2)/ATOPHT=3; Factor=2.0                          *
*   Small Tree Mortality Multiplier: Reduction Scaled Factor                  *
*     - ATOPHT: After-thin average of top 40 tree heights                     *
*     - Radius: Opening Size based                                            *
*     - Calculation: (Radius*2)/ATOPHT=1; Factor=1.0                          *
*                    (Radius*2)/ATOPHT=2; Factor=0.3                          *
*                    (Radius*2)/ATOPHT=3; Factor=0.1                          *
*   Group Age 120+/0: Group Select Cut, 9"=< dbh < 99"                        *
*     - Nat. Regen. of 302 TPA of WS 5 yrs after thinning w/ ave. age of 2 yrs *
```

```
*   Group Age 30: Precommerial Thin from below to 302 TPA, 0"=< dbh <5"        *
*   Group Age 60: POL Thin from below to 60 BA, 5"=< dbh < 9"                  *
*   Group Age 90: Commercial Thin PP to 60 BA, 9"=< dbh < 99"                  *
********************************************************************************
```

Perpetual Thins:

```
********************************************************************************
* P_PPpp_TH.kcp --- Rx for PP overstory w/ PP understory: Thin w/o Regen Cut   *
*     - Nat. Regen. of 100 TPA of PP pulse w/ 75% surv. following thins        *
*   Age 30: Precommerial Thin from below to 302 TPA, 0"=< dbh <5"              *
*   Age 60: POL Thin from below to 60 BA, 5"=< dbh                             *
*   Age 90: Commercial Thin PP to 60 BA, 9"=< dbh                              *
********************************************************************************
```

Second Growth Stands:

```
********************************************************************************
* Extended number of projection cycles for shelterwood prescription.           *
********************************************************************************
```

Complete listings of the FVS keyword file set for each silvicultural prescription can be obtained from the Forest Management Service Center, Fort Collins, Colorado.

B. Support Addfiles

Several keyword component files (i.e. *.kcp, addfiles) were constructed to augment all simulation runs. The "Base.kcp" contains initialization and merchantability specification keywords. The "DelOTab.kcp" deletes the 'Stand Composition' and 'Attributes of Selected Sample Tree' tables from the Main FVS Output report, thus reducing its size. The "InvYr.kcp" configures all inventory data to a common start year; sets the number of projection cycle; and, establishes a fixed time interval per cycle. Inventory data were considered 'condition class' samples. Data was not grown forward to the initial start year. Rather each plot represented a point-in-time estimate of a given stand type at a particular stand age or structure size. Sixteen 10-year projection cycles were needed to cover a 150 year planning horizon. The FVS model does not perform harvest activities in the last cycle. An additional cycle is needed to obtain harvest estimates for the last planning period. The "Compute.kcp" defined Event Monitor variables that were used for accounting or calculation by other FVS addfiles.

Base.kcp:

```
********************************************************************************
* Base.kcp --- Base Model parameter changes:                                   *
*  - Stand Info: set stand age to zero to allow computed stand age             *
*  - SDI Maximum: set at 85% of Ave Max SDI (top 3% of measured values)        *
*  - BF Volume: min. dbh: 9.0", min. top: 6.0" dib                             *
*  - BF Defect: 0-5"=0.0%, 5-10"=14.0%, 10-15"=11.1%, 15-20"=10.8%, 20+"=10.3% *
*  - MC Volume: min. dbh: 5.0", min. top: 4.0" dib                             *
*  - MC Defect: 0-5"=0.0%, 5-10"=14.0%, 10-15"=11.1%, 15-20"=10.8%, 20+"=10.3% *
*  - MinHarv: specify 1,000 board foot removal constraint                      *
*  - SpecPref: favor PP and WS for harvest                                     *
```

```
*  - Echosum: used for AvgSum(mary) Statistics Post Processor                  *
*  - SVS: default paramaters                                                    *
*  - Suppress Tripling and Auto Establishment Capabilities                      *
*  - FVSStand: default parmeters                                                *
*********************************************************************************
StdInfo          203                0
SDIMax           All       340                          55.00     85.00         1
BFVolume           0       All       9.0       6.0         1.       80.         6
BFDefect           0       All     0.000     0.140     0.111     0.108     0.103
Volume             0       All       5.0       4.0         1.       80.         6
MCDefect           0       All     0.000     0.140     0.111     0.108     0.103
SpecPref           0        PP    1000.0
SpecPref           0        WS    1000.0
*MinHarv            0              1000
*EchoSum
*SVS                0     100.0         0         0         2
NoTriple
NoAutoEs
FVSStand           0         0
*********************************************************************************
```

DelOTab.kcp:

```
*********************************************************************************
* DelOTab.kcp --- Delete Percentile Tables from FVS Main Output file           *
*  - 1=Stand Composition Table                                                  *
*  - 2=Selected Sample Tree Table                                               *
*********************************************************************************
DelOTab            1
DelOTab            2
*********************************************************************************
```

InvYr.kcp:

```
*********************************************************************************
* InvYr.kcp --- Inventory plots/stands represent Condition Class Samples       *
*              Establish beginning of planning period and its length            *
*  - Inventory Year: set to current year                                        *
*  - Number of Cycles: 15 10-year cycles +1 (covers no harvest in last period) *
*  - Time Interval: overwrites Suppose interface value                          *
*********************************************************************************
InvYear         2003.
NumCycle          16.
TimeInt            0       10.
*********************************************************************************
```

Compute.kcp:

```
*********************************************************************************
* Compute.kcp --- Computed Variables                                            *
*  Accounting Variables                                                          *
*  _ForTyp  = Forest Cover Type                                                  *
*  _SizCls  = Stand Size Class                                                   *
*  _StkCls  = Stand Stocking Class                                               *
*  _CC%     = Canopy Cover Percent                                               *
*  Calculation Variables                                                          *
```

```
*  _Cut     = 1 Thinning Performed                                              *
*  _BCC     = Before Treatment % Canopy Cover                                   *
*  _ACC     = After Treatment % Canopy Cover                                    *
*  _BQMD    = Before Treatment QMD                                              *
*  _AQMD    = After Treatment QMD                                               *
*  _BSDI    = Before Treatment SDI                                              *
*  _ASDI    = After Treatment SDI                                               *
*  T_PP     = Trees per acre PP                                                 *
*  T_ntPP   = Trees per acre not PP                                             *
*  T_PP05   = Trees per acre PP 0-5"                                            *
*  T_PP5    = Trees per acre PP 5"=<                                            *
*  T_PP010  = Trees per acre PP 0"-10"                                          *
*  T_PP09   = Trees per acre PP 0"-9"                                           *
*  T_PP9    = Trees per acre PP 9"=<                                            *
*  T_PP10   = Trees per acre PP 10"=<                                           *
*  T_PP1020 = Trees per acre PP 10"-20"                                         *
*  T_PP20   = Trees per acre PP 20"=<                                           *
*  T_PP59   = Trees per acre PP 5"-9"                                           *
*  T_PPnt59 = Trees per acre PP not 5"-9"                                       *
*  B_PP05   = Basal area per acre PP 0"-5"                                      *
*  B_PP5    = Basal area per acre PP 5"=<                                       *
*  B_PP09   = Basal area per acre PP 0"-9"                                      *
*  B_PP9    = Basal area per acre PP 9"=<                                       *
*  B_PPnt59 = Basal area per acre PP not 5"-9"                                  *
********************************************************************************
Compute            0
_StndAge=Age
_StAge10=Age/10
_ForTyp=ForTyp
_SizCls=SizCls
_StkCls=StkCls
*_CanCov0=SpMcDBH(7,All,0,0.00,200.0,0.0,500.0,0)
End

Compute            1
_Cut    =0
End

Compute            0
_BCC    =SpMcDbh(7,ALL,0,0,999,0,999,0)
_ACC    =SpMcDbh(7,ALL,0,0,999,0,999,3)
_BQMD   =SpMcDbh(5,ALL,0,0,999,0,999,0)
_AQMD   =SpMcDbh(5,ALL,0,0,999,0,999,3)
_BSDI   =SpMcDbh(11,ALL,0,0,999,0,999,0)
_ASDI   =SpMcDbh(11,ALL,0,0,999,0,999,3)
T_PP    =SpMcDbh(1,PP,0,0,999,0,999,0)
T_ntPP  =SpMcDbh(1,ALL,0,0,999,0,999,0)- T_PP
T_PP05  =SpMcDbh(1,PP,0,0,5,0,999,0)
T_PP5   =SpMcDbh(1,PP,0,5,999,0,999,0)
T_PP010 =SpMcDbh(1,PP,0,0,10,0,999,0)
T_PP09  =SpMcDbh(1,PP,0,0,9,0,999,0)
T_PP9   =SpMcDbh(1,PP,0,9,999,0,999,0)
T_PP10  =SpMcDbh(1,PP,0,10,999,0,999,0)
T_PP1020=SpMcDbh(1,PP,0,10,20,0,999,0)
T_PP20  =SpMcDbh(1,PP,0,20,999,0,999,0)
T_PPnt59=T_PP05+T_PP9
B_PP05  =SpMcDbh(2,PP,0,0,5,0,999,0)
B_PP5   =SpMcDbh(2,PP,0,5,999,0,999,0)
B_PP09  =SpMcDbh(2,PP,0,0,9,0,999,0)
B_PP9   =SpMcDbh(2,PP,0,9,999,0,999,0)
B_PPnt59=B_PP05+B_PP9
End
********************************************************************************
```

A mortality adjustment addfile was developed specifically for use with the group selection silvicultural prescriptions. There was no need to regulate the seedling/sapling size class in regards to tree frequency. All that was needed was the senescence filter and morphological cap.

```
********************************************************************************
* FixMort_G.kcp --- Mortality Adjustment Keywords for Group Selection Rx
*                   _G = Group Selection Qualifier
*  - Mature diameter classes     --> Senescence filter
*  - Overmature diameter class   --> Morphological cap
********************************************************************************
FixMort           0       All    0.1500        25        27         1         0
FixMort           0       All    0.7500        27        29         1         0
FixMort           0       All    1.0000        29        99         1         0
```

C. Classification Addfiles

FVS addfiles were developed to chart changes in forest cover type, the understory component, habitat structural stage, Mountain Pine Beetle hazard, and fire/fuel attributes. These addfiles addressed the crux of the planning problem for the Black Hills. Namely, challenges related to stand structure, insect epidemics, and wild fire impacts.

1. Forest Type

During the summer months of 2002, the Vegetation Simulation Group of the FMSC embedded the forest type, size, and stocking algorithm developed by the Forest Inventory and Analysis Group into the FVS model. This utility enables tracking changes in overstory composition, its size and density, through time. Examine the "Accounting Variables" within the "Compute.kcp" file to view scripting of these items.

2. Understory Component

As previously cited, understory component was a primary element of the base stand type designation. Therefore, it was important to monitor developmental changes of future stand conditions. A procedure was needed to classify the understory component. Investigation of the 1999 FIA data set with regard to existing regeneration rendered insightful trends. These are documented in the "SOS.kcp" addfile. A criterion for classifying the understory was then developed.

3. Habitat Structural Stage

The Northern Goshawk has been identified is an important Management Indicator Species on the Black Hills National Forest. It is also recognized as federally listed Sensitive Species. The Decision Notice from the Phase I Amendment process emphasizes lessening the level of risk for several sensitive species, including the Northern Goshawk. A revised change to the Forestwide Standard and Guidelines for the 1997 Land and Resource Management plan states:

SOS.kcp:

```
*****************************************************************************************
* SOS.kcp -- Determine Seedling/Sapling Occurrence Specifier (_SOS)                     *
*                                                                                       *
*  ASPECTS                                      Degrees                                 *
*  -------                                    Left   Right   Thresholds                 *
*                                  Northwest 292.5   337.5          293                 *
*               N     Northerly   North     337.5    22.5              Northerly        *
*             NW  NE              Northeast  22.5    67.5                               *
*           ----|   E             East       67.5   112.5          112                  *
*           W   |----             ---------------------------------------------         *
*             SW  SE              Southeast 112.5   157.5   113                         *
*  Southerly    S                 South     157.5   202.5              Southerly        *
*                                 Southwest 202.5   247.5                               *
*                                 West      247.5   292.5   292                         *
*                                                                                       *
*                                 Level -->   Northerly                                 *
*                                                                                       *
*  UNDERSTORY OCCURRENCE                                                                *
*  ---------------------                                                                *
*                                                                                       *
*               Southerly Aspects                                                       *
*    Elevation  Juniper ---> Aspen                                                      *
*    Upper       5,600       6,800                                                      *
*    Lower       4,100       5,300                                                      *
*                                                                                       *
*               Northerly Aspects                                                       *
*    Elevation  Juniper --->  Oak     --->   Birch   --->    Aspen   --->    Spruce     *
*    Upper       5,000       5,700           6,200           6,900           6,900      *
*    Lower       3,900       4,000           4,400           4,600           5,000      *
*                                                                                       *
*    Ponderosa Pine   ---> All Aspects, All Elevations                                  *
*                                                                                       *
*    ** Based on 1999 FIA data -- Trees less than or equal to 5.0" diameter             *
*                                                                                       *
*  CRITERIA                                                                             *
*  --------                                                                             *
*           - Minimum Threshold:                                                        *
*                150 TPA < 5.0" dbh/dia                                                 *
*           - Multi-Species Resolution                                                  *
*                Moisture Regime Dry >>> Wet, exclusive of Pine                         *
*                   Juniper -> Oak -> Birch -> Aspen -> Spruce  ~~~>> Pine              *
*                                                                                       *
*  MODIFICATION                                                                         *
*  ------------                                                                         *
*           - Oak occurrence overrides all other species                                *
*           - Aspen occurrence overrides all other species other than Oak               *
*           - Juniper, Birch, Spruce follow moisture-regime hierarchy                   *
*           - Aspen and Birch are ultimately combined                                   *
*           - No Understory designated as Pine                                          *
*                                                                                       *
*****************************************************************************************
```

3114. Design silvicultural prescriptions and manage activities to enhance prey species habitat by maintaining vegetative diversity and striving for a *balance of structural stages*, from stand initiation to late successional, within goshawk fledgling habitat.

The "HSS.kcp" addfile was developed to track changes in habitat structural stage (HSS) over time. Predominance of tree basal area within specified diameter ranges defined the structural stage. For poletimber and sawtimber classes, stand canopy closure was used to further subdivide the stage. The old growth habitat structural stage had further qualifiers. Beyond the base call of HSS of 3 or greater, additionally the stand needed to be multi-storied, have moderate to high canopy closure, have a quadratic-mean-diameter of 9-inches or greater (in trees 1-inch diameter and larger), and have at least two hard snags 9-inches or greater. The _CHESS (computed habitat estimated structural stage) variable stored the base HSS call. The _OGSC (old growth score card) variable indicated whether the stand achieved old growth notoriety or not. If so, the _CHESSER variable is set to a value of 50.

HSS.kcp:

```
********************************************************************************
* HSS.kcp -- Compute Habitat Estimated Structural Stage (_CHESS)              *
* _Chess           Stage   Tree Size              Diameter     Canopy Cover  *
*   10             1       Grass/Forb                            0-10%       *
*   20             2       Shrub/Seedling            <1"         11-100%     *
*   31             3A      Poles/Saplings - low     1-9"         11-40%      *
*   32             3B      Poles/Saplings - med.    1-9"         41-70%      *
*   33             3C      Poles/Saplings - high    1-9"         71-100%     *
*   41             4A      Mature - low              >9"         11-40%      *
*   42             4B      Mature - med.             >9"         41-70%      *
*   43             4C      Mature - high             >9"         71-100%     *
*   50 (_Chesser)  5       Old Growth                >9"         11-100%     *
*                                                                            *
*       _OGSC = Old Growth Score Card                                        *
********************************************************************************
```

4. Mountain Pine Beetle

Expertise was sought from the Forest Health Technology Enterprise Team (FHTET), USDA Forest Service, Washington Office State and Private Staff, located in Fort Collins, Colorado, to scrutinize and code a FVS addfile for classifying the potential impacts of the Mountain Pine Beetle on the Ponderosa Pine forests of the Black Hills. Research Note RM-529, “Hazard Rating Ponderosa Pine Stands for Mountain Pine Beetle in the Black Hills” (1994 – Schmid et al) was identified as the best source for coding the addfile. Three realms of hazard were recognized: low, moderate, and high. If the stand basal area was less than 80 then the stand was classified as low hazard with regard to Mountain Pine Beetle. It the basal area was between 80 and 120, the hazard is considered as moderate. Stands with basal area greater than 120 were deemed to be a high hazard. Considerations beyond basal area per acre were needed for stands with quadratic-mean-diameters less than 10 inches. These were incorporated into the “MPB.kcp” addfile (credit Tony Courter from FHTET).

MPB.kcp:

```
********************************************************************************
* MPB.kcp -- Hazard Rating PP Stands for Mountain Pine Beetle in Black Hills   *
*                                                                              *
* - Determine MPB Hazard                                                       *
*    Risk associated with One or Two stories                                   *
*       IRISK1 = 3                                                             *
*       If BA5pP > 30 And TPA1t5P > 250 Then IRISK1 = 2                        *
*    Risk associated with Stand Basal Area                                     *
*       IRISK2 = 1                                                             *
*       If BA1p >= 80 And BA1p <= 120 Then IRISK2 = 2                          *
*       If BA1p > 120 Then IRISK2 = 3                                          *
*    Risk associated with Quadratic Stand DBH                                  *
```

```
*       IRISK3 = 1                                                             *
*       If QMD1p >= 6 And QMD1p <= 10 Then IRISK3 = 2                          *
*       If QMD1p > 10 Then IRISK3 = 3                                          *
*    Compute Total Risk Factor                                                 *
*       TRISK = IRISK1 * IRISK2 * IRISK3                                       *
*    Group Risk in 5 classes (1, 3, or 5)                                      *
*       If TRISK < 8 Then MPB_Haz = 1                                          *
*       If TRISK >= 8 And TRISK < 18 Then MPB_Haz = 3                          *
*       If TRISK >= 18 Then MPB_Haz = 5                                        *
* - MPB_Hazard variable values;  1 = Low, 3 = Medium, 5 = High                 *
********************************************************************************
```

5. Fire Factors

Recently, the Fire and Fuels Extension (FFE) has been added to the Forest Vegetation Simulator. This feature has greatly enhanced the ability to address fire related issues at the stand level. The FFE is composed of three submodels, namely Snag, Fuel, and Fire. The snag submodel has advantages beyond fire aspects. Snags are very important to wildlife concerns. The Decision Notice from the Phase I Amendment process also mentioned reducing the risk of adverse impacts to cavity-nesting birds, including the Blackbacked Woodpecker. Changes in Forestwide Standards and Guidelines included:

> 2301. Within the associated watershed, for each vegetation management project, retain the following minimum densities of hard snags at least 25 feet in height:
> a. Ponderosa Pine on north- or east-facing slopes or in protected areas which would have historically supported an infrequent, stand replacing fire regime: Retain an average of 4 snags per acre > 10” dbh.
> b. Ponderosa Pine on south- or west-facing slopes or in exposed areas which would have historically supported a more frequent, lower intensity fire regime: Retain an average of 2 snags per acre > 10” dbh.
> c. Retain a minimum average of 6 snags per acre > 10” dbh for forest types other than Ponderosa Pine.
> d. Snags chosen for retention should represent the largest diameter class available.
> e. Provide large diameter trees and snags along habitat interface zones.

Computed variables generated by the Event Monitor within FVS accounted for both hard and soft snags. Four diameter classes were specified: <9”, 9” – 15”, 15” – 19”, and >19”. Counts of large-hard snags also aided in classifying the old growth habitat structural stage.

The fuel and fire submodels were instrumental in classifying wild fire hazard. The national fire hazard rating system (credit Paul Langowski from USDA Forest Service, Rocky Mountain Regional Office and Eric Twombly from the USDA Forest Service, Pacific Northwest stationed at the Wallowa Whitman National Forest) developed for the INFORMS model was used for the Black Hills Phase II project. Refer to Figure V-2. The fire hazard system is simply based on a correlation between the Torching Index (wind speed needed to torch individual trees) and Crowning Index (wind speed needed to carry fire through tree crowns). The “Fire.kcp’ addfile was formulated to conform to the national fire hazard standard.

Two elements:

1. Torching Index = How will the fire get into the crowns
2. Crowning Index = How will the fire move once it is in the crowns

		Crowning Index		
		Low	Med	High
	Low	L	M	M
Torching Index	Med	M	H	VH
	High	H	VH	E

L = Low
M = Medium
H = High
VH = Very High
E = Extreme

	Torching Index	Crowing Index
High	15 mph-	15 mph-
Medium	>=16-39<=	>=16-39<=
Low	40 mph+	40 mph+

Figure V-2 – National Fire Hazard Rating Model

Fire.kcp:

```
*******************************************************************************
* Fire.kcp -- Fire Model Output Variables (from Potential Fire report)        *
*  *** Rules                                                                  *
*   * Use Fuel Model 2 <= CanCov 70%                                          *
*   * Use Fuel Model 9 >  CanCov 70%                                          *
*  _CRBD   =Crown Bulk Density                                                *
*  _CRBHT  =Crown Base Height                                                 *
*  _FLGTH  =Flame Length for severe fire                                      *
*  _CRIDX  =Crowning Index                                                    *
*  _TRIDX  =Torching Index                                                    *
*  _SNAGS  =Number of hard and Soft Snags per Acre                            *
*  Fire Hazard Rating calculated from Torching and Crowning Index             *
*   Hazard matrix developed by Paul Langowski and Eric Twombley               *
*   Low(1), Medium(2), High(3), Very High(4), Extreme(5)                      *
*                                                                             *
* - Determine Fire Hazard - Present Method                                    *
*      F_Hazard = 1                                                           *
*    Fire Hazard Rating: 1 Low                                                *
*      If TRIDX > 39 And CRIDX > 39 Then F_Hazard = 1                         *
*    Fire Hazard Rating: 2 Medium                                             *
*      If TRIDX > 39 And CRIDX >= 16 And CRIDX <= 39 Then F_Hazard = 2        *
*      If TRIDX > 39 And CRIDX < 16 Then F_Hazard = 2                         *
*      If TRIDX >= 16 And TRIDX <= 39 And CRIDX > 39 Then F_Hazard = 2        *
*    Fire Hazard Rating: 3 High                                               *
```

```
*      If TRIDX >= 16 And TRIDX <= 39 And _                                    *
*         CRIDX >= 16 And CRIDX <= 39 Then F_Hazard = 3                        *
*      If TRIDX < 16 And CRIDX > 39 Then F_Hazard = 3                          *
*    Fire Hazard Rating: 4 Very High                                           *
*      If TRIDX >= 16 And TRIDX <= 39 And CRIDX < 16 Then F_Hazard = 4         *
*      If TRIDX < 16 And CRIDX >= 16 And CRIDX <= 39 Then F_Hazard = 4         *
*    Fire Hazard Rating: 5 Extreme                                             *
*      If TRIDX < 16 And CRIDX < 16 Then F_Hazard = 5                          *
********************************************************************************
```

VI. YIELD PROFILES

As the name implies, the Forest Vegetation Simulator is much more than a timber tracking tool. Forest plan revision efforts are embroiled with contemporary issues such as forest structure (wildlife habitat and cover type transition), forest health (insect and disease impacts), and forest disturbance (wild fires and catastrophic wind events). The FVS model has evolved with time. Model Extensions have been added to address a myriad of concerns. Beyond reporting commodity production, ecosystem components are forecast. FVS is truly a full-scale vegetation projection model.

A fundamental step in forest planning is the analysis of the management situation. Various alternatives are proposed to guide future programmatic direction. Inherent to the analysis process is the gathering of inventory data and the projection of potential outcomes. Computer models play an important role in the projection process and formulation of management alternatives. Generally, two types of computer programs are used for forest planning. They are a yield forecasting model and a decision support system. An analogy could be drawn to a mechanized vehicle. The yield model is akin to the motor. It powers current and future developments by providing value estimates. The decision support model is analogous to the chassis. It pulls together the resource supply and user demand components of forest planning. Coefficients computed by the yield model are keyed into the decision support model to drive allocation decisions.

A. Accounting Variables

A list of output variables was developed that would be comprised of yield estimates. These values would be input into the forest planning model to aid in solving for the best combination of activities subject to resource constraints. Yield values for forest overstory cover type, understory attributes, stand structure, insect hazard, snag counts, wild fire rating, and harvest capacity needed to be generated via the Forest Vegetation Simulator. A complete listing of the accounting variables created for the Black Hills Phase II Amendment can be viewed in Appendix II. Several post processing programs have been written to produce the accounting variables needed for forest planning. Use of the various post processors follows.

1. FVSSTAND Yield Files

The FVSSTAND Alone post processing program contains several features that specifically aid yield table production.

1. Aggregates data from one or many plots to produce composite results.
2. Tracks the total and treated inventory plots counts.
3. Generates many of the standard plot level accounting variables (i.e. stand age, average site index, culmination of mean annual increment, quadratic mean diameter).
4. Generates many of the standard tree level accounting variables (i.e. trees per acre, basal area per acre, cubic foot volume per acre, and board foot volume per acre).

5. Produces yield files per individual species or species group (i.e. Ponderosa Pine, White Spruce, appraisal groups).
6. Subtotals output values by size class (i.e. 0"-9" diameter class, "9-15" diameter class, 15"-19" diameter class, 19"+ diameter class).

Perhaps the greatest asset of using FVSSTAND for generated yield table values is that it does not draw upon FVS internal memory arrays. FVS has limited capacity regarding the number of Event Monitor variables that can be computed and the number of conditional statements that can be defined. These internal program resources can be quickly exhausted when trying to develop classification coding schemes. Using FVSSTAND to produce standard accounting variables is a wise choice. Figure VI-1 documents the coding convention used by the FVSSTAND Alone post processor for yield table generation. For the Black Hills Phase II Amendment, Ponderosa Pine, White Spruce, and All Species Combined were identified separately by size class. Values for live, harvest, and mortality tree component were generated.

2. Compute2 Files

User defined variables can be declared by using the "Compute" keyword functionality of the Event Monitor embedded within FVS. The Compute2 post processor produces a comma/column delimited file of variables generated by the Event Monitor. The pre-defined variables forest cover type (ForTyp), size class (SizCls), and stocking class (StkCls) were assigned to a user defined variable. The pre-defined Event Monitor function SpMcDbh was used to describe canopy cover. Classification algorithms were coded to declare the understory component, habitat structural stage, and Mountain Pine Beetle hazard (refer to SOS.kcp, HSS.kcp, and MPB.kcp addfile listings presented previously in the text). Designated user defined variables were parsed into an output file (*.cp2) generated by the Compute2 post processor program.

3. FireTbl Tables

The FireTbl post processor generates a comma/column delimited table of the values contained in the 'Potential Fire Report' and 'All Fuels Report' of the Main FVS Output file. These tables are produced by the Fire and Fuels Extension of the FVS model. Several characteristics of resident snags were reported by decay composition by diameter size class. Refer to the "Fire.kcp" addfile listed in the previous section of this document.

B. Means and Modes

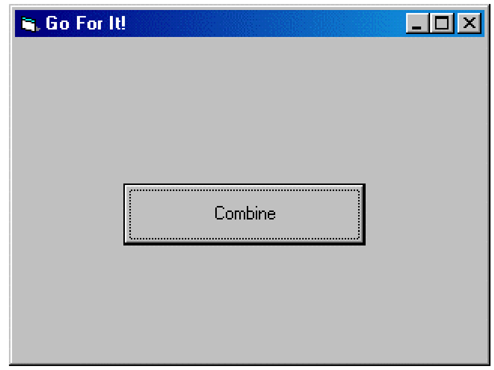
Yields can be expressed in quantitative and qualitative terms. Quantitative data are described by continuous variables that render 'mean' or average value estimates. Examples are: average trees per acre, basal area, or volume units. Qualitative data are described by classification variables that render 'mode' or count value estimates. The class with the maximum count represents the strata condition. Examples are: structural stage, insect hazard, or fire regime.

```
Yield Import File - Variable Definition Template
------------------------------------------------

"Strata    " = Analysis Area
" Proj_YEAR" = Projection Cycle Year
" St_Age/10" = Stand Age/10 years
" Str_Class" = Structure Class
" Stand_Age" = Stand Age
" SiteIndex" = Site Index
" StDnIndex" = Stand Density Index
" CulmMAI-T" = Culmination Mean Annual Increment - Merchantable Cubic Feet, All Trees
" CulmMAI-S" = Culmination Mean Annual Increment - Merchantable Cubic Feet, Sawtimber Trees
" Qd_Mn_Dia" = Quadratic Mean Diameter
" For_Cover" = Forest Cover Type
" Plt_Acres" = Plot Acres (Count)
" Trt_Acres" = Treatment Acres (Count)
" LTr.AllSx" = Live/Trees per Acre/All Species/All Size Classes
" LAD.AllSx" = Live/Average DBH/All Species/All Size Classes
" LAH.AllSx" = Live/Average Height/All Species/All Size Classes
" LBA.AllSx" = Live/Basal Area per Acre/All Species/All Size Classes
" LCA.AllSx" = Live/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top
" LCS.AllSx" = Live/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top
" LCT.AllSx" = Live/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top
" LBd.AllSx" = Live/Board Feet per Acre/All Species/All Size Classes
" HTr.AllSx" = Harvest/Trees per Acre/All Species/All Size Classes
" HAD.AllSx" = Harvest/Average DBH/All Species/All Size Classes
" HAH.AllSx" = Harvest/Average Height/All Species/All Size Classes
" HBA.AllSx" = Harvest/Basal Area per Acre/All Species/All Size Classes
" HCA.AllSx" = Harvest/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top
" HCS.AllSx" = Harvest/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top
" HCT.AllSx" = Harvest/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top
" HBd.AllSx" = Harvest/Board Feet per Acre/All Species/All Size Classes
" MTr.AllSx" = Mortality/Trees per Acre/All Species/All Size Classes
" MAD.AllSx" = Mortality/Average DBH/All Species/All Size Classes
" MAH.AllSx" = Mortality/Average Height/All Species/All Size Classes
" MBA.AllSx" = Mortality/Basal Area per Acre/All Species/All Size Classes
" MCA.AllSx" = Mortality/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top
" MCS.AllSx" = Mortality/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top
" MCT.AllSx" = Mortality/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top
" MBd.AllSx" = Mortality/Board Feet per Acre/All Species/All Size Classes
| |\/
\ / ---> Structural Stage (2 digits) used to identify size class attributes
|          - "Sx" indicates sapling to mature size classes (All sizes) (1)
|          - "Sm" indicates sapling to mid-age size classes            (2)
|          - "Sy" indicates sapling to young size classes              (3)
|          - "Ss" indicates sapling size class                         (4)
|          - "Yx" indicates young to mature size classes               (5)
|          - "Ym" indicates young to mid-age size classes              (6)
|          - "Yy" indicates young size class                           (7)
|          - "Mx" indicates mid-age to mature size classes             (8)
|          - "Mm" indicates mid-age size class                         (9)
|          - "Xx" indicates mature size class                          (0)
|
------> FIA Species Codes (3 digits) used to identify individual species
- "All" indicates all species combined
- "Sft" indicates all softwood species
- "Hrd" indicates all hardwood species
- "Gp1" indicates species group 1
- "Gp2" indicates species group 2
- "Gp3" indicates species group 3
- "Gp4" indicates species group 4
- "Gp5" indicates species group 5
```

Figure VI-1 – FVSSTAND Alone Yield Table, Coding Guide to Accounting Variables

1. Combine Time



The "Combine" computer program was written during the Black Hills Phase II Amendment analysis process for several reasons.

They were:

1. Re-compute the Compute2 output files to assign stand age class (10-year basis).
2. Re-compute the Compute2 output files to save FVS memory elements (SOS, HSS, and MPB class codes calculated).
3. Calculate Compute2 strata mean values for continuous data items.
4. Calculate Compute2 strata mode values for classification data items.
5. Re-compute the FireTbl output tables to assign stand age class (10-year basis).
6. Re-compute the FireTbl output tables to save FVS memory elements (Fire Hazard class code calculated).
7. Calculate FireTbl strata mean values for continuous data items.
8. Calculate FireTbl strata mode values for classification data items.
9. Combine yield file output from FVSSTAND, Compute2, and FireTbl into one composite yield table.

The Combine program was initially written to run as a stand alone program for testing purposes. It was further enhanced to run in batch mode (without user prompts) to allow sequential processing of stand types.

The Combine program was the first attempt by an FVS post processor to generically scale accounting variables by either mean or mode processing. Two options for resolving ties within classification code counts to determine mode values were allowed. If it was reasonable to favor minimum values, then an ascending sort order could be specified. Thus, if two class variables had the exact number of plots counts representing the strata, then the lesser value would be chosen. For example, if a stand type yield estimate for habitat structural stage rendered equal plot counts for mature-high density (4C) and old growth (5), it is more desirable to be conservative and use the mature-high density call rather than old growth. Sorting the mode column in an ascending fashion would accommodate this logic. If it was reasonable to favor maximum values, then a descending sort order could be specified. Good examples would be for insect and fire hazard. Responsiveness to impending impacts would be sensible.

The ability to aggregate output columns from several post processing programs was also a unique feature of the Combine program. Further development is needed to make Combine a fully featured program.

C. SPRAY Program

The Suppose program, the graphical user interface for the Forest Vegetation Simulator, was developed to simplify the task of setting up keyword sets for one or more stands of a given stand type. Suppose was not designed to process series of stand types sequentially.

The Parallel Processing Extension (PPE) of the Forest Vegetation Simulator has the capability to address four types of problems. They are:

1. Multistand treatment scheduling
2. Resource supply trends
3. Contagion in pest dynamics
4. Decision trees

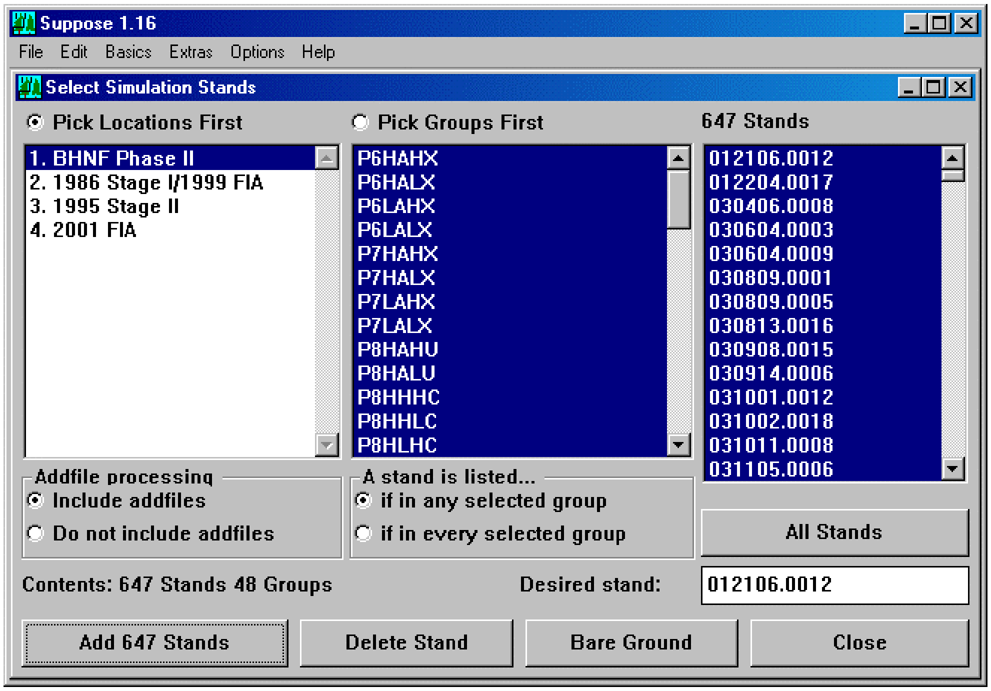
Multistand treatment scheduling involves trade-off analysis. For example, suppose a forested area composed of many stands was utilized for elk hiding cover and timber production. Favoring one entity involves impacts on the other. The PPE allows examination of these tradeoffs. Resource supply analysis involves gaming analysis. For example, suppose a forest analyst wanted to determine if a specified level of timber harvest were sustainable. The PPE, based on resource supply and public demand, can determine the level of diminishing return. Contagion in pest dynamics deals with spatial analysis. For example, suppose a Mountain Pine Beetle epidemic was devastating an area. The PPE can be used to chart the progression of an insect or disease pathogen from one stand into another. Decision trees are used for alternative analysis. For example, suppose a silviculturalist was trying to decide on the timing options for a thinning treatment of a particular stand. The PPE could be used to replicate the stand along several pathways to determine the best solution. The PPE does not have the capacity to process series of stand types sequentially.

Enter the need to develop a program that will run a group of stands with particular treatment activities to produce yield profiles for decision analysis projects such as forest planning. The "Sequential Processing Routine Arraying Yields" (SPRAY) program was designed for such a purpose. The founding principles in the development of the SPRAY program was to utilize as much of the FVS existing software as possible. Then, design a user interface that would allow easy input of stand types, their associated silvicultural prescriptions, and possible timing options. A synopsis of the SPRAY program follows.

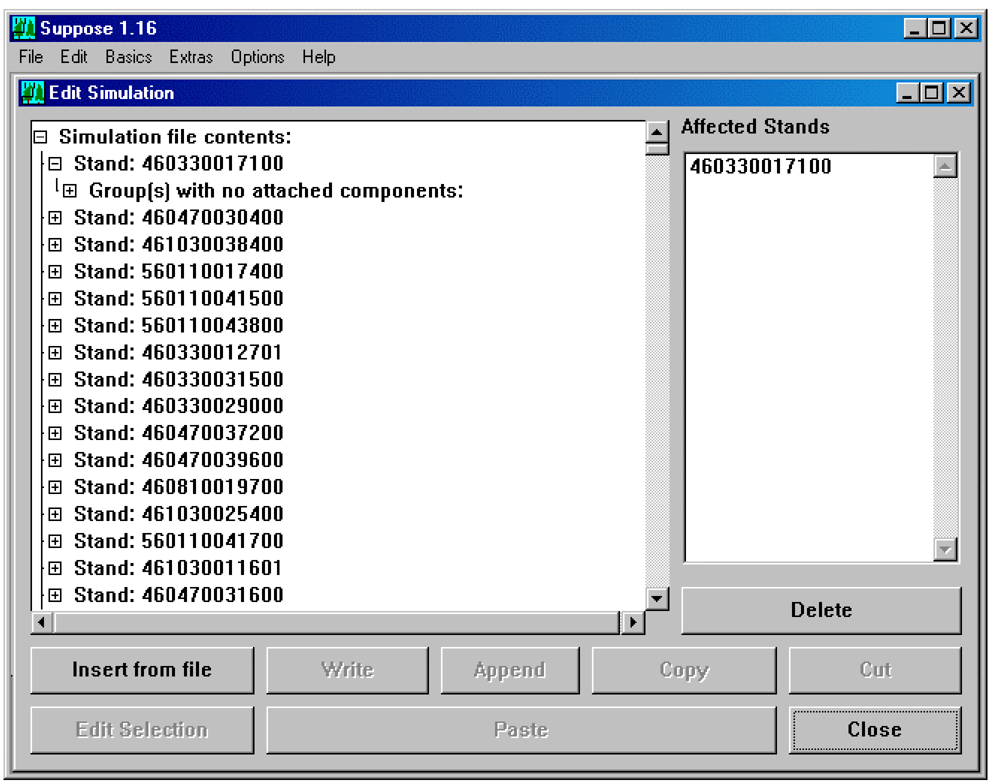
1. Suppose Connections

The objective of maintaining a connection to the Suppose interface was to take advantage of its ability to design FVS keywords that describe basic inventory parameters. Through information provided in the 'Stand List File' (*.slf), the Suppose program builds the StdIdent, InvYear, ModType, StdInfo, Locate, Design, Growth, BAMax, SDIMax, SiteCode, NumCycle, TimeInt, Open, TreeData, SPLabel, and Process keywords per inventory plot. That is a lot of overhead that is being taken care of. Suppose is called upon to build the base keyword set for the entire inventory data base.

- Select all stands for the project:



- No need to include additional FVS keywords or post processors:



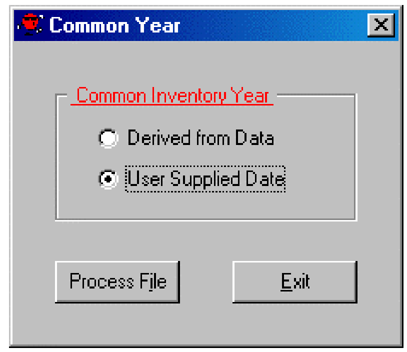
- Run the simulation to generate a global inventory keyword set.

The SPRAY program picks up processing from here.

2. SPRAY Setup

SPRAY has a few initial setup steps prior to running a sequential processing tree. These include:

1. Common Year – Establishes a base inventory year, the number of projection cycles, and the length of the cycle time interval for each plot in the global keyword file. The base inventory year can be derived from the most recent year recorded for all plots or it can be supplied by the user.

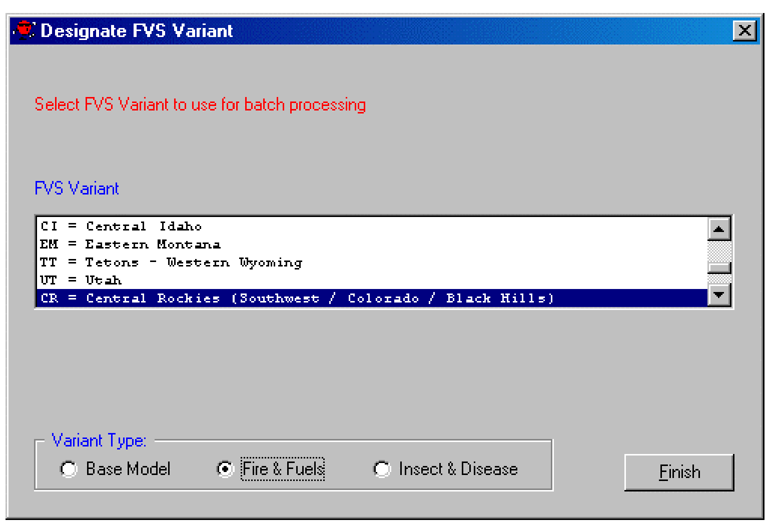


2. Index Strata – Creates a "Spray.key" file that contains FVS keywords. Suppose lines are removed from original global key file. The "Spray.key" is formatted as a 'direct access' file (records have equal length) to allow rapid retrieval of specified records. Creates complementary "Spray.idx" index file that links stand type labels with line numbers in the "Spray.key" file. Thus, an association is established between the "Spray.key" and "Spray.idx" files.

Spray.idx File:

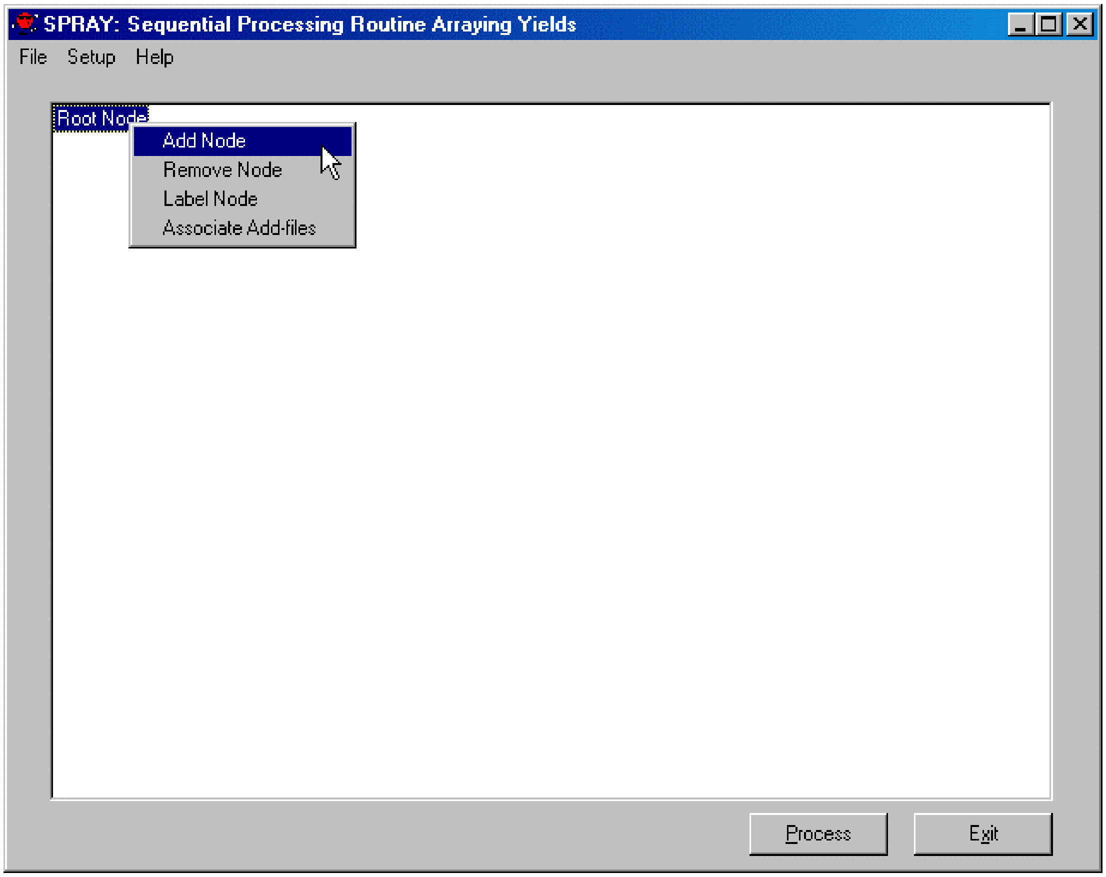
Stand Type Label	Line Index Number
S7AAAX	12314
S7AAAX	12333
S8AAAX	12105
S8AAAX	12124
S8AAAX	12143
S8AAAX	12162
S8AAAX	12181
S8AAAX	12200
S8AAAX	12219
S9AAAX	12029
S9AAAX	12048
S9AAAX	12067

3. Select Variant – Designates the FVS geographic variant to use in the simulation runs. Model extension can be chosen as well.



3. Spray Nodes

Right mouse clicking any existing node will elicit a pop-up menu to be displayed. Four options are available:



The base hierarchy established for sequential processing of the stand types is to assign a global level at the root node. Subordinate nodes declare vegetative stand types, silvicultural treatments, and timing options. Using the "Add Node" menu option will display a new subordinate node. It is recommended to fully complete one level before proceeding to the next lower level (i.e. enter all vegetative stand types before assigning associated silvicultural treatments). Using the "Remove Node" menu option will delete an existing node. Using the "Label Node" menu option will allow renaming the current node assignment. Using the "Associate Add-files" menu option will prompt a pick list window to appear that allows designating specific keyword component files to a path node. This is a very powerful feature that enables progressively building keyword runstreams to process through FVS. Refer to Figure VI-2 for the depiction of the sequential processing tree. Refer to Figure VI-3 for the display of assigning keyword component files to path nodes.

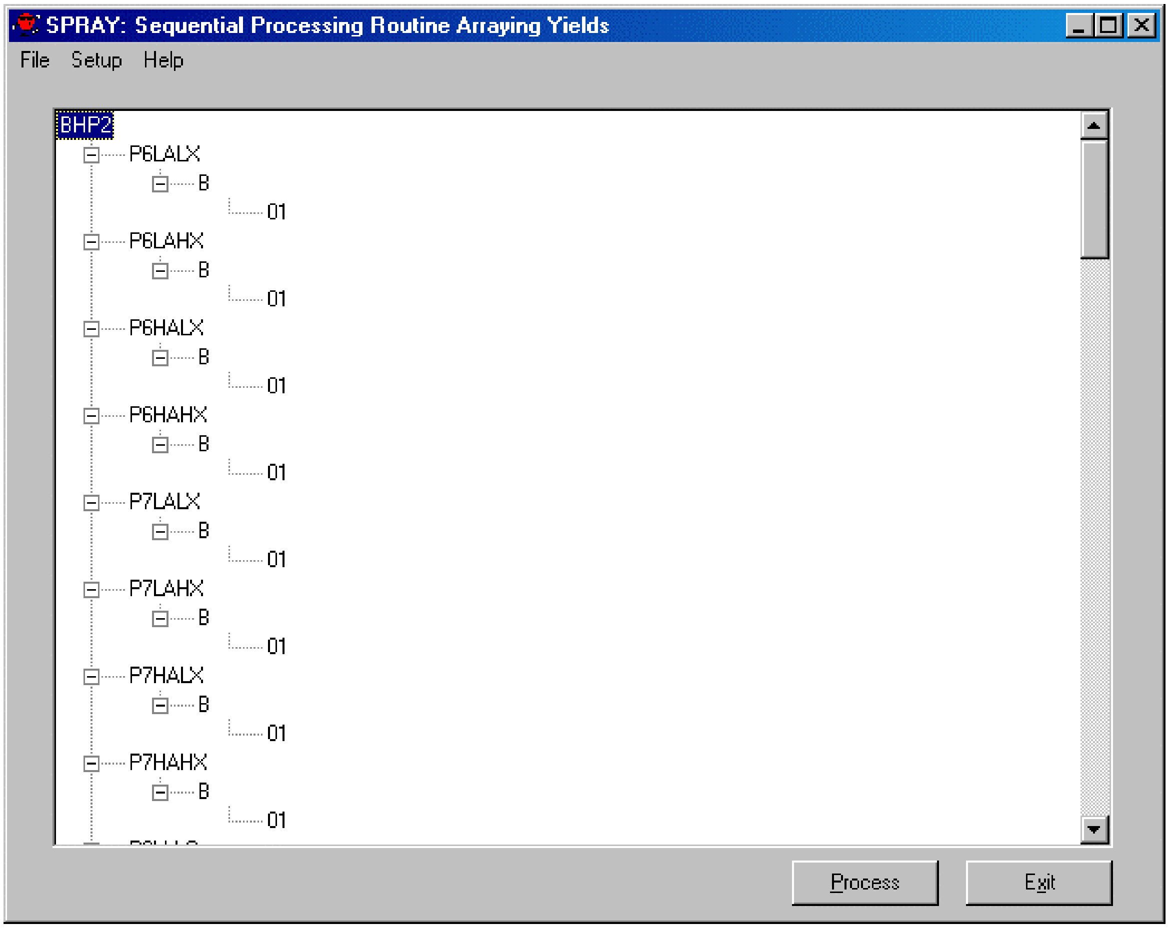


Figure VI-2 – Pathway Nodes for Black Hills Phase II Amendment Project

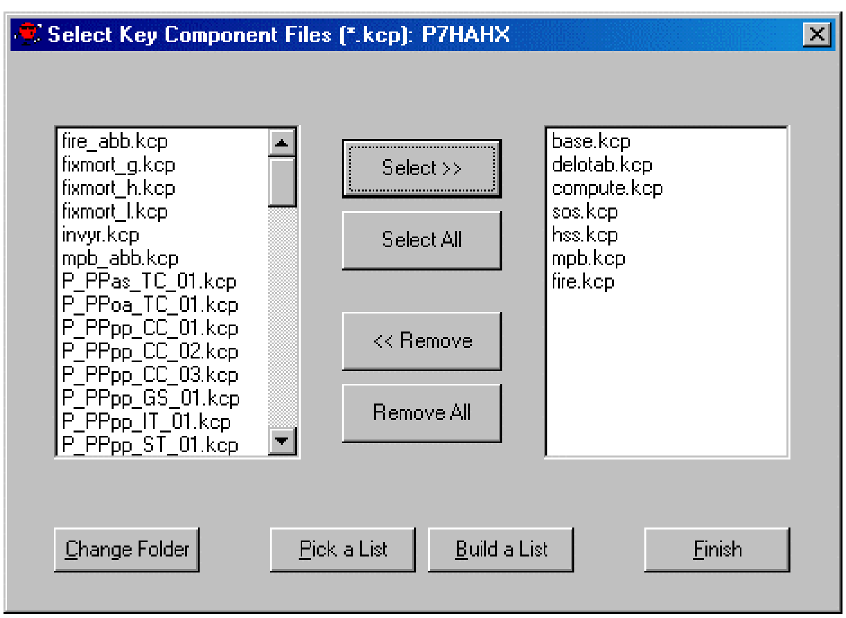


Figure VI-3 – Associating Keyword Component Files (Add-Files) to a Pathway Node

4. Spray Process

Once the pathway nodes have been defined and the associated add-files assigned to their applicable nodes, the runstream can be processed. The SPRAY program captured the user input in two files. The "Spray.prj" file contains the FVS variant designated for the runstream and the layout of the pathway nodes. This allows easy retrieval of existing project files (*.prj). The "Spray.add" file contains a listing of the associated add-files per node assignment. Refer to Appendix III to review an example of the Spray.prj and Spray.add files for the shelterwood prescription (B), first timing option (01).

The SPRAY program builds a composite keyword file set ("Spray.sim" file) per stand type per silvicultural prescription per timing option. Once created, the runstream is process through the specified FVS variant. The FVSSTAND, Compute2, and FireTbl post processor are then called upon. Finally, the Combine program synthesizes the output files from the post processing program into one composite yield profile. The process continues with the next combination of vegetative stand type, silvicultural prescription, and timing option until all combinations have been processed. The resultant yield files provide the input values to the forest planning model.

D. Yield Files

Approximately 700 yield profiles were developed for the Black Hills Phase II Amendment. Approximately 300 accounting variables comprised each yield file. The SPRAY program was used to accommodate this work. As mentioned previously, two types of yield files were created: age-dependent and time-dependent. Even-aged silvicultural systems trigger treatments based on stand age. Thus, age-dependent yield tables best represent these methods. Uneven-aged silvicultural systems are stand age independent. Entries prescribed are specified on a cutting cycle basis. Thus, time-dependent yield tables best represent these methods. A representative age-dependent yield profile for the 'All Species Combined' columns of the P9HMHPBO1 (Ponderosa Pine Overstory – Large Size Class – Single-storied – Moderate Canopy Cover – High Site Productivity – Ponderosa Pine Understory – Shelterwood Silvicultural System – First Timing Option) strata follows:

Strata	Proj_YEAR	St_Age/10	Stand_Age	SiteIndex	StDnIndex	CulmMAI-T	Qd_Mn_Dia	For_Type_	Plt_Acres	Trt_Acres
P9HMHPB01	2083	8	75.00	89.00	238.00	16.34	9.96	221.00	4.00	0.00
P9HMHPB01	2093	9	85.00	80.00	199.00	23.80	10.14	221.00	11.00	11.00
P9HMHPB01	2103	10	95.00	76.00	185.00	20.07	6.89	221.00	21.00	0.00
P9HMHPB01	2113	11	106.00	75.00	199.00	21.18	6.79	221.00	27.00	0.00
P9HMHPB01	2123	12	116.00	74.00	198.00	21.52	7.29	221.00	34.00	0.00
P9HMHPB01	2133	13	125.00	70.00	253.00	23.73	12.24	221.00	3.00	0.00
P9HMHPB01	2143	14	137.00	67.00	260.00	26.79	11.28	221.00	1.00	0.00
P9HMHPB01	2153	15	145.00	71.00	182.00	22.51	12.74	221.00	2.00	0.00
P9HMHPB01	2163	16	155.00	73.00	128.00	16.55	13.58	221.00	1.00	0.00
P9HMHPB01	2013	1	10.00	73.00	68.00	280.87	16.53	221.00	41.00	41.00
P9HMHPB01	2023	2	20.00	73.00	89.00	202.57	7.51	221.00	41.00	41.00
P9HMHPB01	2033	3	30.00	73.00	77.00	102.17	3.88	221.00	41.00	41.00
P9HMHPB01	2043	4	40.00	73.00	104.00	78.20	5.53	221.00	41.00	0.00
P9HMHPB01	2053	5	50.00	73.00	145.00	64.52	6.06	221.00	41.00	0.00
P9HMHPB01	2063	6	60.00	73.00	182.00	57.93	7.00	221.00	41.00	38.00
P9HMHPB01	2073	7	70.00	73.00	135.00	51.71	8.13	221.00	41.00	0.00
P9HMHPB01	2083	8	80.00	73.00	159.00	48.93	7.77	221.00	41.00	0.00
P9HMHPB01	2093	9	90.00	73.00	179.00	53.93	8.48	221.00	41.00	35.00
P9HMHPB01	2103	10	100.00	73.00	139.00	45.20	8.40	221.00	41.00	0.00
P9HMHPB01	2113	11	110.00	73.00	158.00	43.46	7.98	221.00	41.00	0.00
P9HMHPB01	2123	12	120.00	73.00	177.00	42.40	8.53	221.00	41.00	0.00
P9HMHPB01	2013	1	10.00	71.00	64.00	516.03	16.85	221.00	37.00	37.00
P9HMHPB01	2023	2	20.00	70.00	84.00	293.48	6.97	221.00	30.00	20.00
P9HMHPB01	2033	3	30.00	70.00	79.00	166.58	3.82	221.00	20.00	14.00

Stand_Age	LTr.AllSx	LAD.AllSx	LAH.AllSx	LBA.AllSx	LCA.AllSx	LCS.AllSx	LCT.AllSx	LBd.AllSx
75.00	4185.45	0.41	2.73	78.85	1225.97	0.00	0.00	6073.09
85.00	1807.99	1.28	8.49	94.75	1470.30	0.00	0.00	7330.77
95.00	1023.86	2.01	11.35	91.90	1348.45	0.00	0.00	6814.27
106.00	1102.62	1.93	11.45	100.44	1676.95	0.00	0.00	8692.82
116.00	860.78	2.55	15.25	105.77	1926.41	0.00	0.00	10109.77
125.00	3133.79	0.59	5.13	109.50	2397.30	0.00	0.00	12999.24
137.00	1698.41	1.25	7.99	137.82	3110.75	0.00	0.00	16545.90
145.00	126.57	12.19	68.33	112.00	2703.39	0.00	0.00	14344.89
155.00	228.00	4.54	27.05	78.48	2005.20	0.00	0.00	10847.40
10.00	174.95	3.02	16.09	44.48	1257.18	0.00	0.00	7119.75
20.00	469.58	2.00	11.09	52.86	1441.41	0.00	0.00	8352.02
30.00	441.76	2.96	13.64	34.55	454.99	0.00	0.00	2772.11
40.00	367.90	3.93	18.25	49.51	517.93	0.00	0.00	3216.57
50.00	358.50	5.24	24.50	71.57	616.00	0.00	0.00	3787.66
60.00	348.23	6.26	30.60	93.08	799.62	0.00	0.00	4701.76
70.00	275.07	5.38	27.94	73.19	943.64	0.00	0.00	5495.57
80.00	268.44	6.42	32.72	88.29	1238.13	0.00	0.00	7051.93
90.00	258.43	7.19	36.96	101.43	1590.25	0.00	0.00	8921.33
100.00	274.98	5.35	29.13	78.33	1256.90	0.00	0.00	7517.29
110.00	264.63	6.30	33.22	90.35	1517.40	0.00	0.00	8975.69
120.00	258.07	7.02	36.85	102.42	1824.52	0.00	0.00	10583.35
10.00	173.00	2.86	15.16	43.43	1262.49	0.00	0.00	7740.76
20.00	467.52	1.97	10.83	50.63	1343.19	0.00	0.00	8225.42
30.00	446.26	3.01	13.66	35.45	471.02	0.00	0.00	2982.47

Stand_Age	HTr.AllSx	HAD.AllSx	HAH.AllSx	HBA.AllSx	HCA.AllSx	HCS.AllSx	HCT.AllSx	HBd.AllSx
75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
85.00	47.26	11.10	55.98	32.46	561.17	0.00	0.00	2631.41
95.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
106.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
116.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
137.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
145.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
155.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	970.10	1.73	11.39	67.51	990.69	0.00	0.00	4945.09
20.00	19.44	18.14	79.36	36.02	1058.36	0.00	0.00	6086.29
30.00	142.71	2.14	10.66	3.90	0.00	0.00	0.00	0.00
40.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60.00	143.68	6.41	31.67	34.39	66.17	0.00	0.00	304.47
70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90.00	53.02	10.88	54.67	35.25	586.84	0.00	0.00	2872.69
100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
110.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
120.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	240.45	6.05	33.18	63.42	635.26	0.00	0.00	3272.79
20.00	11.37	17.68	76.43	21.53	628.37	0.00	0.00	3824.89
30.00	100.12	2.09	10.16	2.44	0.00	0.00	0.00	0.00

Stand_Age	MTr.AllSx	MAD.AllSx	MAH.AllSx	MBA.AllSx	MCA.AllSx	MCS.AllSx	MCT.AllSx	MBd.AllSx
75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
85.00	139.50	0.54	3.66	3.56	54.60	0.00	0.00	262.21
95.00	527.56	0.66	5.87	3.17	33.99	0.00	0.00	177.70
106.00	107.91	2.39	13.19	7.58	67.25	0.00	0.00	328.52
116.00	89.66	2.42	14.82	7.60	85.73	0.00	0.00	430.32
125.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
137.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
145.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
155.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.19	16.03	72.68	0.28	7.34	0.00	0.00	40.42
20.00	3.29	3.42	18.28	0.90	24.34	0.00	0.00	134.04
30.00	8.38	1.35	8.31	0.29	5.68	0.00	0.00	32.36
40.00	5.63	3.07	14.06	0.41	3.50	0.00	0.00	20.54
50.00	9.40	3.99	18.36	1.07	3.06	0.00	0.00	18.74
60.00	10.27	5.18	23.90	1.75	3.32	0.00	0.00	18.75
70.00	3.96	5.66	28.41	0.91	8.36	0.00	0.00	49.16
80.00	6.63	5.38	28.93	1.57	15.62	0.00	0.00	88.70
90.00	10.01	6.00	32.52	2.61	23.95	0.00	0.00	134.01
100.00	4.91	5.70	30.91	1.18	10.93	0.00	0.00	64.74
110.00	10.35	5.54	31.53	2.36	15.59	0.00	0.00	82.90
120.00	6.56	6.06	32.57	1.92	26.03	0.00	0.00	155.16
10.00	0.15	15.03	69.80	0.21	5.78	0.00	0.00	34.23
20.00	3.26	3.83	20.55	0.98	25.12	0.00	0.00	141.45
30.00	8.47	1.45	8.62	0.33	6.39	0.00	0.00	37.07

Stand_Age	_ForTyp	_SizCls	_StkCls	_CanCov0	_SOS	_CHESS	_OGSC	_CHESSER	_MPB_Haz
75.00	221.00	1.00	4.00	49.46	122.00	42.00	20.00	50.00	3.00
85.00	221.00	1.00	3.00	54.28	122.00	42.00	15.00	0.00	5.00
95.00	221.00	1.00	3.00	53.75	122.00	42.00	15.00	0.00	5.00
106.00	221.00	1.00	3.00	56.54	122.00	42.00	15.00	0.00	5.00
116.00	221.00	1.00	3.00	57.91	122.00	42.00	15.00	0.00	5.00
125.00	221.00	1.00	3.00	59.35	122.00	42.00	20.00	50.00	5.00
137.00	221.00	1.00	2.00	66.38	122.00	42.00	20.00	50.00	5.00
145.00	221.00	1.00	4.00	56.66	999.00	42.00	10.00	0.00	5.00
155.00	221.00	1.00	3.00	45.43	122.00	42.00	10.00	0.00	3.00
10.00	221.00	1.00	4.00	27.65	122.00	41.00	10.00	0.00	3.00
20.00	221.00	1.00	4.00	32.88	122.00	41.00	5.00	0.00	1.00
30.00	221.00	3.00	4.00	26.92	122.00	41.00	5.00	0.00	1.00
40.00	221.00	2.00	4.00	35.09	122.00	31.00	5.00	0.00	1.00
50.00	221.00	2.00	4.00	45.99	122.00	32.00	5.00	0.00	1.00
60.00	221.00	2.00	3.00	54.56	999.00	32.00	5.00	0.00	3.00
70.00	221.00	1.00	4.00	45.87	999.00	42.00	10.00	0.00	1.00
80.00	221.00	1.00	3.00	52.10	999.00	42.00	5.00	0.00	3.00
90.00	221.00	1.00	3.00	56.73	999.00	42.00	5.00	0.00	3.00
100.00	221.00	1.00	4.00	46.58	999.00	42.00	10.00	0.00	1.00
110.00	221.00	1.00	3.00	51.78	999.00	42.00	5.00	0.00	3.00
120.00	221.00	1.00	3.00	56.59	999.00	42.00	5.00	0.00	3.00
10.00	221.00	1.00	4.00	26.90	122.00	41.00	5.00	0.00	3.00
20.00	221.00	1.00	4.00	31.55	122.00	41.00	5.00	0.00	1.00
30.00	221.00	3.00	4.00	25.17	122.00	41.00	5.00	0.00	1.00

Stand_Age	_Snag_H1	_Snag_H2	_Snag_H3	_Snag_H4	_Snag_S1	_Snag_S2	_Snag_S3	_Snag_S4
75.00	743.25	2.86	1.50	0.00	0.00	0.00	0.00	0.00
85.00	253.42	6.70	.38	0.00	2.81	0.00	0.00	0.00
95.00	542.71	3.08	.88	.04	1.10	.01	0.00	0.00
106.00	258.40	6.50	.63	.06	3.99	.08	.01	0.00
116.00	115.63	9.56	.67	.21	.66	.01	.01	0.00
125.00	74.63	3.43	4.79	.55	0.00	0.00	0.00	0.00
137.00	0.00	12.70	0.00	0.00	0.00	0.00	0.00	0.00
145.00	23.86	5.84	0.00	0.00	0.00	0.00	0.00	0.00
155.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	20.20	4.04	.56	.18	1.58	.02	.01	0.00
20.00	2.71	.81	.57	.18	0.00	.08	.01	0.00
30.00	9.34	.16	.29	.11	0.00	0.00	.02	.02
40.00	8.77	.05	.16	.09	0.00	0.00	.02	.02
50.00	11.72	.01	.05	.07	0.00	0.00	.01	.02
60.00	14.40	.04	.02	.06	0.00	0.00	.02	.02
70.00	8.21	.38	.01	.07	0.00	0.00	.01	.01
80.00	7.59	.82	0.00	.10	0.00	0.00	.01	.01
90.00	11.53	1.38	.07	.13	0.00	0.00	.01	.01
100.00	8.62	.79	.11	.14	0.00	0.00	.01	.01
110.00	11.83	.70	.17	.12	0.00	0.00	0.00	.01
120.00	10.58	.89	.21	.15	0.00	0.00	0.00	.01
10.00	2.75	.51	.10	.11	0.00	0.00	0.00	.01
20.00	2.58	.52	.24	.17	0.00	0.00	0.00	.01
30.00	9.22	.39	.18	.10	0.00	0.00	0.00	.01

Stand_Age	BulkDens	CnpyBase	S_Flame	S_Crown	S_Torch	F_Hazard
75.00	.05	19.00	9.00	37.03	20.75	4.00
85.00	.03	22.00	6.79	55.37	20.76	2.00
95.00	.06	20.00	9.82	39.35	25.85	3.00
106.00	.06	23.00	7.89	39.86	29.96	2.00
116.00	.02	49.00	7.65	85.93	31.26	2.00
125.00	.02	54.00	7.57	86.57	34.40	2.00
137.00	.02	44.00	7.60	76.80	28.50	2.00
145.00	.01	59.00	7.50	100.00	37.00	2.00
155.00	.02	52.00	7.60	83.10	33.10	2.00
10.00	.02	47.00	7.42	80.93	31.55	2.00
20.00	.02	6.00	14.15	80.93	1.46	3.00
30.00	.04	3.00	15.47	45.34	.13	3.00
40.00	.06	6.00	18.11	34.36	4.06	4.00
50.00	.08	9.00	19.11	29.94	9.85	4.00
60.00	.05	17.00	10.20	39.21	16.44	4.00
70.00	.05	21.00	7.55	38.59	21.92	3.00
80.00	.05	23.00	5.68	38.47	27.00	3.00
90.00	.03	26.00	6.10	68.42	25.10	2.00
100.00	.03	19.00	6.01	57.20	21.58	2.00
110.00	.03	22.00	5.48	54.94	27.33	2.00
120.00	.02	52.00	7.62	91.41	32.90	2.00
10.00	.02	41.00	7.69	83.83	27.36	2.00
20.00	.02	2.00	14.15	72.09	0.00	3.00
30.00	.04	3.00	14.16	46.59	0.00	3.00

A total of 41 inventory plots represented the P9HMHPB01 stand type. Plots were grown forward for 150 years. As stand ages coincided, their values were combined to formulate the yield estimate at that particular age class. The shelterwood system grew stands through 120 years. Thereafter, regeneration cutting transitioned the plots into second-growth conditions. After another 120 years, a third generation was produced. This accounts for the repetition of certain age classes down the yield files. Existing stands that were in excess of 120 years at the start of the simulation could indeed grow through a complete rotation into a third generation stand because of the 150 year projection length. Figure VI-4a-g provide a pictorial of the shelterwood system.

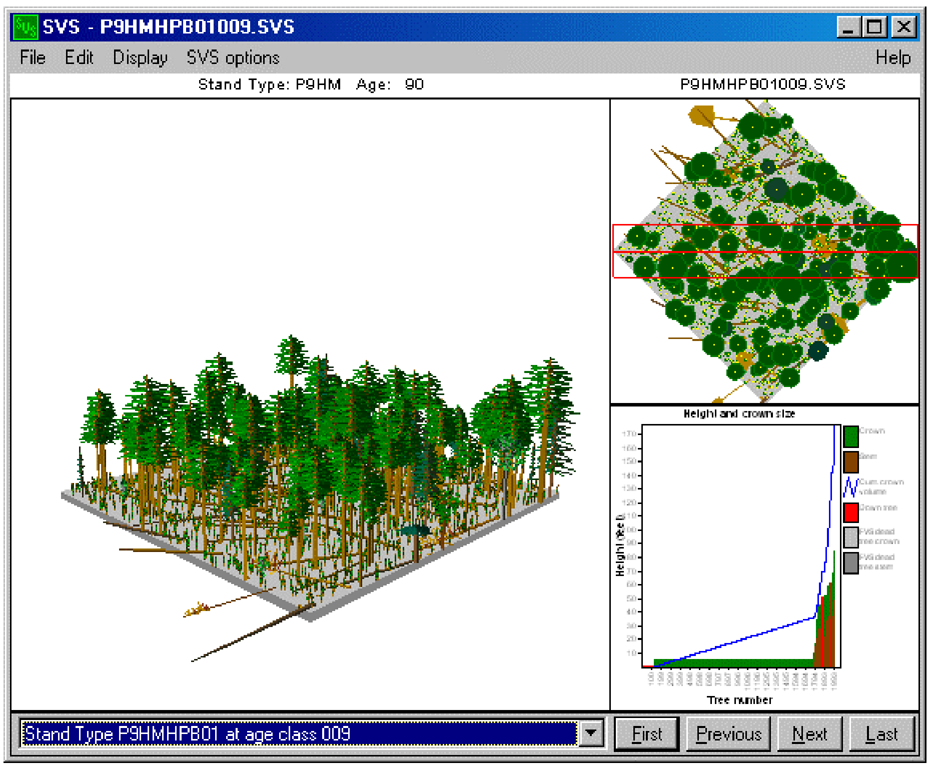


Figure VI-4a – P9HMHPB01 Strata, Existing Stand Type: 90-Year Age Class

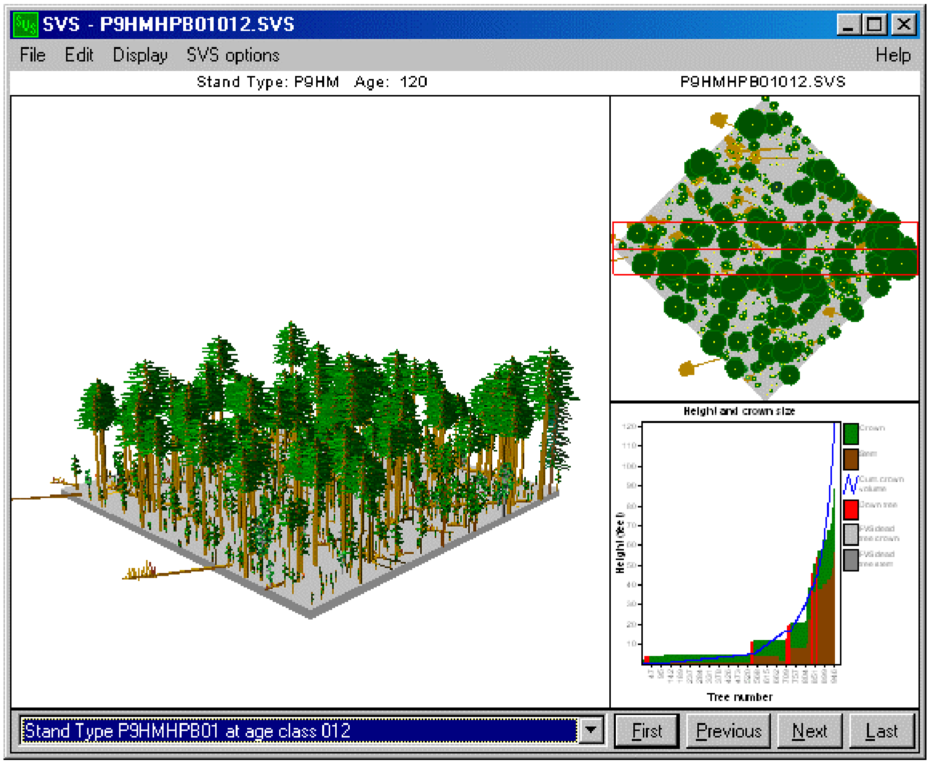


Figure VI-4b – P9HMHPB01 Strata, Existing Stand Type: 120-Year Age Class

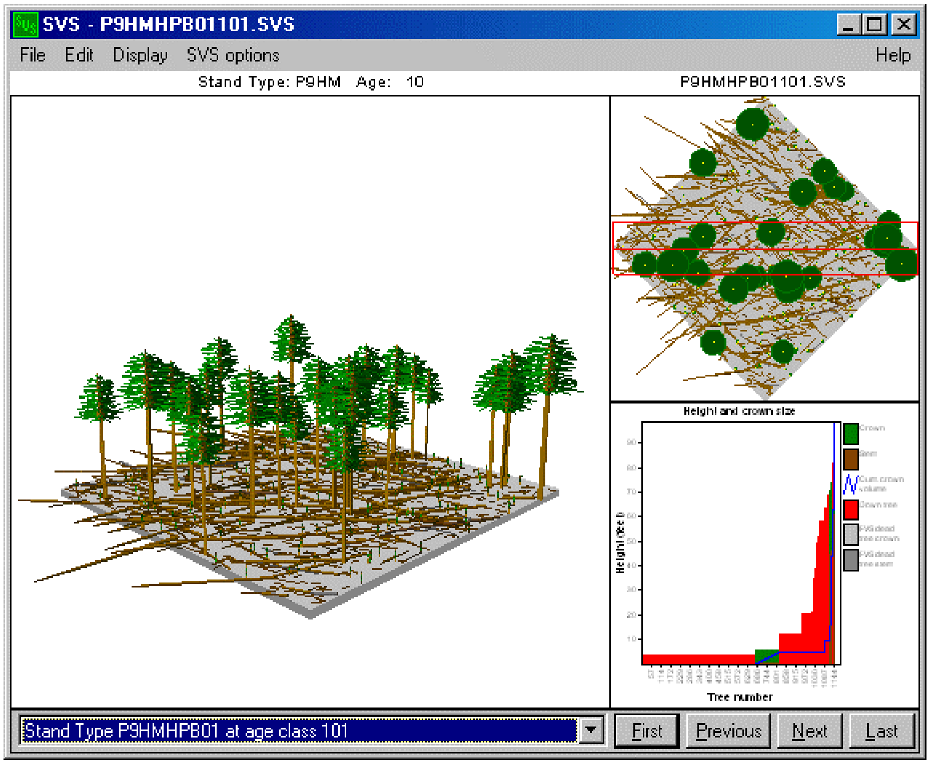


Figure VI-4c – P9HMHPB01 Strata, Regenerated Stand Type: 10-Year Age Class

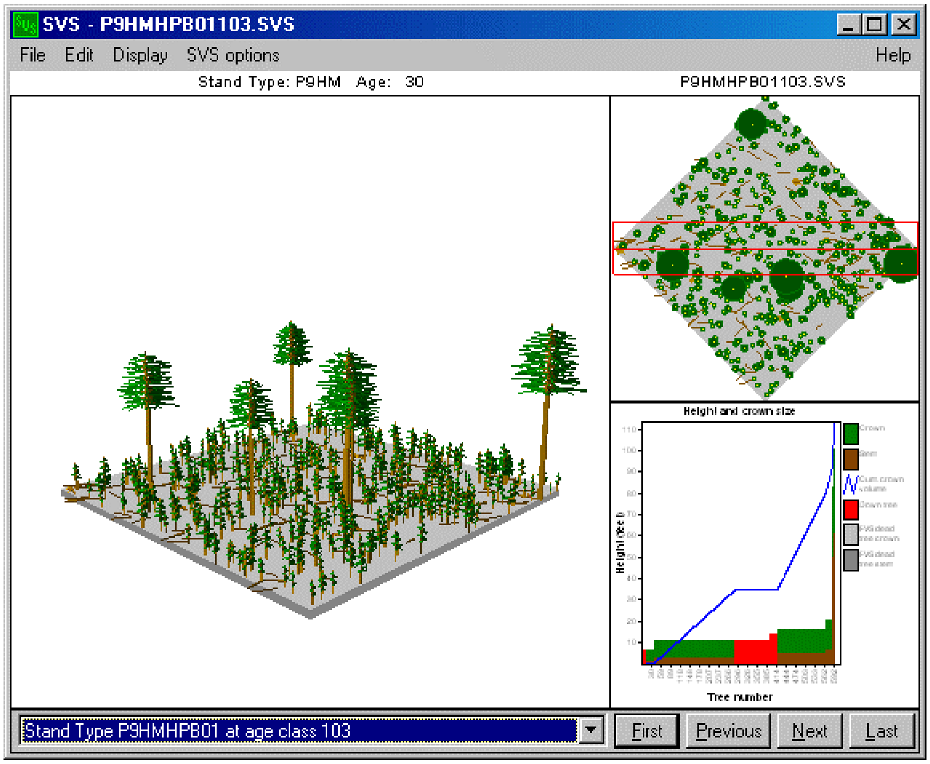


Figure VI-4d – P9HMHPB01 Strata, Regenerated Stand Type: 30-Year Age Class

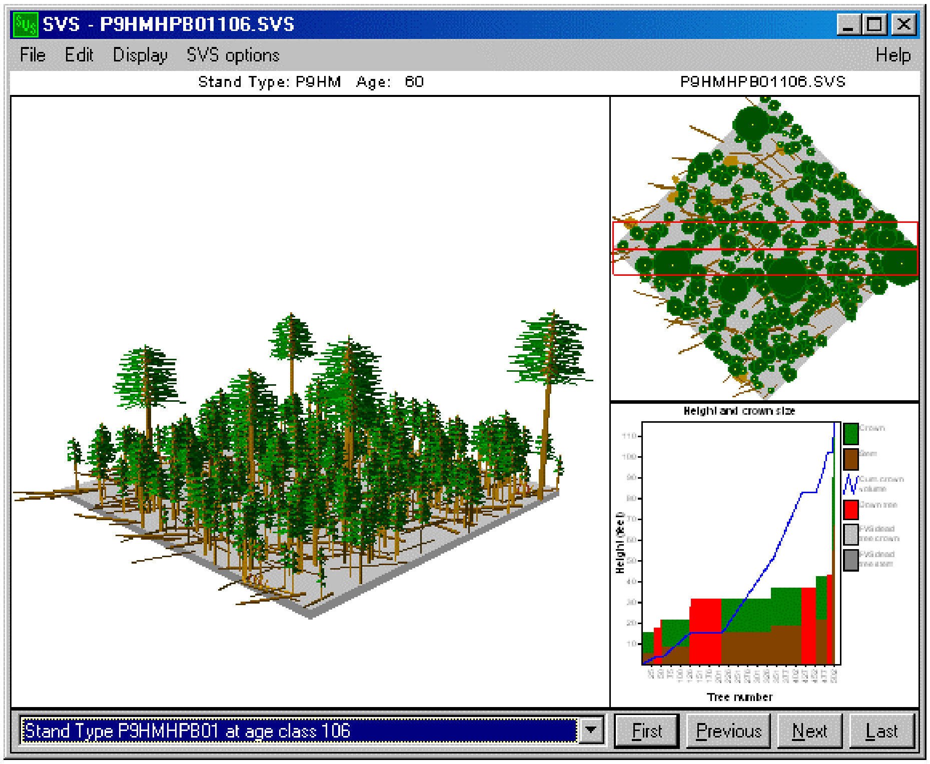


Figure VI-4e – P9HMHPB01 Strata, Regenerated Stand Type: 60-Year Age Class

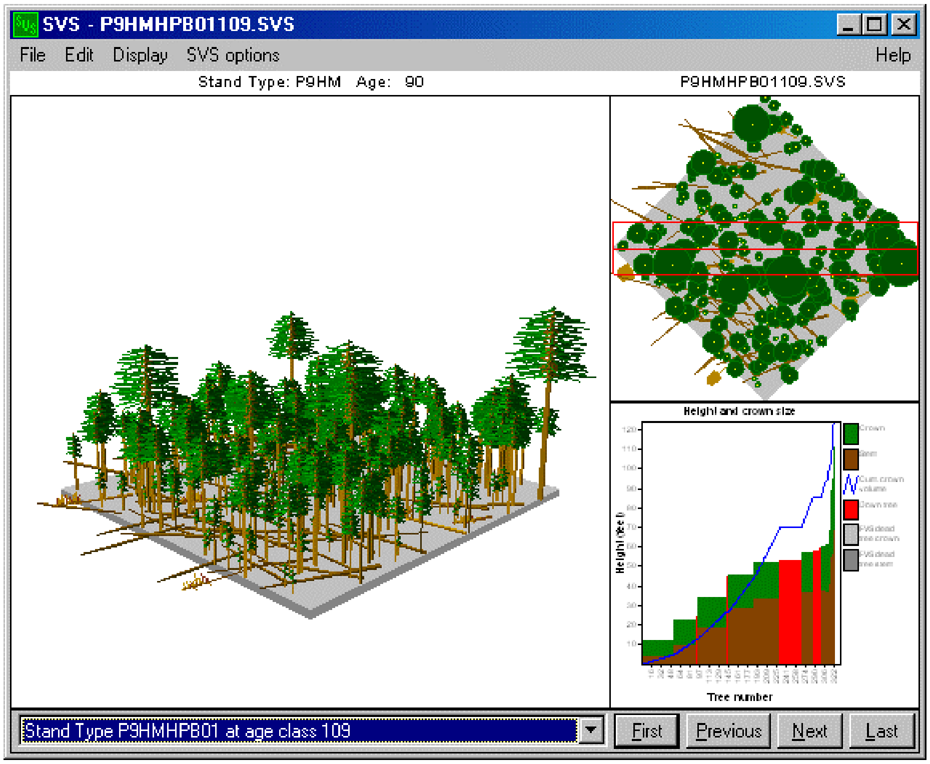


Figure VI-4f – P9HMHPB01 Strata, Regenerated Stand Type: 90-Year Age Class

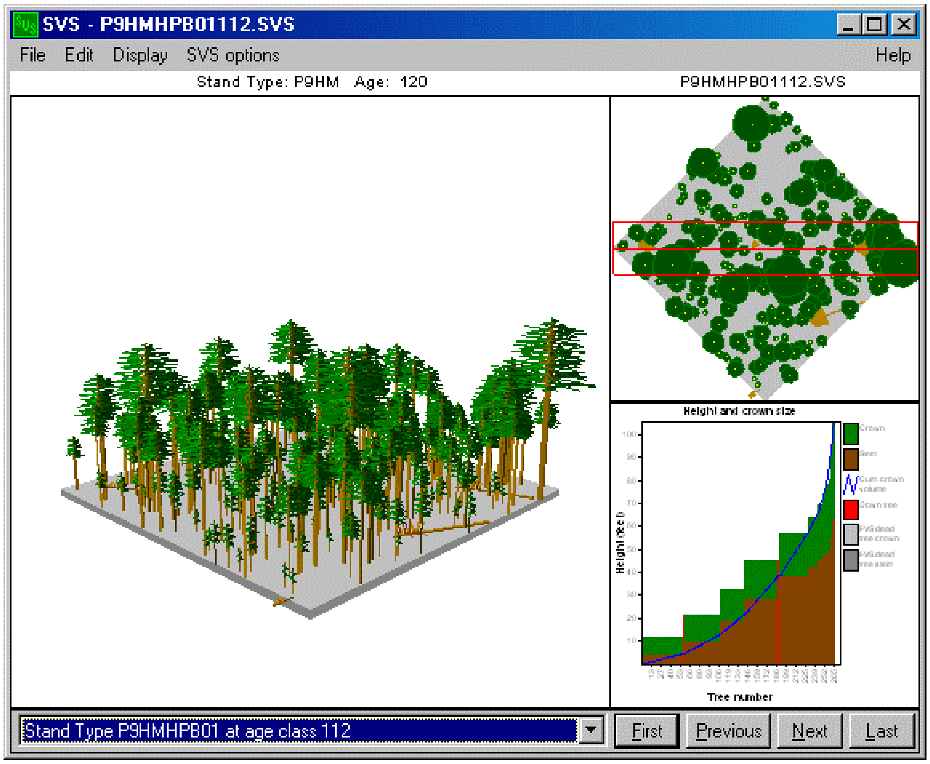


Figure VI-4g – P9HMHPB01 Strata, Regenerated Stand Type: 120-Year Age Class

Pulses of regeneration were added following each thinning. During the course of a full rotation, the stand structure contains several size classes as depicted by the crown distribution graph.

A representative time-dependent yield profile for the ‘All Species Combined’ columns of the S9AAAXLO1 (White Spruce Overstory – Large Size Class – All-Storied Classes – All Canopy Cover Classes– All Site Productivity Classes – Non-qualified Understory – Group Selection Silvicultural System – First Timing Option) strata follows:

Strata	Proj_YEAR	St_Age/10	Stand_Age	SiteIndex	StDnIndex	CulmMAI-T	Qd_Mn_Dia	For_Type_	Plt_Acres	Trt_Acres
S9AAAXL01	2003	10	104.00	77.00	186.00	13.24	7.90	122.00	10.00	0.00
S9AAAXL01	2013	11	114.00	77.00	108.00	15.13	7.00	122.00	10.00	9.00
S9AAAXL01	2023	12	124.00	77.00	137.00	16.98	6.80	122.00	10.00	0.00
S9AAAXL01	2033	13	134.00	77.00	79.00	17.43	8.65	122.00	10.00	10.00
S9AAAXL01	2043	14	144.00	77.00	98.00	17.94	8.48	122.00	10.00	0.00
S9AAAXL01	2053	15	154.00	77.00	82.00	17.79	8.46	122.00	10.00	10.00
S9AAAXL01	2063	16	164.00	77.00	102.00	17.70	8.32	122.00	10.00	0.00
S9AAAXL01	2073	17	174.00	77.00	91.00	17.99	8.79	122.00	10.00	8.00
S9AAAXL01	2083	18	184.00	77.00	106.00	17.76	8.59	122.00	10.00	0.00
S9AAAXL01	2093	19	194.00	77.00	89.00	17.76	8.54	122.00	10.00	9.00
S9AAAXL01	2103	20	204.00	77.00	106.00	17.55	8.37	122.00	10.00	0.00
S9AAAXL01	2113	21	214.00	77.00	92.00	17.61	8.53	122.00	10.00	8.00
S9AAAXL01	2123	22	224.00	77.00	109.00	17.54	8.47	122.00	10.00	0.00
S9AAAXL01	2133	23	234.00	77.00	87.00	17.41	8.38	122.00	10.00	9.00
S9AAAXL01	2143	24	244.00	77.00	108.00	17.80	8.51	122.00	10.00	0.00
S9AAAXL01	2153	25	254.00	77.00	92.00	18.05	8.58	122.00	10.00	9.00

Proj_YEAR	LTr.AllSx	LAD.AllSx	LAH.AllSx	LBA.AllSx	LCA.AllSx	LCS.AllSx	LCT.AllSx	LBd.AllSx
2003	1043.17	1.78	10.97	91.68	1375.31	0.00	0.00	6738.72
2013	250.63	4.79	28.93	59.19	933.49	0.00	0.00	4844.57
2023	361.34	4.30	26.44	75.63	1314.17	0.00	0.00	6764.30
2033	148.45	5.33	30.07	46.63	869.67	0.00	0.00	4772.49
2043	147.14	6.64	36.96	57.70	1117.41	0.00	0.00	6073.67
2053	158.59	5.33	29.82	47.29	834.60	0.00	0.00	4717.65
2063	157.23	6.67	36.76	59.37	998.89	0.00	0.00	5514.45
2073	154.79	5.98	33.61	52.18	934.22	0.00	0.00	5069.97
2083	151.21	7.15	39.73	60.89	1072.35	0.00	0.00	5630.90
2093	160.14	5.78	31.79	49.83	839.38	0.00	0.00	4335.93
2103	157.13	7.01	37.86	60.09	973.57	0.00	0.00	4836.04
2113	159.52	6.04	33.27	51.14	806.77	0.00	0.00	3955.05
2123	155.55	7.20	38.99	60.89	965.84	0.00	0.00	4718.86
2133	156.40	5.84	31.96	48.31	736.68	0.00	0.00	3684.33
2143	155.11	7.15	38.82	61.27	1004.90	0.00	0.00	4937.76
2153	160.11	5.90	32.30	52.11	854.24	0.00	0.00	4377.94

Proj_YEAR	HTr.AllSx	HAD.AllSx	HAH.AllSx	HBA.AllSx	HCA.AllSx	HCS.AllSx	HCT.AllSx	HBd.AllSx
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	830.93	1.26	8.05	48.60	789.36	0.00	0.00	3716.48
2023	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2033	261.89	3.53	22.81	39.23	674.42	0.00	0.00	3277.49
2043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2053	37.55	8.09	44.25	20.31	439.24	0.00	0.00	2280.06
2063	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2073	40.44	6.90	35.29	16.29	291.08	0.00	0.00	1417.37
2083	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2093	33.63	9.31	51.94	19.84	410.78	0.00	0.00	1975.54
2103	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2113	35.13	8.56	41.78	19.23	355.56	0.00	0.00	1694.02
2123	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2133	40.47	8.57	44.88	20.78	375.28	0.00	0.00	1715.50
2143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2153	39.47	9.00	46.42	21.63	392.65	0.00	0.00	1776.56

Proj_YEAR	MTr.AllSx	MAD.AllSx	MAH.AllSx	MBA.AllSx	MCA.AllSx	MCS.AllSx	MCT.AllSx	MBd.AllSx
2003	94.18	6.46	39.72	27.87	295.46	0.00	0.00	1309.90
2013	6.58	3.89	21.40	1.38	24.49	0.00	0.00	134.41
2023	6.60	4.18	26.91	1.11	17.16	0.00	0.00	88.56
2033	1.01	8.56	44.40	0.63	15.08	0.00	0.00	88.13
2043	1.32	13.09	58.12	1.89	52.34	0.00	0.00	309.16
2053	1.01	12.22	53.14	1.16	29.18	0.00	0.00	172.93
2063	1.35	13.20	63.89	1.78	40.87	0.00	0.00	241.64
2073	1.94	14.89	69.64	3.08	79.72	0.00	0.00	474.04
2083	3.58	15.21	73.22	5.35	118.18	0.00	0.00	686.20
2093	2.42	15.71	71.35	4.17	109.15	0.00	0.00	644.01
2103	3.01	15.29	83.33	4.64	152.39	0.00	0.00	889.80

2113	2.42	14.56	76.54	3.35	100.23	0.00	0.00	560.85
2123	3.97	14.92	83.81	5.47	161.56	0.00	0.00	862.04
2133	3.66	14.46	67.63	4.53	110.74	0.00	0.00	562.27
2143	1.29	16.09	68.34	2.08	52.96	0.00	0.00	283.78
2153	0.50	16.25	63.75	0.92	24.33	0.00	0.00	138.57

Proj_YEAR	_ForTyp	_SizCls	_StkCls	_CanCov0	_SOS	_CHESS	_OGSC	_CHESSER	_MPB_Haz
2003	122.00	1.00	3.00	51.63	94.00	42.00	15.00	0.00	3.00
2013	122.00	1.00	4.00	38.29	999.00	41.00	5.00	0.00	1.00
2023	122.00	1.00	4.00	45.75	999.00	42.00	10.00	0.00	1.00
2033	122.00	1.00	4.00	30.74	999.00	41.00	0.00	0.00	1.00
2043	122.00	1.00	4.00	36.86	999.00	41.00	0.00	0.00	1.00
2053	122.00	1.00	4.00	31.75	999.00	41.00	5.00	0.00	1.00
2063	122.00	1.00	4.00	38.13	999.00	41.00	0.00	0.00	1.00
2073	122.00	1.00	4.00	34.88	999.00	41.00	0.00	0.00	1.00
2083	122.00	2.00	4.00	40.29	999.00	42.00	5.00	0.00	1.00
2093	122.00	1.00	4.00	34.66	999.00	41.00	5.00	0.00	1.00
2103	122.00	1.00	4.00	40.21	999.00	41.00	10.00	0.00	1.00
2113	122.00	1.00	4.00	35.63	999.00	41.00	5.00	0.00	1.00
2123	122.00	1.00	4.00	39.54	999.00	41.00	5.00	0.00	1.00
2133	122.00	1.00	4.00	31.98	999.00	41.00	5.00	0.00	1.00
2143	122.00	1.00	4.00	37.94	999.00	41.00	5.00	0.00	1.00
2153	122.00	1.00	4.00	33.04	999.00	41.00	0.00	0.00	1.00

Proj_YEAR	_Snag_H1	_Snag_H2	_Snag_H3	_Snag_H4	_Snag_S1	_Snag_S2	_Snag_S3	_Snag_S4
2003	76.61	14.10	2.87	.60	0.00	0.00	0.00	0.00
2013	17.60	7.80	1.86	.64	20.17	0.00	0.00	0.00
2023	6.87	.71	.84	.60	.04	.92	0.00	0.00
2033	1.25	.24	.05	.17	0.00	0.00	0.00	.42
2043	.76	.32	.03	.50	0.00	0.00	0.00	.36
2053	.52	.42	.05	.59	0.00	0.00	0.00	.30
2063	.49	.63	0.00	.78	0.00	0.00	0.00	.25
2073	.64	.77	.02	1.24	0.00	0.00	0.00	.19
2083	.47	2.53	.02	1.73	0.00	0.00	0.00	.14
2093	.68	.52	.59	2.01	0.00	0.00	0.00	.24
2103	.46	2.13	.01	2.31	0.00	0.00	0.00	.19
2113	.40	1.42	.33	2.20	0.00	0.00	0.00	.25
2123	.33	3.09	.18	2.13	0.00	0.00	0.00	.41
2133	.28	2.54	.67	1.82	0.00	0.00	0.00	.51
2143	.16	.86	.16	1.46	0.00	0.00	0.00	.65
2153	.15	.08	.17	1.15	0.00	0.00	0.00	.68

Proj_YEAR	BulkDens	CnpyBase	S_Flame	S_Crown	S_Torch	F_Hazard
2003	.04	13.00	14.09	43.22	10.00	3.00
2013	.05	14.00	13.52	38.87	12.82	3.00
2023	.02	19.00	11.48	71.83	11.71	3.00
2033	.03	15.00	11.69	62.91	10.59	3.00
2043	.03	8.00	12.84	64.18	3.20	3.00
2053	.04	9.00	14.97	52.17	4.96	3.00
2063	.04	5.00	13.79	52.13	2.31	3.00
2073	.05	6.00	16.03	43.55	3.37	3.00
2083	.04	5.00	14.85	47.72	2.00	3.00
2093	.05	6.00	17.67	39.87	2.96	3.00
2103	.05	5.00	16.51	41.55	1.77	3.00
2113	.06	5.00	19.83	35.11	3.06	4.00
2123	.05	5.00	17.77	39.34	2.11	4.00
2133	.06	6.00	21.19	34.09	3.09	4.00
2143	.05	4.00	18.60	39.88	1.16	3.00
2153	.06	5.00	21.79	33.97	2.35	4.00

A total of 10 sample plots represented the S9AAAXL01 stand type. The plots were simulated for a 150 year time period. Plots were average at the projection cycle year. A cutting cycle of 20 years predicated the entry interval. It was estimated that the largest tree age would be approximately 120 years. Thus, six size-groups would be represented throughout the stand type. FVS is a distance independent model. Tree locations are not gathered or tracked through the projection. Group selection silviculture as represented by FVS modeling can only approximate the canopy layering. Figure VI-5a-e provide a pictorial of the group selection silvicultural system.

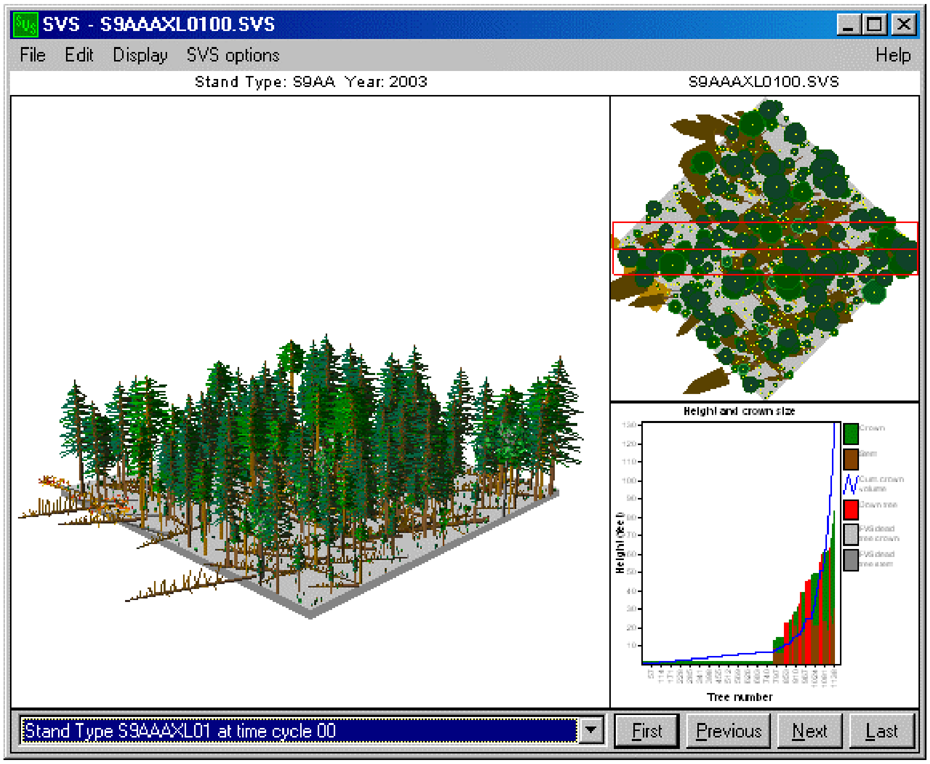


Figure VI-5a – S9AAAXL01 Strata, Uneven-Aged Stand Type: Year 2003

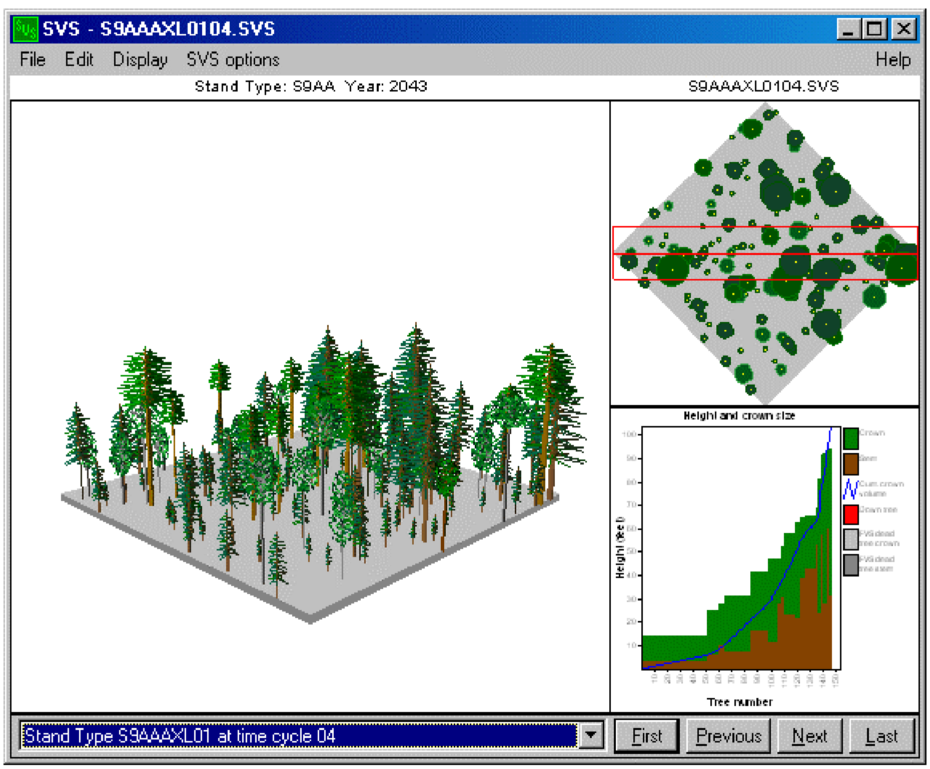


Figure VI-5b – S9AAAXL01 Strata, Uneven-Aged Stand Type: Year 2043

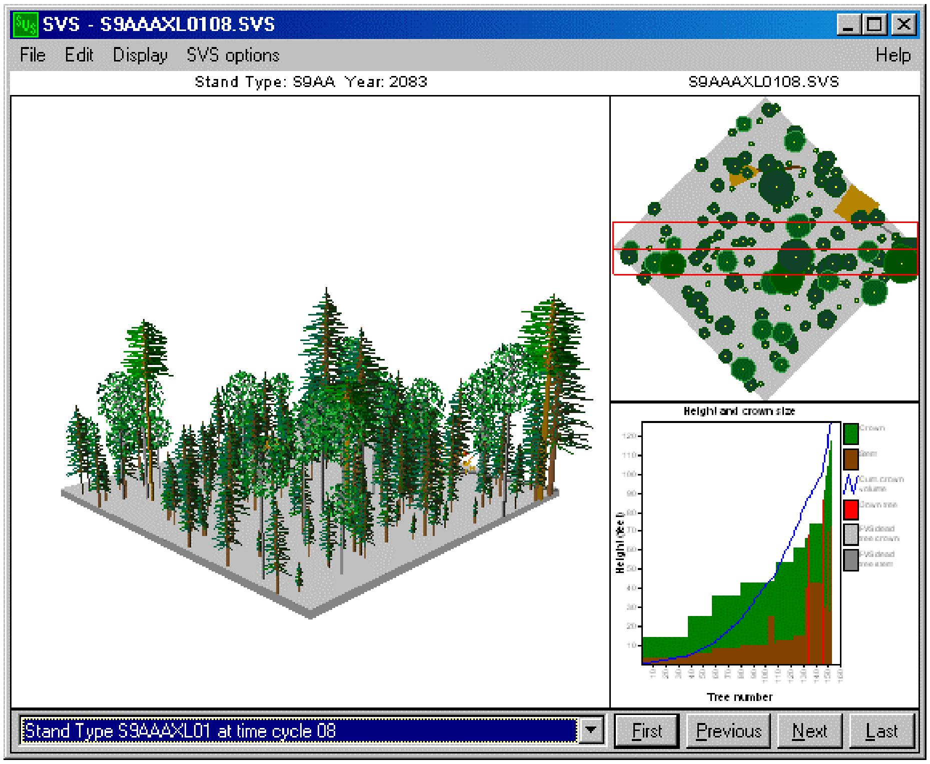


Figure VI-5c – S9AAAXL01 Strata, Uneven-Aged Stand Type: Year 2083

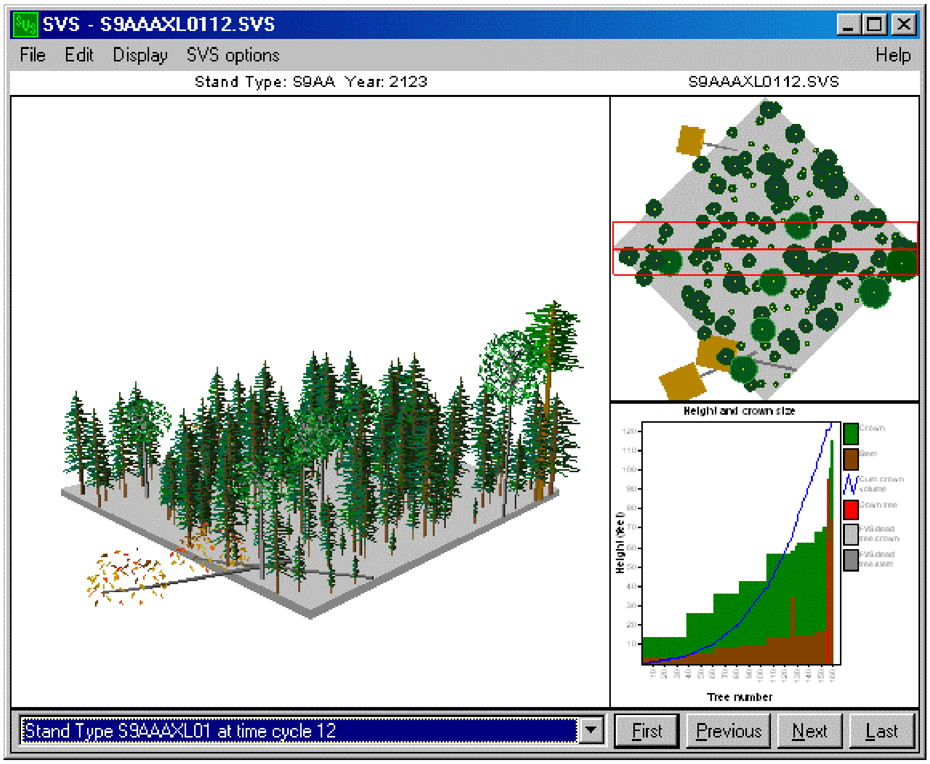


Figure VI-5d – S9AAAXL01 Strata, Uneven-Aged Stand Type: Year 2123

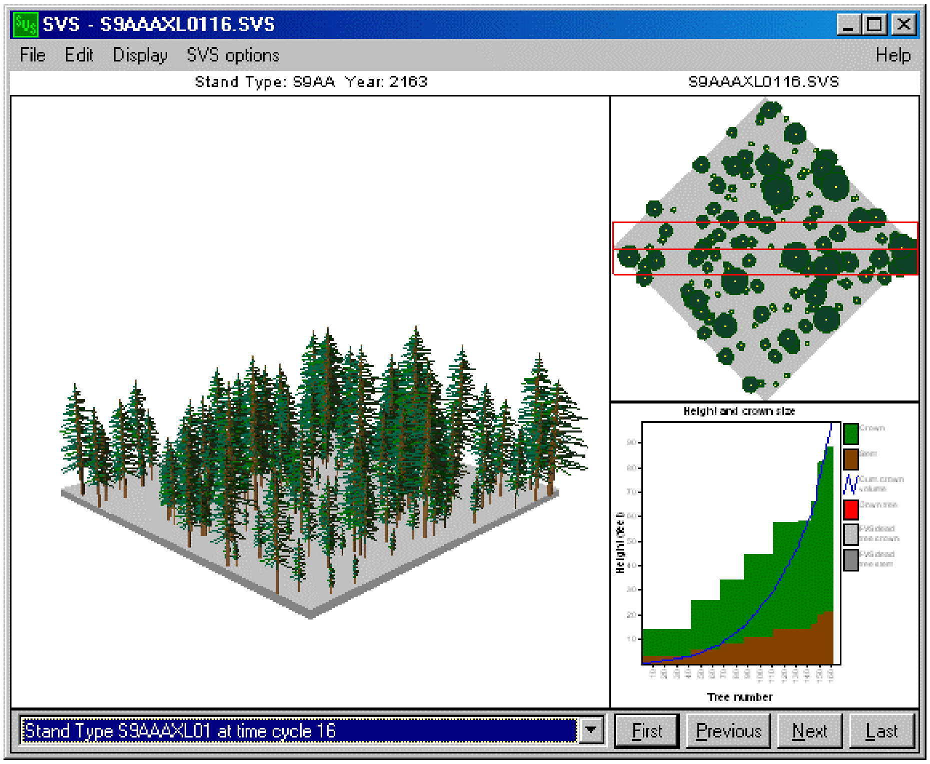


Figure VI-5e – S9AAAXL01 Strata, Uneven-Aged Stand Type: Year 2163

Of significance is the final time period frame. Notice the crown distribution graph. A total of six size classes are represented throughout the stand type. This was the goal of the group selection silvicultural system for White Spruce stands.

1. Yep and Yip

Matching the stand age distribution from the inventory data set to that derived from the spatial polygons proved to be problematic. As an example, the P9HMHP (Ponderosa Pine Overstory – Large Size Class – Single-storied – Moderate Canopy Cover – High Site Productivity – Ponderosa Pine Understory) stand type is represented by inventory plots that have stand ages ranging from 90 years old to 150 years. The polygon stand age distribution extracted from the Rocky Mountain Resource Information System (RMRIS) database for the P9HMHP type spans from 40 years old to 180 years. The challenge is how to infer yield estimates for the polygons from 40 years old to 90 and those from 150 years old to 180 years. The age-based yield profiles needed to be extended at both ends of the stand age spectrum.

Initially, employing regression techniques was suggested as a means to accomplish the task of extending the yield profiles. The YEP (Yield Extension Processor) computer program was developed to examine this possibility. YEP was designed to fit a trend line through associated data points. Any one of 15 curve fit methods could be used to best represent the data. Figure VI-6a-c displays the results of fitting a natural logarithmic curve to the P7HAHX, P8HMHC, and P9HMHP stand types. Figure VI-7 portrays a combined graphic of all P#HH stand types.

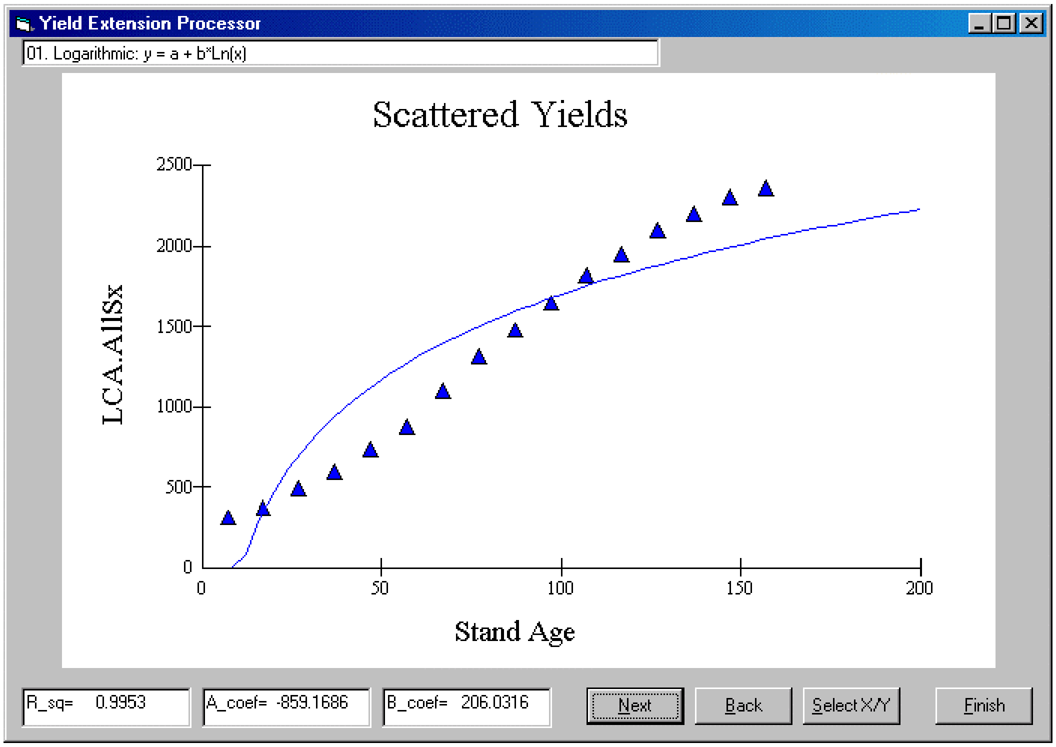


Figure VI-6a – P7HAHXA01 Strata, Cubic Foot Volume versus Stand Age

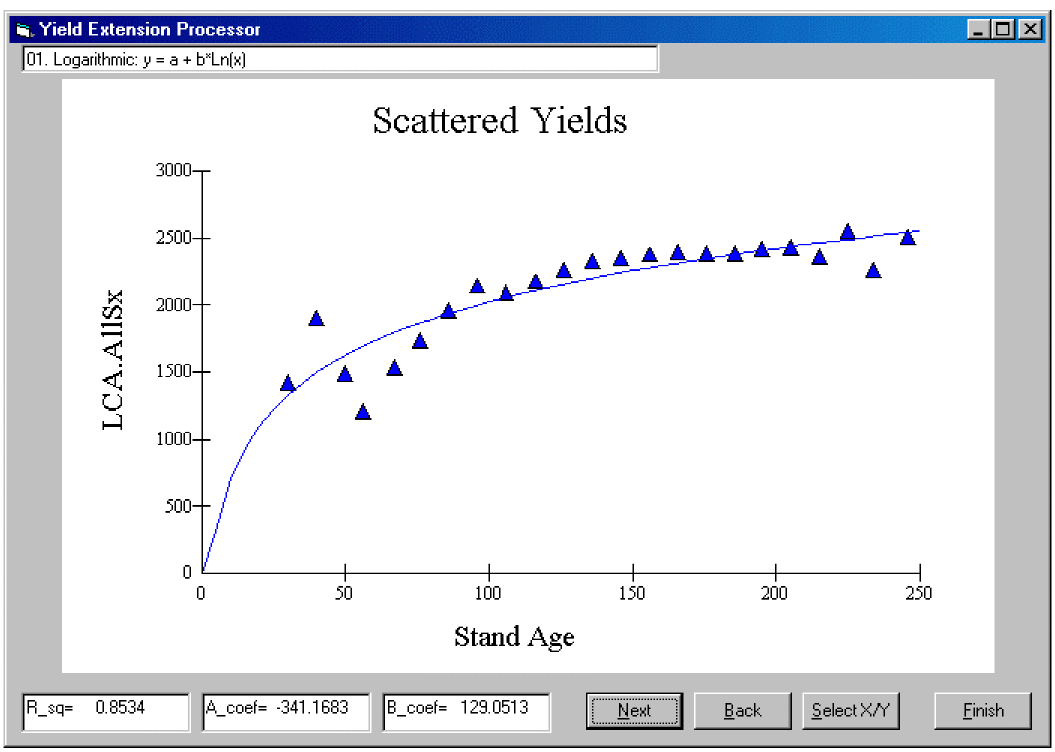


Figure VI-6b – P8HMHCA01 Strata, Cubic Foot Volume versus Stand Age

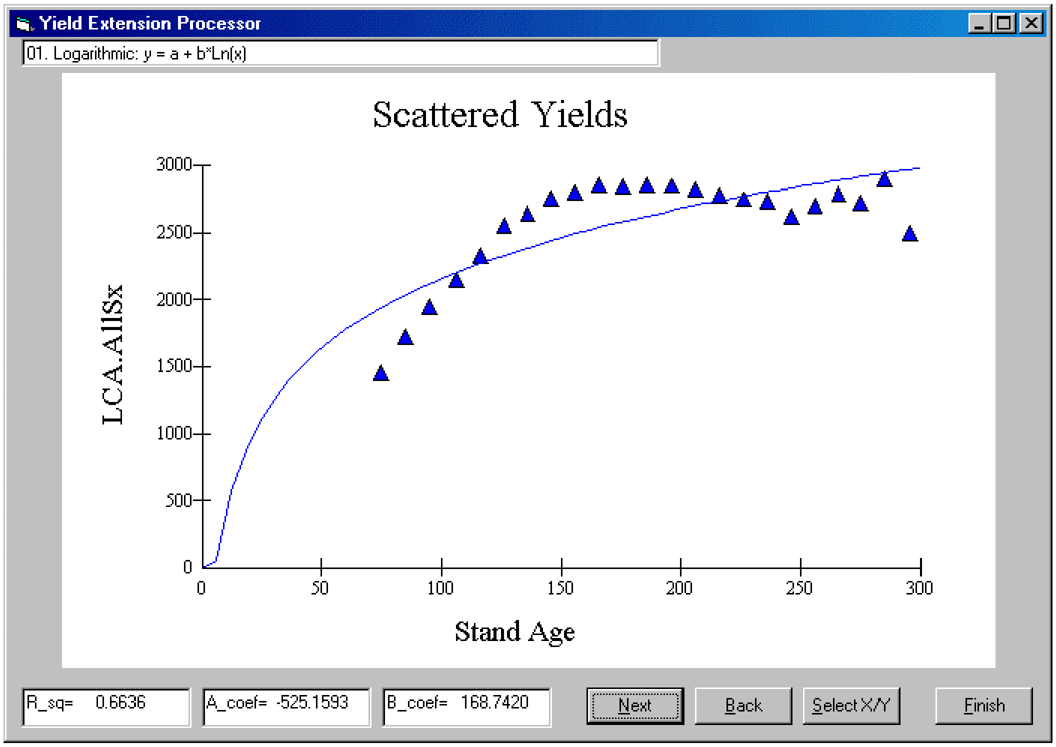


Figure VI-6c – P9HMHPA01 Strata, Cubic Foot Volume versus Stand Age

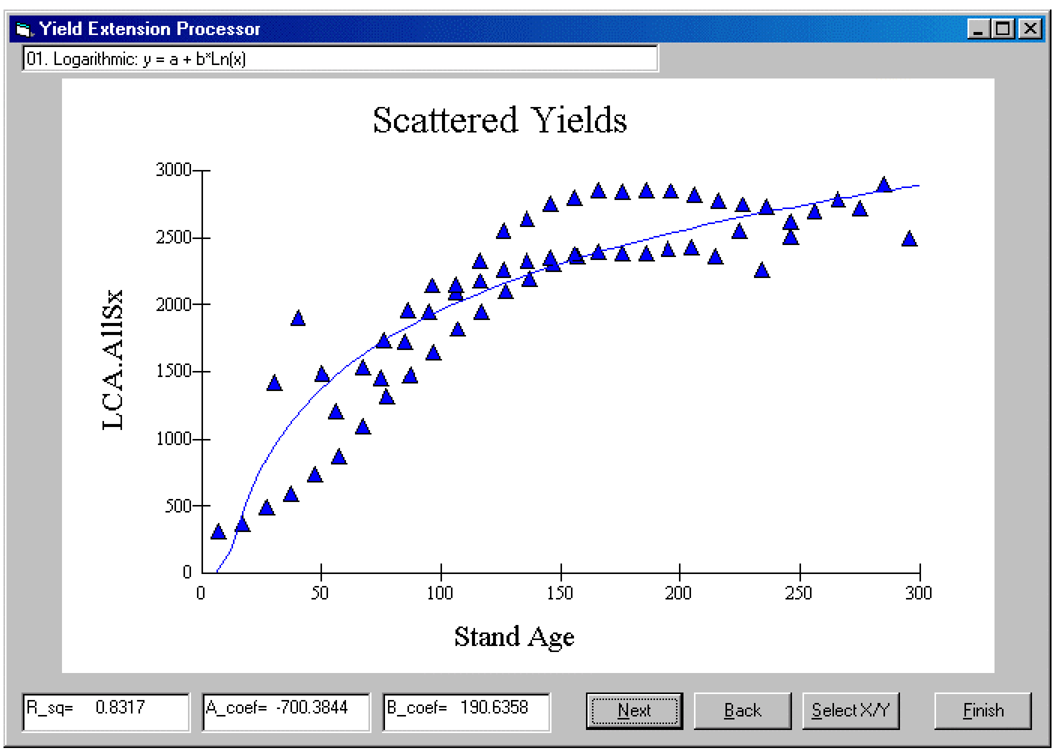


Figure VI-7 – P#HHA01 Strata, Cubic Foot Volume versus Stand Age

Noticeably, there is a confounding array of data elements presented in the scatter diagram depicted in Figure VI-7. Approximately 600 of the 700 yield tables developed for the Black Hills Phase II Amendment were age-dependent profiles. Within each were hundreds of columns of data that would need to be regressed. Given the enormity of this endeavor, it was decided to abandon the use of regression techniques for extending the base yield profiles.

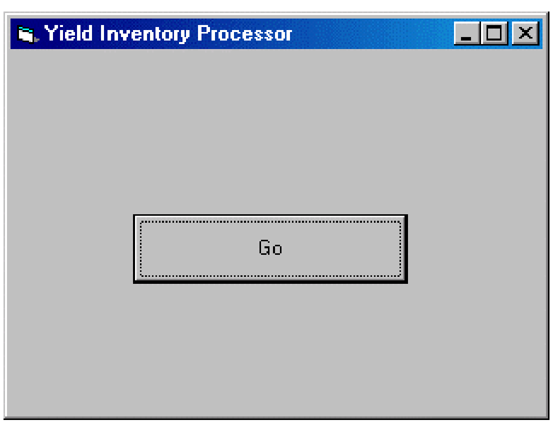
As an alternative approach, merging common yield tables using the core stand type to guide file concatenation was pursued. Each of the base 47 yield files (refer to Figure II-4 for a listing of the base stand types) were examined to determine the stand age range that contained a minimum of four sample plots. Exceptions were considered for stand types that were comprised of less than four samples. Overlaying the core stand age range for the stand type and augmenting with logical size classes enabled extending the yield profiles. A stand age template was devised to capture stand age ranges by base stand type by size class. Refer to Figure VI-8.

As an initial step, the base 47 stand types were extended for the Natural Growth simulation runs. A stand age range from 0 to 300 years needed to be represented. Using the sawtimber size class P9 and stand type P9HMHP as an example, with reference to Figure VI-8, the merging process was as follows:

- Base yield profile P7HAHX Stand_Age/10 rows from 1 to 6 were concatenated with base yield profile P8HMHC Stand_Age/10 rows 7 to 8. Subsequently, these were merged with base yield profile P9HMHP Stand_Age/10 rows 9 to 30.

This resulted in the creation of the Natural Growth yield table extension file for P9HMHPA01 stand type.

The process was repeated for each of the base 47 yield profiles. A computer program (YIP – Yield Inventory Processor) was developed to mimic this routine.



The representative extended yield profile for the Natural Growth P9HMHPA01 stand type follows Figure VI-8.

Age/10	St_Typ	Age/10	St_Typ	Age/10	St_Typ	Age/10
P9						
32	P9LLLP	8	P8LLLC	6	P7LALX	1
29	P9LLHP	8	P8LLHC	4	P7LAHX	1
30	P9LMLO	10	P8LALU	5	P7LALX	1
31	P9LMLP	9	P8LMLC	7	P7LALX	1
30	P9LMLA	11	P8LALU	5	P7LALX	1
32	P9LMLS	13	P8LMLC	7	P7LALX	1
30	P9LMHP	7	P8LMHC	5	P7LAHX	1
29	P9LMHA	8	P8LAHU	4	P7LAHX	1
31	P9LHLP	11	P8LHLC	9	P7LALX	1
28	P9LHHP	9	P8LHHC	6	P7LAHX	1
31	P9HLLP	10	P8HLLC	9	P7HALX	1
31	P9HLHP	8	P8HLHC	7	P7HAHX	1
30	P9HMLO	13	P8HALU	6	P7HALX	1
31	P9HMLP	9	P8HMLC	7	P7HALX	1
31	P9HMLA	10	P8HALU	6	P7HALX	1
30	P9HMLS	14	P8HMLC	7	P7HALX	1
30	***P9HMHP***	***9***	***P8HMHC***	***7***	***P7HAHX***	***1***
31	P9HMHA	9	P8HAHU	6	P7HAHX	1
31	P9HHLP	11	P8HHLC	11	P7HALX	1
28	P9HHHP	10	P8HHHC	8	P7HAHX	1
30	S9AAAX	9	S8AAAX	6	S7AAAX	2
P8						
32	P9LLLP	22	P8LLLC	6	P7LALX	1
29	P9LLHP	20	P8LLHC	4	P7LAHX	1
31	P9LMLP	26	P8LMLC	7	P7LALX	1
30	P9LMHP	24	P8LMHC	5	P7LAHX	1
31	P9LHLP	27	P8LHLC	9	P7LALX	1
28	P9LHHP	23	P8LHHC	6	P7LAHX	1
30	P9LMLA	24	P8LALU	5	P7LALX	1
29	P9LMHA	22	P8LAHU	4	P7LAHX	1
31	P9HLLP	25	P8HLLC	9	P7HALX	1
31	P9HLHP	23	P8HLHC	7	P7HAHX	1
31	P9HMLP	28	P8HMLC	7	P7HALX	1
30	P9HMHP	24	P8HMHC	7	P7HAHX	1
31	P9HHLP	25	P8HHLC	11	P7HALX	1
28	P9HHHP	20	P8HHHC	8	P7HAHX	1
31	P9HMLA	20	P8HALU	6	P7HALX	1
31	P9HMHA	23	P8HAHU	6	P7HAHX	1
30	S9AAAX	24	S8AAAX	6	S7AAAX	2
P7						
31	P9LMLP	26	P8LMLC	19	P7LALX	1
30	P9LMHP	24	P8LMHC	17	P7LAHX	1
31	P9HMLP	28	P8HMLC	17	P7HALX	1
30	P9HMHP	24	P8HMHC	16	P7HAHX	1
30	S9AAAX	24	S8AAAX	16	S7AAAX	2
P6						
31	P9LMLP	26	P8LMLC	16	P6LALX	0
30	P9LMHP	24	P8LMHC	16	P6LAHX	0
31	P9HMLP	28	P8HMLC	16	P6HALX	0
30	P9HMHP	24	P8HMHC	16	P6HAHX	0
AS						
27	AAAAAX	0				
OA						
28	OAAAAX	1				

Figure VI-8 – Stand_Age/10 Range per Stand Type by Size Class

Strata	Proj_YEAR	St_Age/10	Stand_Age	SiteIndex	StDnIndex	CulmMAI-T	Qd_Mn_Dia	For_Type_	Plt_Acres	Trt_Acres
P7HAHXA01	2013	1	7.00	69.00	106.00	42.87	8.32	221.00	10.00	0.00
P7HAHXA01	2023	2	17.00	69.00	63.00	21.57	3.65	221.00	10.00	0.00
P7HAHXA01	2033	3	27.00	69.00	131.00	18.02	3.07	221.00	10.00	0.00
P7HAHXA01	2043	4	37.00	69.00	199.00	15.99	3.34	221.00	10.00	0.00
P7HAHXA01	2053	5	47.00	69.00	225.00	15.60	3.69	221.00	10.00	0.00
P7HAHXA01	2063	6	57.00	69.00	221.00	15.29	3.91	221.00	10.00	0.00
P8HMHCA01	2073	7	67.00	76.00	204.00	23.06	8.16	221.00	10.00	0.00
P8HMHCA01	2083	8	76.00	74.00	213.00	22.98	8.44	221.00	14.00	0.00
P9HMHPA01	2093	9	85.00	80.00	169.00	20.20	10.58	221.00	11.00	0.00
P9HMHPA01	2103	10	95.00	76.00	196.00	20.50	9.22	221.00	21.00	0.00
P9HMHPA01	2113	11	106.00	75.00	196.00	20.34	9.01	221.00	27.00	0.00
P9HMHPA01	2123	12	116.00	74.00	189.00	20.18	9.35	221.00	34.00	0.00
P9HMHPA01	2133	13	126.00	73.00	197.00	20.31	9.49	221.00	37.00	0.00
P9HMHPA01	2143	14	136.00	73.00	189.00	19.50	9.21	221.00	38.00	0.00
P9HMHPA01	2153	15	146.00	73.00	187.00	18.92	8.85	221.00	40.00	0.00
P9HMHPA01	2163	16	156.00	73.00	186.00	18.01	8.73	221.00	41.00	0.00
P9HMHPA01	2173	17	166.00	73.00	187.00	17.26	8.46	221.00	41.00	0.00
P9HMHPA01	2183	18	176.00	73.00	186.00	16.18	8.25	221.00	41.00	0.00
P9HMHPA01	2193	19	186.00	73.00	187.00	15.36	7.98	221.00	41.00	0.00
P9HMHPA01	2203	20	196.00	73.00	188.00	14.57	7.81	221.00	41.00	0.00
P9HMHPA01	2213	21	206.00	73.00	188.00	13.70	7.76	221.00	41.00	0.00
P9HMHPA01	2223	22	216.00	73.00	189.00	12.86	7.66	221.00	41.00	0.00
P9HMHPA01	2233	23	226.00	73.00	191.00	12.18	7.62	221.00	41.00	0.00
P9HMHPA01	2243	24	236.00	73.00	193.00	11.61	7.64	221.00	41.00	0.00
P9HMHPA01	2253	25	246.00	71.00	190.00	10.65	7.59	221.00	37.00	0.00
P9HMHPA01	2263	26	256.00	70.00	194.00	10.56	7.82	221.00	30.00	0.00
P9HMHPA01	2273	27	266.00	70.00	194.00	10.47	7.79	221.00	20.00	0.00
P9HMHPA01	2283	28	275.00	70.00	189.00	9.88	7.70	221.00	14.00	0.00
P9HMHPA01	2293	29	285.00	70.00	196.00	10.16	7.63	221.00	7.00	0.00
P9HMHPA01	2303	30	296.00	70.00	174.00	8.45	7.56	221.00	4.00	0.00

Proj_YEAR	LTr.AllSx	LAD.AllSx	LAH.AllSx	LBA.AllSx	LCA.AllSx	LCS.AllSx	LCT.AllSx	LBd.AllSx
2013	3047.94	0.21	1.92	17.75	313.18	0.00	0.00	1399.25
2023	919.56	1.14	8.09	24.60	373.28	0.00	0.00	1785.48
2033	1547.73	1.64	9.84	48.66	492.09	0.00	0.00	2383.66
2043	1776.23	2.07	11.99	75.77	596.52	0.00	0.00	2980.57
2053	1715.64	2.27	13.34	89.33	737.80	0.00	0.00	3353.92
2063	1457.81	2.51	14.84	91.76	876.31	0.00	0.00	3563.16
2073	508.77	4.35	23.95	104.95	1535.93	0.00	0.00	4801.27
2083	639.14	3.50	19.64	109.63	1736.41	0.00	0.00	5831.22
2093	631.30	2.54	13.78	92.25	1724.12	0.00	0.00	7330.77
2103	855.94	2.19	12.62	103.27	1950.46	0.00	0.00	8368.38
2113	777.14	2.41	14.00	106.26	2149.80	0.00	0.00	9922.29
2123	464.90	3.85	21.86	108.25	2332.81	0.00	0.00	11206.65
2133	733.25	2.46	14.79	110.85	2549.84	0.00	0.00	12555.34
2143	551.81	3.20	18.46	110.63	2644.07	0.00	0.00	13404.86
2153	495.75	3.54	19.98	111.47	2753.57	0.00	0.00	14280.18
2163	513.17	3.41	19.21	111.38	2800.66	0.00	0.00	14730.47
2173	522.89	3.40	18.99	112.35	2856.95	0.00	0.00	15358.32
2183	521.14	3.44	18.97	111.79	2840.39	0.00	0.00	15374.21
2193	530.74	3.44	18.83	112.37	2849.77	0.00	0.00	15510.17
2203	526.67	3.54	19.16	113.11	2848.31	0.00	0.00	15573.42
2213	524.36	3.56	19.14	112.92	2816.02	0.00	0.00	15504.92
2223	525.13	3.61	19.30	113.00	2771.66	0.00	0.00	15205.92
2233	517.28	3.73	19.83	113.95	2746.93	0.00	0.00	14963.62
2243	515.36	3.78	19.96	114.69	2734.84	0.00	0.00	14845.78
2253	507.34	3.82	20.05	112.55	2615.03	0.00	0.00	14040.93
2263	491.85	3.93	20.73	115.58	2698.90	0.00	0.00	14359.07
2273	496.19	3.88	20.33	117.07	2785.13	0.00	0.00	14924.44
2283	495.59	3.83	20.28	113.83	2719.82	0.00	0.00	14454.90
2293	516.25	3.82	20.23	118.19	2897.72	0.00	0.00	16155.93
2303	483.74	3.66	19.24	103.82	2495.90	0.00	0.00	13755.49

Proj_YEAR	HTr.AllSx	HAD.AllSx	HAH.AllSx	HBA.AllSx	HCA.AllSx	HCS.AllSx	HCT.AllSx	HBd.AllSx
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2023	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2033	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2063	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2073	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2083	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2093	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2103	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2113	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2123	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2133	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2163	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

2173	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2183	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2193	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2203	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2213	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2223	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2233	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2243	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2253	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2263	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2273	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2283	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2293	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2303	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Proj_YEAR	_ForTyp	_SizCls	_StkCls	_CanCov0	_SOS	_CHESS	_OGSC	_CHESSER	_MPB_Haz
2013	221.00	3.00	3.00	15.67	746.00	31.00	0.00	0.00	1.00
2023	221.00	3.00	4.00	20.31	746.00	41.00	5.00	0.00	1.00
2033	221.00	3.00	3.00	38.51	746.00	32.00	10.00	0.00	1.00
2043	221.00	3.00	2.00	53.39	122.00	32.00	10.00	0.00	1.00
2053	221.00	3.00	2.00	58.85	122.00	32.00	15.00	0.00	1.00
2063	221.00	2.00	3.00	59.29	122.00	32.00	10.00	0.00	1.00
2073	221.00	2.00	3.00	59.93	122.00	32.00	10.00	0.00	3.00
2083	221.00	1.00	3.00	60.69	122.00	42.00	15.00	0.00	3.00
2093	221.00	1.00	3.00	52.22	999.00	42.00	15.00	0.00	5.00
2103	221.00	1.00	3.00	57.24	122.00	42.00	15.00	0.00	5.00
2113	221.00	1.00	3.00	57.69	122.00	42.00	20.00	50.00	5.00
2123	221.00	1.00	3.00	57.60	122.00	42.00	15.00	0.00	5.00
2133	221.00	1.00	3.00	58.22	122.00	42.00	15.00	0.00	5.00
2143	221.00	1.00	3.00	57.61	122.00	42.00	15.00	0.00	5.00
2153	221.00	1.00	3.00	57.41	122.00	42.00	15.00	0.00	5.00
2163	221.00	1.00	3.00	57.01	122.00	42.00	15.00	0.00	5.00
2173	221.00	1.00	3.00	57.29	122.00	42.00	15.00	0.00	3.00
2183	221.00	1.00	3.00	56.91	122.00	42.00	15.00	0.00	3.00
2193	221.00	1.00	3.00	57.14	122.00	42.00	15.00	0.00	3.00
2203	221.00	1.00	3.00	57.44	122.00	42.00	15.00	0.00	3.00
2213	221.00	1.00	3.00	57.18	122.00	42.00	15.00	0.00	3.00
2223	221.00	1.00	3.00	57.46	122.00	42.00	15.00	0.00	3.00
2233	221.00	1.00	3.00	58.00	122.00	42.00	15.00	0.00	3.00
2243	221.00	1.00	3.00	57.62	122.00	42.00	15.00	0.00	3.00
2253	221.00	1.00	2.00	58.57	122.00	42.00	15.00	0.00	3.00
2263	221.00	1.00	2.00	58.04	122.00	42.00	15.00	0.00	3.00
2273	221.00	1.00	2.00	56.28	122.00	42.00	15.00	0.00	3.00
2283	221.00	1.00	3.00	57.24	122.00	42.00	15.00	0.00	3.00
2293	221.00	1.00	3.00	54.48	122.00	42.00	15.00	0.00	3.00
2303	221.00	1.00	3.00	55.17	122.00	42.00	15.00	0.00	3.00

Proj_YEAR	_Snag_H1	_Snag_H2	_Snag_H3	_Snag_H4	_Snag_S1	_Snag_S2	_Snag_S3	_Snag_S4
2013	19.20	5.40	1.70	.60	0.00	0.00	0.00	0.00
2023	2715.77	4.12	1.23	.53	0.00	0.00	0.00	0.00
2033	451.93	1.04	.60	.28	.05	.32	0.00	0.00
2043	673.99	1.78	.16	.13	0.00	0.00	0.00	0.00
2053	981.89	1.91	.17	.05	0.00	0.00	0.00	.03
2063	1021.99	2.56	.15	.16	0.00	0.00	.01	.03
2073	539.53	1.78	.09	.22	0.00	0.00	0.00	0.00
2083	299.20	4.32	.28	.13	0.00	0.00	0.00	0.00
2093	1456.35	6.70	.38	0.00	2.81	0.00	0.00	0.00
2103	217.50	5.24	.30	.09	1.10	.01	0.00	0.00
2113	472.54	9.00	.66	.14	3.99	.08	.01	0.00
2123	440.13	10.88	.91	.33	.66	.01	.01	0.00
2133	264.31	11.71	1.69	.44	0.00	.03	.01	0.00
2143	504.41	13.70	2.10	.54	1.71	.02	.01	.01
2153	403.74	11.18	1.99	.69	0.00	.01	.03	.02
2163	293.51	8.06	2.59	.81	0.00	.02	.03	.03
2173	288.40	6.98	2.38	1.04	0.00	.03	.02	.07
2183	287.32	6.52	2.42	1.54	0.00	0.00	.03	.10
2193	274.82	5.30	2.35	1.81	0.00	0.00	.03	.11
2203	267.20	3.96	2.20	2.13	0.00	0.00	.04	.13
2213	257.70	3.41	2.34	2.32	0.00	0.00	.05	.13
2223	244.35	3.31	2.17	2.63	0.00	0.00	.06	.16
2233	233.26	3.07	1.91	2.75	0.00	0.00	.07	.20
2243	226.09	2.91	1.62	2.77	0.00	0.00	.05	.21
2253	207.03	3.15	1.55	2.23	0.00	0.00	.05	.14
2263	192.65	2.20	1.79	2.52	0.00	0.00	.05	.12
2273	208.08	2.23	1.36	2.36	0.00	0.00	.05	.13
2283	194.10	1.16	1.49	2.85	0.00	0.00	.06	.12
2293	215.98	1.16	1.71	3.38	0.00	0.00	.10	.11
2303	208.75	1.13	1.38	2.44	0.00	0.00	.10	.13

Proj_YEAR	BulkDens	CnpyBase	S_Flame	S_Crown	S_Torch	F_Hazard
2013	.01	30.00	11.63	148.65	14.68	3.00

2023	.03	16.00	13.62	86.66	7.34	3.00
2033	.08	7.00	20.82	35.62	3.66	4.00
2043	.11	7.00	26.75	30.78	3.99	4.00
2053	.10	2.00	26.48	29.91	.42	4.00
2063	.07	2.00	20.90	34.48	.70	4.00
2073	.06	19.00	10.33	35.94	22.77	3.00
2083	.06	22.00	7.76	36.23	30.66	3.00
2093	.05	24.00	7.76	39.89	28.43	2.00
2103	.06	23.00	6.69	36.65	31.61	3.00
2113	.05	27.00	6.98	39.41	38.61	2.00
2123	.05	25.00	7.73	42.93	31.92	2.00
2133	.05	27.00	7.16	44.07	33.84	1.00
2143	.04	22.00	7.56	45.74	28.65	3.00
2153	.04	20.00	7.52	47.29	25.38	3.00
2163	.04	18.00	7.26	48.36	23.91	3.00
2173	.04	20.00	7.12	48.91	27.71	3.00
2183	.04	18.00	7.24	50.02	26.52	3.00
2193	.04	16.00	7.34	50.23	25.36	3.00
2203	.04	17.00	7.18	50.47	28.60	3.00
2213	.04	16.00	7.09	51.25	28.41	3.00
2223	.04	17.00	7.18	50.97	25.96	3.00
2233	.04	16.00	7.08	50.71	25.69	3.00
2243	.04	16.00	6.77	52.15	26.28	3.00
2253	.04	19.00	6.27	51.15	30.40	3.00
2263	.04	19.00	6.19	53.17	26.73	3.00
2273	.03	18.00	5.89	58.90	26.62	3.00
2283	.03	15.00	5.63	58.74	24.91	3.00
2293	.03	20.00	6.20	59.12	25.22	3.00
2303	.03	23.00	6.03	58.73	29.60	3.00

Notice the "Strata" label column at the top of the listing. This column denotes the origins of the base stand type used to comprise the yield profile. The transition of size class from P7 to P8 to P9 within the P9HMHP stand type can be observed. Also note the "Plt_Acres" column. The resultant values within the various St_Age/10 rows are dependent on the inventory sample size. In most cases, a minimum of four plots were used in the development of the extended yield profiles. The YEP program created the graphical view in Figure VI-9.

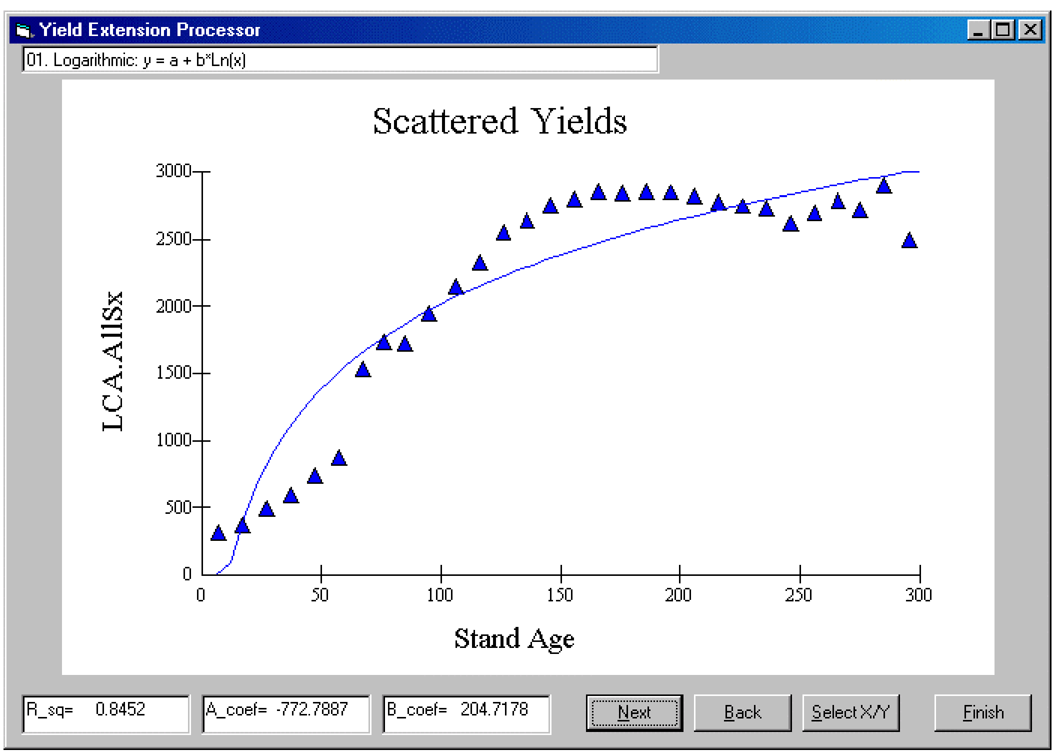


Figure VI-9 – Scatter Plot of P9HMHPA01 Cubic Foot Yields Extended

To extend the treatment prescription base yield profiles, additional steps were added to the techniques used for the Natural Growth tables. Using the sawtimber size class P9 and stand type P9HMHP as an example, with reference to the Shelterwood silvicultural prescription, the following steps were used to extend the yield projections:

- Concatenated the P7HAHX, P8HMHC, and P9HMHP shelterwood base yield files as described previously through Stand_Age/10 equal to 12 (120 years, shelterwood preparation cut). Append the Natural Growth extended yield table Stand_Age/10 rows from 13 to 30 to represent existing stand conditions greater than 120 years old. Merge second growth Stand_Age/10 rows from the shelterwood based yield file P9HMHP Stand_Age/10 rows 1 to 12 plus two additional decades to report cut volumes. Thus, the existing stand condition and regenerated stand profile would be reported in the same file.

The representative extended yield profile for the P9HMHPB01 stand type, shelterwood prescription, follows:

Strata	Proj_YEAR	St_Age/10	Stand_Age	SiteIndex	StDnIndex	CulmMAI-T	Qd_Mn_Dia	For_Type_	Plt_Acres	Trt_Acres
P7HAHXB01	2013	1	7.00	69.00	106.00	42.87	8.32	221.00	10.00	0.00
P7HAHXB01	2023	2	17.00	69.00	132.00	21.57	2.82	221.00	10.00	0.00
P7HAHXB01	2033	3	27.00	69.00	215.00	15.14	2.39	221.00	10.00	10.00
P7HAHXB01	2043	4	37.00	69.00	95.00	14.64	5.18	901.00	10.00	0.00
P7HAHXB01	2053	5	47.00	69.00	135.00	16.41	5.64	901.00	10.00	0.00
P7HAHXB01	2063	6	57.00	69.00	176.00	23.44	6.61	901.00	10.00	7.00
P8HMHCB01	2073	7	67.00	76.00	166.00	25.98	8.77	221.00	10.00	0.00
P8HMHCB01	2083	8	76.00	74.00	202.00	27.99	8.49	221.00	14.00	0.00
P9HMHPB01	2093	9	85.00	80.00	199.00	27.15	10.14	221.00	11.00	11.00
P9HMHPB01	2103	10	95.00	76.00	185.00	23.17	6.89	221.00	21.00	0.00
P9HMHPB01	2113	11	106.00	75.00	199.00	23.50	6.79	221.00	27.00	0.00
P9HMHPB01	2123	12	116.00	74.00	198.00	23.37	7.29	221.00	34.00	0.00
P9HMHPA01	2133	13	126.00	73.00	197.00	20.31	9.49	221.00	37.00	0.00
P9HMHPA01	2143	14	136.00	73.00	189.00	19.50	9.21	221.00	38.00	0.00
P9HMHPA01	2153	15	146.00	73.00	187.00	18.92	8.85	221.00	40.00	0.00
P9HMHPA01	2163	16	156.00	73.00	186.00	18.01	8.73	221.00	41.00	0.00
P9HMHPA01	2173	17	166.00	73.00	187.00	17.26	8.46	221.00	41.00	0.00
P9HMHPA01	2183	18	176.00	73.00	186.00	16.18	8.25	221.00	41.00	0.00
P9HMHPA01	2193	19	186.00	73.00	187.00	15.36	7.98	221.00	41.00	0.00
P9HMHPA01	2203	20	196.00	73.00	188.00	14.57	7.81	221.00	41.00	0.00
P9HMHPA01	2213	21	206.00	73.00	188.00	13.70	7.76	221.00	41.00	0.00
P9HMHPA01	2223	22	216.00	73.00	189.00	12.86	7.66	221.00	41.00	0.00
P9HMHPA01	2233	23	226.00	73.00	191.00	12.18	7.62	221.00	41.00	0.00
P9HMHPA01	2243	24	236.00	73.00	193.00	11.61	7.64	221.00	41.00	0.00
P9HMHPA01	2253	25	246.00	71.00	190.00	10.65	7.59	221.00	37.00	0.00
P9HMHPA01	2263	26	256.00	70.00	194.00	10.56	7.82	221.00	30.00	0.00
P9HMHPA01	2273	27	266.00	70.00	194.00	10.47	7.79	221.00	20.00	0.00
P9HMHPA01	2283	28	275.00	70.00	189.00	9.88	7.70	221.00	14.00	0.00
P9HMHPA01	2293	29	285.00	70.00	196.00	10.16	7.63	221.00	7.00	0.00
P9HMHPA01	2303	30	296.00	70.00	174.00	8.45	7.56	221.00	4.00	0.00
P9HMHPB01	2013	1	10.00	73.00	68.00	302.17	16.53	221.00	41.00	41.00
P9HMHPB01	2023	2	20.00	73.00	89.00	213.64	7.51	221.00	41.00	41.00
P9HMHPB01	2033	3	30.00	73.00	77.00	109.51	3.88	221.00	41.00	41.00
P9HMHPB01	2043	4	40.00	73.00	104.00	85.96	5.53	221.00	41.00	0.00
P9HMHPB01	2053	5	50.00	73.00	145.00	74.26	6.06	221.00	41.00	0.00
P9HMHPB01	2063	6	60.00	73.00	182.00	73.17	7.00	221.00	41.00	38.00
P9HMHPB01	2073	7	70.00	73.00	135.00	62.50	8.13	221.00	41.00	0.00
P9HMHPB01	2083	8	80.00	73.00	159.00	58.70	7.77	221.00	41.00	0.00
P9HMHPB01	2093	9	90.00	73.00	179.00	62.94	8.48	221.00	41.00	35.00
P9HMHPB01	2103	10	100.00	73.00	139.00	53.21	8.40	221.00	41.00	0.00
P9HMHPB01	2113	11	110.00	73.00	158.00	50.92	7.98	221.00	41.00	0.00
P9HMHPB01	2123	12	120.00	73.00	177.00	49.12	8.53	221.00	41.00	0.00
P9HMHPB01	2013	1	10.00	71.00	64.00	598.10	16.85	221.00	37.00	37.00
P9HMHPB01	2023	2	20.00	70.00	84.00	334.85	6.97	221.00	30.00	20.00

Proj_YEAR	LTr.AllSx	LAD.AllSx	LAH.AllSx	LBA.AllSx	LCA.AllSx	LCS.AllSx	LCT.AllSx	LBd.AllSx
2013	3047.94	0.21	1.92	17.75	313.18	0.00	0.00	1399.25
2023	3276.74	0.67	6.40	31.55	373.28	0.00	0.00	1785.48
2033	2530.17	1.94	11.14	74.16	413.49	0.00	0.00	1983.34
2043	381.02	3.57	19.45	44.78	546.16	0.00	0.00	2704.34
2053	374.86	4.83	25.15	64.95	776.46	0.00	0.00	3375.71

2063	369.05	5.89	30.87	87.89	1141.03	0.00	0.00	4115.88
2073	326.66	5.40	28.77	87.65	1320.52	0.00	0.00	4210.11
2083	544.38	3.85	21.19	105.52	1705.18	0.00	0.00	5820.74
2093	1807.99	1.28	8.49	94.75	1724.12	0.00	0.00	7330.77
2103	1023.86	2.01	11.35	91.90	1610.33	0.00	0.00	6814.27
2113	1102.62	1.93	11.45	100.44	1889.27	0.00	0.00	8692.82
2123	860.78	2.55	15.25	105.77	2108.15	0.00	0.00	10109.77
2133	733.25	2.46	14.79	110.85	2549.84	0.00	0.00	12555.34
2143	551.81	3.20	18.46	110.63	2644.07	0.00	0.00	13404.86
2153	495.75	3.54	19.98	111.47	2753.57	0.00	0.00	14280.18
2163	513.17	3.41	19.21	111.38	2800.66	0.00	0.00	14730.47
2173	522.89	3.40	18.99	112.35	2856.95	0.00	0.00	15358.32
2183	521.14	3.44	18.97	111.79	2840.39	0.00	0.00	15374.21
2193	530.74	3.44	18.83	112.37	2849.77	0.00	0.00	15510.17
2203	526.67	3.54	19.16	113.11	2848.31	0.00	0.00	15573.42
2213	524.36	3.56	19.14	112.92	2816.02	0.00	0.00	15504.92
2223	525.13	3.61	19.30	113.00	2771.66	0.00	0.00	15205.92
2233	517.28	3.73	19.83	113.95	2746.93	0.00	0.00	14963.62
2243	515.36	3.78	19.96	114.69	2734.84	0.00	0.00	14845.78
2253	507.34	3.82	20.05	112.55	2615.03	0.00	0.00	14040.93
2263	491.85	3.93	20.73	115.58	2698.90	0.00	0.00	14359.07
2273	496.19	3.88	20.33	117.07	2785.13	0.00	0.00	14924.44
2283	495.59	3.83	20.28	113.83	2719.82	0.00	0.00	14454.90
2293	516.25	3.82	20.23	118.19	2897.72	0.00	0.00	16155.93
2303	483.74	3.66	19.24	103.82	2495.90	0.00	0.00	13755.49
2013	174.95	3.02	16.09	44.48	1271.85	0.00	0.00	7119.75
2023	469.58	2.00	11.09	52.86	1454.45	0.00	0.00	8352.02
2033	441.76	2.96	13.64	34.55	466.87	0.00	0.00	2772.11
2043	367.90	3.93	18.25	49.51	619.86	0.00	0.00	3216.57
2053	358.50	5.24	24.50	71.57	894.21	0.00	0.00	3787.66
2063	348.23	6.26	30.60	93.08	1265.76	0.00	0.00	4701.76
2073	275.07	5.38	27.94	73.19	1250.63	0.00	0.00	5495.57
2083	268.44	6.42	32.72	88.29	1571.31	0.00	0.00	7051.93
2093	258.43	7.19	36.96	101.43	1914.66	0.00	0.00	8921.33
2103	274.98	5.35	29.13	78.33	1570.78	0.00	0.00	7517.29
2113	264.63	6.30	33.22	90.35	1850.39	0.00	0.00	8975.69
2123	258.07	7.02	36.85	102.42	2144.56	0.00	0.00	10583.35
2013	173.00	2.86	15.16	43.43	1277.87	0.00	0.00	7740.76
2023	467.52	1.97	10.83	50.63	1358.06	0.00	0.00	8225.42

Proj_YEAR	HTr.AllSx	HAD.AllSx	HAH.AllSx	HBA.AllSx	HCA.AllSx	HCS.AllSx	HCT.AllSx	HBd.AllSx
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2023	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2033	2220.11	1.77	10.29	44.60	0.00	0.00	0.00	0.00
2043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2063	101.28	6.35	33.38	22.72	202.27	0.00	0.00	0.00
2073	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2083	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2093	47.26	11.10	55.98	32.46	593.96	0.00	0.00	2631.41
2103	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2113	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2123	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2133	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2163	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2173	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2183	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2193	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2203	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2213	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2223	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2233	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2243	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2253	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2263	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2273	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2283	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2293	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2303	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	970.10	1.73	11.39	67.51	1156.31	0.00	0.00	4945.09
2023	19.44	18.14	79.36	36.02	1068.37	0.00	0.00	6086.29
2033	142.71	2.14	10.66	3.90	0.00	0.00	0.00	0.00
2043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2063	143.68	6.41	31.67	34.39	305.99	0.00	0.00	304.47
2073	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2083	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2093	53.02	10.88	54.67	35.25	625.76	0.00	0.00	2872.69
2103	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

2113	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2123	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	240.45	6.05	33.18	63.42	953.58	0.00	0.00	3272.79
2023	11.37	17.68	76.43	21.53	635.46	0.00	0.00	3824.89

Proj_YEAR	_ForTyp	_SizCls	_StkCls	_CanCov0	_SOS	_CHESS	_OGSC	_CHESSER	_MPB_Haz
2013	221.00	3.00	3.00	15.67	746.00	31.00	0.00	0.00	1.00
2023	221.00	3.00	1.00	27.25	746.00	41.00	5.00	0.00	1.00
2033	221.00	3.00	1.00	57.04	746.00	32.00	10.00	0.00	1.00
2043	901.00	3.00	3.00	35.44	746.00	41.00	5.00	0.00	1.00
2053	901.00	3.00	3.00	47.23	375.00	32.00	5.00	0.00	1.00
2063	901.00	2.00	3.00	57.32	999.00	32.00	5.00	0.00	3.00
2073	221.00	2.00	3.00	53.84	999.00	32.00	10.00	0.00	3.00
2083	221.00	1.00	3.00	59.87	122.00	42.00	15.00	0.00	3.00
2093	221.00	1.00	3.00	54.28	122.00	42.00	15.00	0.00	5.00
2103	221.00	1.00	3.00	53.75	122.00	42.00	15.00	0.00	5.00
2113	221.00	1.00	3.00	56.54	122.00	42.00	15.00	0.00	5.00
2123	221.00	1.00	3.00	57.91	122.00	42.00	15.00	0.00	5.00
2133	221.00	1.00	3.00	58.22	122.00	42.00	15.00	0.00	5.00
2143	221.00	1.00	3.00	57.61	122.00	42.00	15.00	0.00	5.00
2153	221.00	1.00	3.00	57.41	122.00	42.00	15.00	0.00	5.00
2163	221.00	1.00	3.00	57.01	122.00	42.00	15.00	0.00	5.00
2173	221.00	1.00	3.00	57.29	122.00	42.00	15.00	0.00	3.00
2183	221.00	1.00	3.00	56.91	122.00	42.00	15.00	0.00	3.00
2193	221.00	1.00	3.00	57.14	122.00	42.00	15.00	0.00	3.00
2203	221.00	1.00	3.00	57.44	122.00	42.00	15.00	0.00	3.00
2213	221.00	1.00	3.00	57.18	122.00	42.00	15.00	0.00	3.00
2223	221.00	1.00	3.00	57.46	122.00	42.00	15.00	0.00	3.00
2233	221.00	1.00	3.00	58.00	122.00	42.00	15.00	0.00	3.00
2243	221.00	1.00	3.00	57.62	122.00	42.00	15.00	0.00	3.00
2253	221.00	1.00	2.00	58.57	122.00	42.00	15.00	0.00	3.00
2263	221.00	1.00	2.00	58.04	122.00	42.00	15.00	0.00	3.00
2273	221.00	1.00	2.00	56.28	122.00	42.00	15.00	0.00	3.00
2283	221.00	1.00	3.00	57.24	122.00	42.00	15.00	0.00	3.00
2293	221.00	1.00	3.00	54.48	122.00	42.00	15.00	0.00	3.00
2303	221.00	1.00	3.00	55.17	122.00	42.00	15.00	0.00	3.00
2013	221.00	1.00	4.00	27.65	122.00	41.00	10.00	0.00	3.00
2023	221.00	1.00	4.00	32.88	122.00	41.00	5.00	0.00	1.00
2033	221.00	3.00	4.00	26.92	122.00	41.00	5.00	0.00	1.00
2043	221.00	2.00	4.00	35.09	122.00	31.00	5.00	0.00	1.00
2053	221.00	2.00	4.00	45.99	122.00	32.00	5.00	0.00	1.00
2063	221.00	2.00	3.00	54.56	999.00	32.00	5.00	0.00	3.00
2073	221.00	1.00	4.00	45.87	999.00	42.00	10.00	0.00	1.00
2083	221.00	1.00	3.00	52.10	999.00	42.00	5.00	0.00	3.00
2093	221.00	1.00	3.00	56.73	999.00	42.00	5.00	0.00	3.00
2103	221.00	1.00	4.00	46.58	999.00	42.00	10.00	0.00	1.00
2113	221.00	1.00	3.00	51.78	999.00	42.00	5.00	0.00	3.00
2123	221.00	1.00	3.00	56.59	999.00	42.00	5.00	0.00	3.00
2013	221.00	1.00	4.00	26.90	122.00	41.00	5.00	0.00	3.00
2023	221.00	1.00	4.00	31.55	122.00	41.00	5.00	0.00	1.00

Proj_YEAR	_Snag_H1	_Snag_H2	_Snag_H3	_Snag_H4	_Snag_S1	_Snag_S2	_Snag_S3	_Snag_S4
2013	19.20	5.40	1.70	.60	0.00	0.00	0.00	0.00
2023	180.41	4.12	1.23	.44	0.00	0.00	0.00	0.00
2033	1021.03	2.11	1.05	.67	.05	.32	0.00	0.00
2043	90.52	.95	.36	.38	0.00	0.00	0.00	0.00
2053	6.51	.33	.14	.16	0.00	0.00	0.00	.03
2063	6.69	.18	.02	.04	0.00	0.00	.01	.03
2073	468.39	.78	.04	.20	0.00	0.00	0.00	0.00
2083	140.63	1.68	.10	.10	0.00	0.00	0.00	0.00
2093	253.42	6.70	.38	0.00	2.81	0.00	0.00	0.00
2103	542.71	3.08	.88	.04	1.10	.01	0.00	0.00
2113	258.40	6.50	.63	.06	3.99	.08	.01	0.00
2123	115.63	9.56	.67	.21	.66	.01	.01	0.00
2133	264.31	11.71	1.69	.44	0.00	.03	.01	0.00
2143	504.41	13.70	2.10	.54	1.71	.02	.01	.01
2153	403.74	11.18	1.99	.69	0.00	.01	.03	.02
2163	293.51	8.06	2.59	.81	0.00	.02	.03	.03
2173	288.40	6.98	2.38	1.04	0.00	.03	.02	.07
2183	287.32	6.52	2.42	1.54	0.00	0.00	.03	.10
2193	274.82	5.30	2.35	1.81	0.00	0.00	.03	.11
2203	267.20	3.96	2.20	2.13	0.00	0.00	.04	.13
2213	257.70	3.41	2.34	2.32	0.00	0.00	.05	.13
2223	244.35	3.31	2.17	2.63	0.00	0.00	.06	.16
2233	233.26	3.07	1.91	2.75	0.00	0.00	.07	.20
2243	226.09	2.91	1.62	2.77	0.00	0.00	.05	.21
2253	207.03	3.15	1.55	2.23	0.00	0.00	.05	.14
2263	192.65	2.20	1.79	2.52	0.00	0.00	.05	.12
2273	208.08	2.23	1.36	2.36	0.00	0.00	.05	.13

2283	194.10	1.16	1.49	2.85	0.00	0.00	.06	.12
2293	215.98	1.16	1.71	3.38	0.00	0.00	.10	.11
2303	208.75	1.13	1.38	2.44	0.00	0.00	.10	.13
2013	20.20	4.04	.56	.18	1.58	.02	.01	0.00
2023	2.71	.81	.57	.18	0.00	.08	.01	0.00
2033	9.34	.16	.29	.11	0.00	0.00	.02	.02
2043	8.77	.05	.16	.09	0.00	0.00	.02	.02
2053	11.72	.01	.05	.07	0.00	0.00	.01	.02
2063	14.40	.04	.02	.06	0.00	0.00	.02	.02
2073	8.21	.38	.01	.07	0.00	0.00	.01	.01
2083	7.59	.82	0.00	.10	0.00	0.00	.01	.01
2093	11.53	1.38	.07	.13	0.00	0.00	.01	.01
2103	8.62	.79	.11	.14	0.00	0.00	.01	.01
2113	11.83	.70	.17	.12	0.00	0.00	0.00	.01
2123	10.58	.89	.21	.15	0.00	0.00	0.00	.01
2013	2.75	.51	.10	.11	0.00	0.00	0.00	.01
2023	2.58	.52	.24	.17	0.00	0.00	0.00	.01

Proj_YEAR	BulkDens	CnpyBase	S_Flame	S_Crown	S_Torch	F_Hazard
2013	.01	30.00	11.63	148.65	14.68	3.00
2023	.05	16.00	14.64	70.59	9.81	3.00
2033	.02	34.00	10.55	140.86	20.50	2.00
2043	.02	32.00	9.28	134.11	24.77	2.00
2053	.03	20.00	8.96	106.52	18.84	3.00
2063	.02	25.00	8.08	99.20	22.89	3.00
2073	.05	19.00	9.40	31.44	19.63	3.00
2083	.06	22.00	6.67	49.03	30.57	3.00
2093	.03	22.00	6.79	55.37	20.76	2.00
2103	.06	20.00	9.82	39.35	25.85	3.00
2113	.06	23.00	7.89	39.86	29.96	2.00
2123	.02	49.00	7.65	85.93	31.26	2.00
2133	.05	27.00	7.16	44.07	33.84	1.00
2143	.04	22.00	7.56	45.74	28.65	3.00
2153	.04	20.00	7.52	47.29	25.38	3.00
2163	.04	18.00	7.26	48.36	23.91	3.00
2173	.04	20.00	7.12	48.91	27.71	3.00
2183	.04	18.00	7.24	50.02	26.52	3.00
2193	.04	16.00	7.34	50.23	25.36	3.00
2203	.04	17.00	7.18	50.47	28.60	3.00
2213	.04	16.00	7.09	51.25	28.41	3.00
2223	.04	17.00	7.18	50.97	25.96	3.00
2233	.04	16.00	7.08	50.71	25.69	3.00
2243	.04	16.00	6.77	52.15	26.28	3.00
2253	.04	19.00	6.27	51.15	30.40	3.00
2263	.04	19.00	6.19	53.17	26.73	3.00
2273	.03	18.00	5.89	58.90	26.62	3.00
2283	.03	15.00	5.63	58.74	24.91	3.00
2293	.03	20.00	6.20	59.12	25.22	3.00
2303	.03	23.00	6.03	58.73	29.60	3.00
2013	.02	47.00	7.42	80.93	31.55	2.00
2023	.02	6.00	14.15	80.93	1.46	3.00
2033	.04	3.00	15.47	45.34	.13	3.00
2043	.06	6.00	18.11	34.36	4.06	4.00
2053	.08	9.00	19.11	29.94	9.85	4.00
2063	.05	17.00	10.20	39.21	16.44	4.00
2073	.05	21.00	7.55	38.59	21.92	3.00
2083	.05	23.00	5.68	38.47	27.00	3.00
2093	.03	26.00	6.10	68.42	25.10	2.00
2103	.03	19.00	6.01	57.20	21.58	2.00
2113	.03	22.00	5.48	54.94	27.33	2.00
2123	.02	52.00	7.62	91.41	32.90	2.00
2013	.02	41.00	7.69	83.83	27.36	2.00
2023	.02	2.00	14.15	72.09	0.00	3.00

Refer to Figure VI-10 for the YEP program depiction of this yield profile. Notice the stagger in cubic foot yields between stand ages 0 to 120. This represents the overlay of the existing stand structure versus the regenerated stand structure. The remnant cubic foot volumes in the 0 to 10 year old age classes represent the residual seed trees that remain after the preparation cut of the shelterwood treatment.

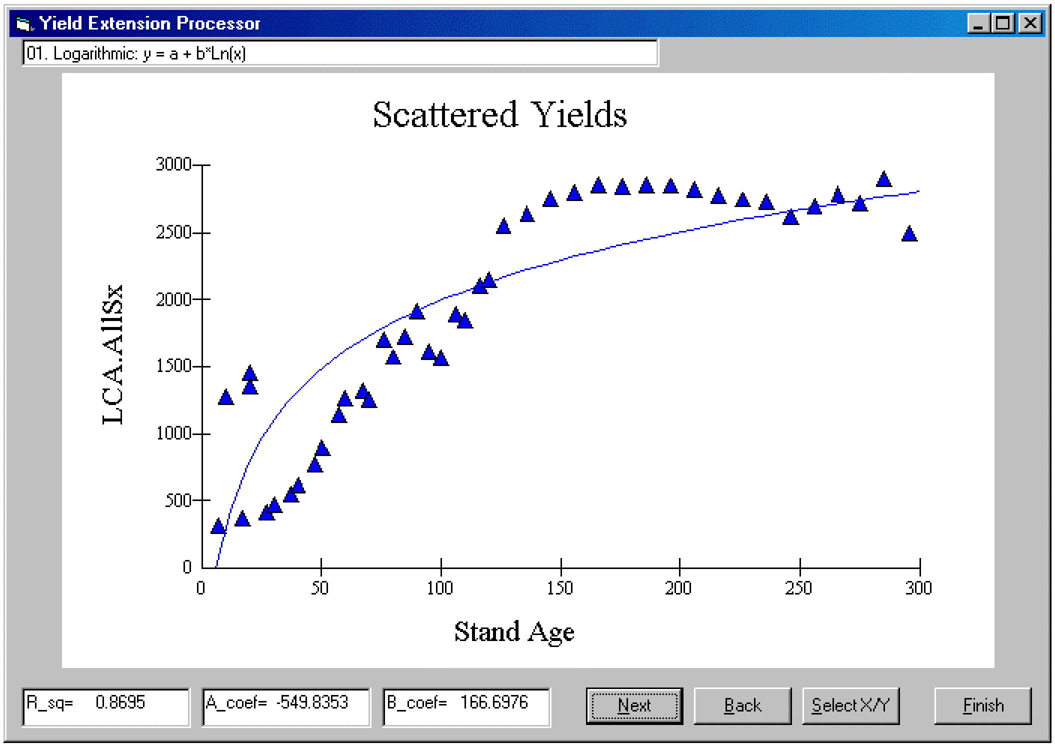


Figure VI-10 – Scatter Plot of P9HMHPB01 Cubic Foot Yields Extended

A total of 587 age-based yield profiles were extended for the Black Hills Phase II Amendment. A total of 98 time-based yield profiles were also updated. These files were uploaded to the Forest Management Service Center's FTP site for easy access.

All data, keyword, and yield files for the Black Hills Phase II Amendment are available from the Forest Management Service Center in Fort Collins, Colorado. As a permanent repository, a Compact Disk has been made to store the data and processing software. Versions of this CD will be stored at the Black Hills National Forest Supervisor's Office and at the FMSC.

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions Regarding Yield Profile Construction

The fundamental objective in preparing this report was to develop a white paper that documented the process of constructing vegetative yield profiles in support of the Phase II Amendment project. A secondary objective was to describe the current technologies used in the process. A systematic approach was employed to perform the required analysis. The major steps in the process were: formulating a forestland classification strategy, assembling inventory data, calibrating the Forest Vegetation Simulator, preparing natural growth runs, implementing treatment prescriptions, and constructing yield profiles.

Preparing yield tables in support of forest planning efforts is not akin to processing inventory data through developed software. You can not simply feed data in one end and produce meaningful output reports at the other end. The professional talents required to construct relevant vegetative trends include that of a mensurationist, silviculturalist, forest analyst, forest planner, technical writer, and computer scientist. This is not a complete of specialty skills. Possessing these abilities does not ensure proper integration of tasks. Formal experience on several projects aids in solidifying the corporate memory to conduct such analyses. There is as much art as science that goes into the process.

With regard to the Black Hills Phase II Amendment project, 47 vegetative stand types were recognized. Stand types were defined by unique combinations of overstory cover type, size class, storied-ness, crown density, site productivity, and understory component. Data from permanent and temporary inventories was assembled to represent the assortment of stand types. A thorough effort was untaken to calibrate the model estimates with measure values. Sixteen different silvicultural regimes with various timing options were simulated per stand type over a 160-year projection period. In all, 685 yield profiles were produced. (Several iterations were performed to refine the output). Initially, 299 accounting variables were tracked per yield file. Later, the number was reduced to 115 columns. Standard forestry metrics such as trees per acre, average diameter, average height, basal area, cubic foot volume, and board foot volume were generated. Additionally, class variables for forest cover type, habitat structural stage, Mountain Pine Beetle incidence, and wildfire hazard were determined. Finally, the yield profiles were made available for use by a forest planning scheduling model.

Several new computer programs were written in support of the Black Hills effort. Future planning projects should benefit. These endeavors will be able to take advantage of in-place software resulting in a reduced time frame needed for processing.

B. Recommendations Regarding Yield Profile Construction

It all gets back to the data. Bad data produces bad results. The foundation of the analysis effort rests squarely on the underlying inventory data. In general, if enough time is not budgeted to do it right the first time, it will have to be done again, guaranteed. Gathering and assembling a representative data set is an important first step. Having the inventory data bases current and correct is paramount. Several mis-starts occurred in the Black Hills project as a result of incomplete data elements.

Proper definition of stand types is often difficult. Simplifying the attributes helps. Focusing on significant overstory and understory stand characteristics narrows the focus. Site quality is only important if silvicultural activities revolve around such parameters. Defining existing and potential management regimes comes into play. Silvicultural treatments need to be agreed upon and clearly defined. Track only the variables that are needed to solve the overall forest planning problem. If wildlife habitat, insect outbreaks, and wildfire hazard are driving management direction, finding the proper mix of output variables to adequately describe the tradeoffs of the different alternatives is vital.

Lastly, being flexible to respond to the ever-changing rule sets that get tossed into the fray is crucial. Take your best shot. Document the steps taken.

APPENDIX I

Sample Plot Distribution by Stand Type by Inventory

1986 Stage I

	Understory Cover Type									
	Juniper (J)	Oak (O)	Pine (P)	Aspen (A)	Spruce (S)	P-S (C)	J-O-A (U)	N Qual. (X)	Sub	
P6LAL								6	6	
P6LAH								1	1	
P6HAL								6	6	
P6HAH								4	4	17
P7LAL								6	6	
P7LAH								3	3	
P7HAL								1	1	
P7HAH								3	3	13
P8LLL						5			5	
P8LLH						1			1	
P8LML						16			16	
P8LMH						7			7	
P8LHL						6			6	
P8LHH						2			2	
P8LAL							1		1	
P8LAH							3		3	
P8HLL						3			3	
P8HLH						0			0	
P8HML						6			6	
P8HMH						1			1	
P8HHL						0			0	
P8HHH						0			0	
P8HAL							1		1	
P8HAH							1		1	53
P9LLL			10	1					11	
P9LLH			8	1					9	
P9LML			34	1	1				36	
P9LMH			19	2	1				22	
P9LHL			7						7	
P9LHH			3						3	
P9HLL			9	3					12	
P9HLH		1	15	3					19	
P9HML			10	1					11	
P9HMH			20	3	1				24	
P9HHL			0						0	
P9HHH			0						0	154
S7AAA								0	0	
S8AAA								1	1	
S9AAA								3	3	4
Total	0	1	135	15	3	47	6	34	241	

1995 Stage II

	Understory Cover Type									
	Juniper (J)	Oak (O)	Pine (P)	Aspen (A)	Spruce (S)	P-S (C)	J-O-A (U)	N Qual. (X)	Sub	
P6LAL								0	0	
P6LAH								1	1	
P6HAL								0	0	
P6HAH								0	0	1
P7LAL								2	2	
P7LAH								5	5	
P7HAL								1	1	
P7HAH								2	2	10
P8LLL						3			3	
P8LLH						5			5	
P8LML						3			3	
P8LMH						14			14	
P8LHL						2			2	
P8LHH						15			15	
P8LAL							3		3	
P8LAH							8		8	
P8HLL						2			2	
P8HLH						4			4	
P8HML						4			4	
P8HMH						16			16	
P8HHL						1			1	
P8HHH						4			4	
P8HAL							1		1	
P8HAH							8		8	93
P9LLL			1						1	
P9LLH			3						3	
P9LML			7	5					12	
P9LMH		1	14	6					21	
P9LHL									0	
P9LHH			2	1					3	
P9HLL			1						1	
P9HLH				2					2	
P9HML			3	1					4	
P9HMH		1	8	4	1				14	
P9HHL									0	
P9HHH			2						2	63
S7AAA								2	2	
S8AAA								9	9	
S9AAA								4	4	15
Total	0	2	41	19	1	73	20	26	182	

1999 FIA 5M & Hx

	Understory Cover Type									
	Juniper (J)	Oak (O)	Pine (P)	Aspen (A)	Spruce (S)	P-S (C)	J-O-A (U)	N Qual. (X)	Sub	
P6LAL								1	1	
P6LAH								0	0	
P6HAL								1	1	
P6HAH								1	1	3
P7LAL								9	9	
P7LAH								3	3	
P7HAL								8	8	
P7HAH								2	2	22
P8LLL						0			0	
P8LLH						0			0	
P8LML						6			6	
P8LMH						0			0	
P8LHL						4			4	
P8LHH						1			1	
P8LAL							6		6	
P8LAH							4		4	
P8HLL						1			1	
P8HLH						0			0	
P8HML						6			6	
P8HMH						0			0	
P8HHL						1			1	
P8HHH						0			0	
P8HAL							0		0	
P8HAH							2		2	31
P9LLL			3	3					6	
P9LLH		1	5		1				7	
P9LML	3	3	20	6	2				34	
P9LMH	1	2	10	8	2				23	
P9LHL		1	3		1				5	
P9LHH			3						3	
P9HLL			4	2					6	
P9HLH			5						5	
P9HML			13	4	1				18	
P9HMH		3	9	6	1				19	
P9HHL			3						3	
P9HHH			1						1	130
S7AAA								0	0	
S8AAA								1	1	
S9AAA								3	3	4
Total	4	10	79	29	8	19	12	29	190	

2001 FIA

	Understory Cover Type									
	Juniper (J)	Oak (O)	Pine (P)	Aspen (A)	Spruce (S)	P-S (C)	J-O-A (U)	N Qual. (X)	Sub	
P6LAL								0	0	
P6LAH								0	0	
P6HAL								0	0	
P6HAH								0	0	0
P7LAL								1	1	
P7LAH								0	0	
P7HAL								0	0	
P7HAH								3	3	4
P8LLL						0			0	
P8LLH						0			0	
P8LML						0			0	
P8LMH						0			0	
P8LHL						0			0	
P8LHH						1			1	
P8LAL							0		0	
P8LAH							1		1	
P8HLL						0			0	
P8HLH						0			0	
P8HML						1			1	
P8HMH						0			0	
P8HHL						1			1	
P8HHH						0			0	
P8HAL							0		0	
P8HAH							1		1	5
P9LLL			1	1					2	
P9LLH									0	
P9LML			1	1					2	
P9LMH		1		2					3	
P9LHL		1	1		2				4	
P9LHH									0	
P9HLL	1		3	1					5	
P9HLH			1						1	
P9HML			1	2					3	
P9HMH			4	1					5	
P9HHL									0	
P9HHH									0	25
S7AAA								0	0	
S8AAA								0	0	
S9AAA								0	0	0
Total	1	2	12	8	2	3	2	4	34	

Total Sample

	Understory Cover Type									
	Juniper (J)	Oak (O)	Pine (P)	Aspen (A)	Spruce (S)	P-S (C)	J-O-A (U)	N Qual. (X)	Sub	
P6LAL								7	7	
P6LAH								2	2	
P6HAL								7	7	
P6HAH								5	5	21
P7LAL								18	18	
P7LAH								11	11	
P7HAL								10	10	
P7HAH								10	10	49
P8LLL						8			8	
P8LLH						6			6	
P8LML						25			25	
P8LMH						21			21	
P8LHL						12			12	
P8LHH						19			19	
P8LAL							10		10	
P8LAH							16		16	
P8HLL						6			6	
P8HLH						4			4	
P8HML						17			17	
P8HMH						17			17	
P8HHL						3			3	
P8HHH						4			4	
P8HAL							2		2	
P8HAH							12		12	182
P9LLL			15	5					20	
P9LLH		1	16	1	1				19	
P9LML	3	3	62	13	3				84	
P9LMH	1	4	43	18	3				69	
P9LHL		2	11		3				16	
P9LHH			8	1					9	
P9HLL	1		17	6					24	
P9HLH		1	21	5					27	
P9HML			27	8	1				36	
P9HMH		4	41	14	3				62	
P9HHL			3						3	
P9HHH			3						3	372
S7AAA								2	2	
S8AAA								11	11	
S9AAA								10	10	23
Total	5	15	267	71	14	142	40	93	647	

APPENDIX II

Accounting Variables for Black Hills Phase II Amendment

```
* Base Model Output Variables: Fvsstand Alone Post Processor
1  - Strata    = Stand Type/Rx/Timing Choice Label
1  - Proj_YEAR = Projection Cycle Year
1  - St_Age/10 = Stand_Age/10 years
1  - Stand_Age = Stand Age
1  - SiteIndex = Site Index
1  - StDnIndex = Stand Density Index
1  - CulmMAI-T = Culmination Mean Annual Increment - Merchantable Cubic Feet, All Trees
1  - CulmMAI-S = Culmination Mean Annual Increment - Merchantable Cubic Feet, Sawtimber Trees
1  - Qd_Mn_Dia = Quadratic Mean Diameter
1  - For_Type_ = Forest Cover Type
1  - Plt_Acres = Plot Acres (Count)
1  - Trt_Acres = Treatment Acres (Count)                                                 ______________________________
1  - LTr.094Sx = Live/Trees per Acre/All Species/All Size Classes                        |
1  - LAD.094Sx = Live/Average DBH/All Species/All Size Classes                           |
1  - LAH.094Sx = Live/Average Height/All Species/All Size Classes                        |
1  - LBA.094Sx = Live/Basal Area per Acre/All Species/All Size Classes                   |
1  - LCA.094Sx = Live/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top  |
1  - LCS.094Sx = Live/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top  |
1  - LCT.094Sx = Live/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - LBd.094Sx = Live/Board Feet per Acre/All Species/All Size Classes                   |  White Spruce
1  - HTr.094Sx = Harv/Trees per Acre/All Species/All Size Classes                        |  - Sx = All Size Classes
1  - HAD.094Sx = Harv/Average DBH/All Species/All Size Classes                           |
1  - HAH.094Sx = Harv/Average Height/All Species/All Size Classes                        |
1  - HBA.094Sx = Harv/Basal Area per Acre/All Species/All Size Classes                   |
1  - HCA.094Sx = Harv/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top  |
1  - HCS.094Sx = Harv/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top  |
1  - HCT.094Sx = Harv/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - HBd.094Sx = Harv/Board Feet per Acre/All Species/All Size Classes                   |
1  - MTr.094Sx = Mort/Trees per Acre/All Species/All Size Classes                        |
1  - MAD.094Sx = Mort/Average DBH/All Species/All Size Classes                           |
1  - MAH.094Sx = Mort/Average Height/All Species/All Size Classes                        |
1  - MBA.094Sx = Mort/Basal Area per Acre/All Species/All Size Classes                   |
1  - MCA.094Sx = Mort/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top  |
1  - MCS.094Sx = Mort/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top  |
1  - MCT.094Sx = Mort/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - MBd.094Sx = Mort/Board Feet per Acre/All Species/All Size Classes                   |______________________________
1  - LTr.122Sx = Live/Trees per Acre/All Species/All Size Classes                        |
1  - LAD.122Sx = Live/Average DBH/All Species/All Size Classes                           |
1  - LAH.122Sx = Live/Average Height/All Species/All Size Classes                        |
1  - LBA.122Sx = Live/Basal Area per Acre/All Species/All Size Classes                   |
1  - LCA.122Sx = Live/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top  |
1  - LCS.122Sx = Live/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top  |
1  - LCT.122Sx = Live/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - LBd.122Sx = Live/Board Feet per Acre/All Species/All Size Classes                   |  Ponderosa Pine
1  - HTr.122Sx = Harv/Trees per Acre/All Species/All Size Classes                        |  - Sx = All Size Classes
1  - HAD.122Sx = Harv/Average DBH/All Species/All Size Classes                           |
1  - HAH.122Sx = Harv/Average Height/All Species/All Size Classes                        |
1  - HBA.122Sx = Harv/Basal Area per Acre/All Species/All Size Classes                   |
1  - HCA.122Sx = Harv/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top  |
1  - HCS.122Sx = Harv/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top  |
1  - HCT.122Sx = Harv/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - HBd.122Sx = Harv/Board Feet per Acre/All Species/All Size Classes                   |
1  - MTr.122Sx = Mort/Trees per Acre/All Species/All Size Classes                        |
1  - MAD.122Sx = Mort/Average DBH/All Species/All Size Classes                           |
1  - MAH.122Sx = Mort/Average Height/All Species/All Size Classes                        |
1  - MBA.122Sx = Mort/Basal Area per Acre/All Species/All Size Classes                   |
1  - MCA.122Sx = Mort/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top  |
1  - MCS.122Sx = Mort/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top  |
1  - MCT.122Sx = Mort/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - MBd.122Sx = Mort/Board Feet per Acre/All Species/All Size Classes                   |______________________________
1  - LTr.AllSx = Live/Trees per Acre/All Species/All Size Classes                        |
1  - LAD.AllSx = Live/Average DBH/All Species/All Size Classes                           |
1  - LAH.AllSx = Live/Average Height/All Species/All Size Classes                        |
1  - LBA.AllSx = Live/Basal Area per Acre/All Species/All Size Classes                   |
1  - LCA.AllSx = Live/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top  |
1  - LCS.AllSx = Live/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top  |
1  - LCT.AllSx = Live/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - LBd.AllSx = Live/Board Feet per Acre/All Species/All Size Classes                   |  All Species
1  - HTr.AllSx = Harv/Trees per Acre/All Species/All Size Classes                        |  - Sx = All Size Classes
1  - HAD.AllSx = Harv/Average DBH/All Species/All Size Classes                           |
```

```
1  - HAH.AllSx = Harv/Average Height/All Species/All Size Classes                                 |
1  - HBA.AllSx = Harv/Basal Area per Acre/All Species/All Size Classes                            |
1  - HCA.AllSx = Harv/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top     |
1  - HCS.AllSx = Harv/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top     |
1  - HCT.AllSx = Harv/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - HBd.AllSx = Harv/Board Feet per Acre/All Species/All Size Classes                            |
1  - MTr.AllSx = Mort/Trees per Acre/All Species/All Size Classes                                 |
1  - MAD.AllSx = Mort/Average DBH/All Species/All Size Classes                                    |
1  - MAH.AllSx = Mort/Average Height/All Species/All Size Classes                                 |
1  - MBA.AllSx = Mort/Basal Area per Acre/All Species/All Size Classes                            |
1  - MCA.AllSx = Mort/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top     |
1  - MCS.AllSx = Mort/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top     |
1  - MCT.AllSx = Mort/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - MBd.AllSx = Mort/Board Feet per Acre/All Species/All Size Classes                            |______________________________
1  - LTr.Gp1Ss = Live/Trees per Acre/All Species/All Size Classes                                 |
1  - LAD.Gp1Ss = Live/Average DBH/All Species/All Size Classes                                    |
1  - LAH.Gp1Ss = Live/Average Height/All Species/All Size Classes                                 |
1  - LBA.Gp1Ss = Live/Basal Area per Acre/All Species/All Size Classes                            |
1  - LCA.Gp1Ss = Live/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top     |
1  - LCS.Gp1Ss = Live/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top     |
1  - LCT.Gp1Ss = Live/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - LBd.Gp1Ss = Live/Board Feet per Acre/All Species/All Size Classes                            |  White Spruce/Ponderosa Pine
1  - HTr.Gp1Ss = Harv/Trees per Acre/All Species/All Size Classes                                 |  - Ss = 0"-9" Size Class
1  - HAD.Gp1Ss = Harv/Average DBH/All Species/All Size Classes                                    |
1  - HAH.Gp1Ss = Harv/Average Height/All Species/All Size Classes                                 |
1  - HBA.Gp1Ss = Harv/Basal Area per Acre/All Species/All Size Classes                            |
1  - HCA.Gp1Ss = Harv/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top     |
1  - HCS.Gp1Ss = Harv/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top     |
1  - HCT.Gp1Ss = Harv/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - HBd.Gp1Ss = Harv/Board Feet per Acre/All Species/All Size Classes                            |
1  - MTr.Gp1Ss = Mort/Trees per Acre/All Species/All Size Classes                                 |
1  - MAD.Gp1Ss = Mort/Average DBH/All Species/All Size Classes                                    |
1  - MAH.Gp1Ss = Mort/Average Height/All Species/All Size Classes                                 |
1  - MBA.Gp1Ss = Mort/Basal Area per Acre/All Species/All Size Classes                            |
1  - MCA.Gp1Ss = Mort/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top     |
1  - MCS.Gp1Ss = Mort/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top     |
1  - MCT.Gp1Ss = Mort/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - MBd.Gp1Ss = Mort/Board Feet per Acre/All Species/All Size Classes                            |______________________________
1  - LTr.Gp2Yy = Live/Trees per Acre/All Species/All Size Classes                                 |
1  - LAD.Gp2Yy = Live/Average DBH/All Species/All Size Classes                                    |
1  - LAH.Gp2Yy = Live/Average Height/All Species/All Size Classes                                 |
1  - LBA.Gp2Yy = Live/Basal Area per Acre/All Species/All Size Classes                            |
1  - LCA.Gp2Yy = Live/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top     |
1  - LCS.Gp2Yy = Live/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top     |
1  - LCT.Gp2Yy = Live/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - LBd.Gp2Yy = Live/Board Feet per Acre/All Species/All Size Classes                            |  White Spruce/Ponderosa Pine
1  - HTr.Gp2Yy = Harv/Trees per Acre/All Species/All Size Classes                                 |  - Yy = 9"-15" Size Class
1  - HAD.Gp2Yy = Harv/Average DBH/All Species/All Size Classes                                    |
1  - HAH.Gp2Yy = Harv/Average Height/All Species/All Size Classes                                 |
1  - HBA.Gp2Yy = Harv/Basal Area per Acre/All Species/All Size Classes                            |
1  - HCA.Gp2Yy = Harv/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top     |
1  - HCS.Gp2Yy = Harv/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top     |
1  - HCT.Gp2Yy = Harv/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - HBd.Gp2Yy = Harv/Board Feet per Acre/All Species/All Size Classes                            |
1  - MTr.Gp2Yy = Mort/Trees per Acre/All Species/All Size Classes                                 |
1  - MAD.Gp2Yy = Mort/Average DBH/All Species/All Size Classes                                    |
1  - MAH.Gp2Yy = Mort/Average Height/All Species/All Size Classes                                 |
1  - MBA.Gp2Yy = Mort/Basal Area per Acre/All Species/All Size Classes                            |
1  - MCA.Gp2Yy = Mort/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top     |
1  - MCS.Gp2Yy = Mort/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top     |
1  - MCT.Gp2Yy = Mort/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - MBd.Gp2Yy = Mort/Board Feet per Acre/All Species/All Size Classes                            |______________________________
1  - LTr.Gp3Mm = Live/Trees per Acre/All Species/All Size Classes                                 |
1  - LAD.Gp3Mm = Live/Average DBH/All Species/All Size Classes                                    |
1  - LAH.Gp3Mm = Live/Average Height/All Species/All Size Classes                                 |
1  - LBA.Gp3Mm = Live/Basal Area per Acre/All Species/All Size Classes                            |
1  - LCA.Gp3Mm = Live/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top     |
1  - LCS.Gp3Mm = Live/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top     |
1  - LCT.Gp3Mm = Live/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - LBd.Gp3Mm = Live/Board Feet per Acre/All Species/All Size Classes                            |  White Spruce/Ponderosa Pine
1  - HTr.Gp3Mm = Harv/Trees per Acre/All Species/All Size Classes                                 |  - Mm = 15"-19" Size Class
1  - HAD.Gp3Mm = Harv/Average DBH/All Species/All Size Classes                                    |
1  - HAH.Gp3Mm = Harv/Average Height/All Species/All Size Classes                                 |
1  - HBA.Gp3Mm = Harv/Basal Area per Acre/All Species/All Size Classes                            |
1  - HCA.Gp3Mm = Harv/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top     |
1  - HCS.Gp3Mm = Harv/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top     |
1  - HCT.Gp3Mm = Harv/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - HBd.Gp3Mm = Harv/Board Feet per Acre/All Species/All Size Classes                            |
1  - MTr.Gp3Mm = Mort/Trees per Acre/All Species/All Size Classes                                 |
1  - MAD.Gp3Mm = Mort/Average DBH/All Species/All Size Classes                                    |
1  - MAH.Gp3Mm = Mort/Average Height/All Species/All Size Classes                                 |
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1  - MBA.Gp3Mm = Mort/Basal Area per Acre/All Species/All Size Classes                               |
1  - MCA.Gp3Mm = Mort/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - MCS.Gp3Mm = Mort/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top        |
1  - MCT.Gp3Mm = Mort/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - MBd.Gp3Mm = Mort/Board Feet per Acre/All Species/All Size Classes                               |______________________________
1  - LTr.Gp4Xx = Live/Trees per Acre/All Species/All Size Classes                                    |
1  - LAD.Gp4Xx = Live/Average DBH/All Species/All Size Classes                                       |
1  - LAH.Gp4Xx = Live/Average Height/All Species/All Size Classes                                    |
1  - LBA.Gp4Xx = Live/Basal Area per Acre/All Species/All Size Classes                               |
1  - LCA.Gp4Xx = Live/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - LCS.Gp4Xx = Live/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top        |
1  - LCT.Gp4Xx = Live/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - LBd.Gp4Xx = Live/Board Feet per Acre/All Species/All Size Classes                               |  White Spruce/Ponderosa Pine
1  - HTr.Gp4Xx = Harv/Trees per Acre/All Species/All Size Classes                                    |  - Xx = 19"+ Size Class
1  - HAD.Gp4Xx = Harv/Average DBH/All Species/All Size Classes                                       |
1  - HAH.Gp4Xx = Harv/Average Height/All Species/All Size Classes                                    |
1  - HBA.Gp4Xx = Harv/Basal Area per Acre/All Species/All Size Classes                               |
1  - HCA.Gp4Xx = Harv/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - HCS.Gp4Xx = Harv/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top        |
1  - HCT.Gp4Xx = Harv/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - HBd.Gp4Xx = Harv/Board Feet per Acre/All Species/All Size Classes                               |
1  - MTr.Gp4Xx = Mort/Trees per Acre/All Species/All Size Classes                                    |
1  - MAD.Gp4Xx = Mort/Average DBH/All Species/All Size Classes                                       |
1  - MAH.Gp4Xx = Mort/Average Height/All Species/All Size Classes                                    |
1  - MBA.Gp4Xx = Mort/Basal Area per Acre/All Species/All Size Classes                               |
1  - MCA.Gp4Xx = Mort/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - MCS.Gp4Xx = Mort/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top        |
1  - MCT.Gp4Xx = Mort/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - MBd.Gp4Xx = Mort/Board Feet per Acre/All Species/All Size Classes                               |______________________________
1  - LTr.Gp5Ss = Live/Trees per Acre/All Species/All Size Classes                                    |
1  - LAD.Gp5Ss = Live/Average DBH/All Species/All Size Classes                                       |
1  - LAH.Gp5Ss = Live/Average Height/All Species/All Size Classes                                    |
1  - LBA.Gp5Ss = Live/Basal Area per Acre/All Species/All Size Classes                               |
1  - LCA.Gp5Ss = Live/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - LCS.Gp5Ss = Live/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top        |
1  - LCT.Gp5Ss = Live/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - LBd.Gp5Ss = Live/Board Feet per Acre/All Species/All Size Classes                               |  All Species
1  - HTr.Gp5Ss = Harv/Trees per Acre/All Species/All Size Classes                                    |  - Ss = 0"-9" Size Class
1  - HAD.Gp5Ss = Harv/Average DBH/All Species/All Size Classes                                       |
1  - HAH.Gp5Ss = Harv/Average Height/All Species/All Size Classes                                    |
1  - HBA.Gp5Ss = Harv/Basal Area per Acre/All Species/All Size Classes                               |
1  - HCA.Gp5Ss = Harv/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - HCS.Gp5Ss = Harv/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top        |
1  - HCT.Gp5Ss = Harv/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - HBd.Gp5Ss = Harv/Board Feet per Acre/All Species/All Size Classes                               |
1  - MTr.Gp5Ss = Mort/Trees per Acre/All Species/All Size Classes                                    |
1  - MAD.Gp5Ss = Mort/Average DBH/All Species/All Size Classes                                       |
1  - MAH.Gp5Ss = Mort/Average Height/All Species/All Size Classes                                    |
1  - MBA.Gp5Ss = Mort/Basal Area per Acre/All Species/All Size Classes                               |
1  - MCA.Gp5Ss = Mort/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - MCS.Gp5Ss = Mort/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top        |
1  - MCT.Gp5Ss = Mort/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - MBd.Gp5Ss = Mort/Board Feet per Acre/All Species/All Size Classes                               |______________________________
1  - LTr.Gp6Yy = Live/Trees per Acre/All Species/All Size Classes                                    |
1  - LAD.Gp6Yy = Live/Average DBH/All Species/All Size Classes                                       |
1  - LAH.Gp6Yy = Live/Average Height/All Species/All Size Classes                                    |
1  - LBA.Gp6Yy = Live/Basal Area per Acre/All Species/All Size Classes                               |
1  - LCA.Gp6Yy = Live/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - LCS.Gp6Yy = Live/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top        |
1  - LCT.Gp6Yy = Live/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - LBd.Gp6Yy = Live/Board Feet per Acre/All Species/All Size Classes                               |  All Species
1  - HTr.Gp6Yy = Harv/Trees per Acre/All Species/All Size Classes                                    |  - Yy = 9"-15" Size Class
1  - HAD.Gp6Yy = Harv/Average DBH/All Species/All Size Classes                                       |
1  - HAH.Gp6Yy = Harv/Average Height/All Species/All Size Classes                                    |
1  - HBA.Gp6Yy = Harv/Basal Area per Acre/All Species/All Size Classes                               |
1  - HCA.Gp6Yy = Harv/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - HCS.Gp6Yy = Harv/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top        |
1  - HCT.Gp6Yy = Harv/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - HBd.Gp6Yy = Harv/Board Feet per Acre/All Species/All Size Classes                               |
1  - MTr.Gp6Yy = Mort/Trees per Acre/All Species/All Size Classes                                    |
1  - MAD.Gp6Yy = Mort/Average DBH/All Species/All Size Classes                                       |
1  - MAH.Gp6Yy = Mort/Average Height/All Species/All Size Classes                                    |
1  - MBA.Gp6Yy = Mort/Basal Area per Acre/All Species/All Size Classes                               |
1  - MCA.Gp6Yy = Mort/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - MCS.Gp6Yy = Mort/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top        |
1  - MCT.Gp6Yy = Mort/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - MBd.Gp6Yy = Mort/Board Feet per Acre/All Species/All Size Classes                               |______________________________
1  - LTr.Gp7Mm = Live/Trees per Acre/All Species/All Size Classes                                    |
1  - LAD.Gp7Mm = Live/Average DBH/All Species/All Size Classes                                       |
1  - LAH.Gp7Mm = Live/Average Height/All Species/All Size Classes                                    |
1  - LBA.Gp7Mm = Live/Basal Area per Acre/All Species/All Size Classes                               |
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1  - LCA.Gp7Mm = Live/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - LCS.Gp7Mm = Live/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top       |
1  - LCT.Gp7Mm = Live/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - LBd.Gp7Mm = Live/Board Feet per Acre/All Species/All Size Classes                              |  All Species
1  - HTr.Gp7Mm = Harv/Trees per Acre/All Species/All Size Classes                                   |  - Mm = 15"-19" Size Class
1  - HAD.Gp7Mm = Harv/Average DBH/All Species/All Size Classes                                      |
1  - HAH.Gp7Mm = Harv/Average Height/All Species/All Size Classes                                   |
1  - HBA.Gp7Mm = Harv/Basal Area per Acre/All Species/All Size Classes                              |
1  - HCA.Gp7Mm = Harv/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - HCS.Gp7Mm = Harv/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top       |
1  - HCT.Gp7Mm = Harv/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - HBd.Gp7Mm = Harv/Board Feet per Acre/All Species/All Size Classes                              |
1  - MTr.Gp7Mm = Mort/Trees per Acre/All Species/All Size Classes                                   |
1  - MAD.Gp7Mm = Mort/Average DBH/All Species/All Size Classes                                      |
1  - MAH.Gp7Mm = Mort/Average Height/All Species/All Size Classes                                   |
1  - MBA.Gp7Mm = Mort/Basal Area per Acre/All Species/All Size Classes                              |
1  - MCA.Gp7Mm = Mort/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - MCS.Gp7Mm = Mort/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top       |
1  - MCT.Gp7Mm = Mort/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - MBd.Gp7Mm = Mort/Board Feet per Acre/All Species/All Size Classes                              |____________________________
1  - LTr.Gp8Xx = Live/Trees per Acre/All Species/All Size Classes                                   |
1  - LAD.Gp8Xx = Live/Average DBH/All Species/All Size Classes                                      |
1  - LAH.Gp8Xx = Live/Average Height/All Species/All Size Classes                                   |
1  - LBA.Gp8Xx = Live/Basal Area per Acre/All Species/All Size Classes                              |
1  - LCA.Gp8Xx = Live/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - LCS.Gp8Xx = Live/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top       |
1  - LCT.Gp8Xx = Live/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - LBd.Gp8Xx = Live/Board Feet per Acre/All Species/All Size Classes                              |  All Species
1  - HTr.Gp8Xx = Harv/Trees per Acre/All Species/All Size Classes                                   |  - Xx = 19"+ Size Class
1  - HAD.Gp8Xx = Harv/Average DBH/All Species/All Size Classes                                      |
1  - HAH.Gp8Xx = Harv/Average Height/All Species/All Size Classes                                   |
1  - HBA.Gp8Xx = Harv/Basal Area per Acre/All Species/All Size Classes                              |
1  - HCA.Gp8Xx = Harv/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - HCS.Gp8Xx = Harv/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top       |
1  - HCT.Gp8Xx = Harv/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - HBd.Gp8Xx = Harv/Board Feet per Acre/All Species/All Size Classes                              |
1  - MTr.Gp8Xx = Mort/Trees per Acre/All Species/All Size Classes                                   |
1  - MAD.Gp8Xx = Mort/Average DBH/All Species/All Size Classes                                      |
1  - MAH.Gp8Xx = Mort/Average Height/All Species/All Size Classes                                   |
1  - MBA.Gp8Xx = Mort/Basal Area per Acre/All Species/All Size Classes                              |
1  - MCA.Gp8Xx = Mort/Cubic Feet per Acre/All Species/All Size Classes, All Trees - Cubic Top        |
1  - MCS.Gp8Xx = Mort/Cubic Feet per Acre/All Species/All Size Classes, Sawtimber - Board Top       |
1  - MCT.Gp8Xx = Mort/Cubic Feet per Acre/All Species/All Size Classes, Topwood - Board to Cubic Top |
1  - MBd.Gp8Xx = Mort/Board Feet per Acre/All Species/All Size Classes                              |____________________________
* Compute.kcp -- Computed Variables: Compute Post Processor
2  a _ForTyp   = Forest Cover Type
2  d _SizCls   = Stand Size Class
2  d _StkCls   = Stand Stocking Class
2  - _CanCov   = Canopy Cover Percent
* SOS.kcp -- Computed Variables: Compute Post Processor
2  a _SOS      = Seedling/Sapling Occurrence Specifier (Understory Composition)
* HSS.kcp -- Computed Variables: Compute Post Processor
2  a _CHESS    = Computed Habitat Estimated Structural Stage
2  a _OGSC     = Old Growth Score Card
2  a _CHESSER  = _CHESS Old Growth (HSS=5)
* MPB.kcp -- Computed Variables: Compute Post Processor
2  d _MPB_Haz  = Mountain Pine Beetle Hazard Rating (Low/Medium/High)
* Fire.kcp -- Computed Variables: Fire Compute Post Processor
2  - _Snag_H1  = Hard Snags  0"- 9"
2  - _Snag_H2  = Hard Snags  9"-15"
2  - _Snag_H3  = Hard Snags 15"-19"
2  - _Snag_H4  = Hard Snags 19"-99"
2  - _Snag_S1  = Soft Snags  0"- 9"
2  - _Snag_S2  = Soft Snags  9"-15"
2  - _Snag_S3  = Soft Snags 15"-19"
2  - _Snag_S4  = Soft Snags 19"-99"
3  - _CRBD     = Crown Bulk Density
3  - _CRBHT    = Canopy Base Height
3  - _FLGTH    = Flame Length for Severe Fire
3  - _CRIDX    = Crowning Index for Severe Fire
3  - _TRIDX    = Torching Index for Severe Fire
3  d _Fire_Hz  = Fire Hazard Rating calculated from Torching and Crowning Index
```

APPENDIX III

Layout for Spray.prj And Spray.add files

Spray.prj – RxB01 (Shelterwood)

```
CRFM
0   n0        n0        BHP2
1   n0        n1        P6LALX
2   n0        n2        P6LAHX
3   n0        n3        P6HALX
4   n0        n4        P6HAHX
5   n0        n5        P7LALX
6   n0        n6        P7LAHX
7   n0        n7        P7HALX
8   n0        n8        P7HAHX
9   n0        n9        P8LLLC
10  n0        n10       P8LLHC
11  n0        n11       P8LMLC
12  n0        n12       P8LMHC
13  n0        n13       P8LHLC
14  n0        n14       P8LHHC
15  n0        n15       P8LALU
16  n0        n16       P8LAHU
17  n0        n17       P8HLLC
18  n0        n18       P8HLHC
19  n0        n19       P8HMLC
20  n0        n20       P8HMHC
21  n0        n21       P8HHLC
22  n0        n22       P8HHHC
23  n0        n23       P8HALU
24  n0        n24       P8HAHU
25  n0        n25       P9LMLO
26  n0        n26       P9LLLP
27  n0        n27       P9LLHP
28  n0        n28       P9LMLP
29  n0        n29       P9LMHP
30  n0        n30       P9LHLP
31  n0        n31       P9LHHP
32  n0        n32       P9LMLA
33  n0        n33       P9LMHA
34  n0        n34       P9LMLS
35  n0        n35       P9HMLO
36  n0        n36       P9HLLP
37  n0        n37       P9HLHP
38  n0        n38       P9HMLP
39  n0        n39       P9HMHP
40  n0        n40       P9HHLP
41  n0        n41       P9HHHP
42  n0        n42       P9HMLA
43  n0        n43       P9HMHA
44  n0        n44       P9HMLS
45  n0        n45       S7AAAX
46  n0        n46       S8AAAX
47  n0        n47       S9AAAX
48  n1        n48       B
49  n2        n49       B
50  n3        n50       B
51  n4        n51       B
52  n5        n52       B
53  n6        n53       B
54  n7        n54       B
55  n8        n55       B
56  n9        n56       B
57  n10       n57       B
58  n11       n58       B
59  n12       n59       B
60  n13       n60       B
61  n14       n61       B
62  n15       n62       B
63  n16       n63       B
64  n17       n64       B
65  n18       n65       B
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66	n19	n66	B
67	n20	n67	B
68	n21	n68	B
69	n22	n69	B
70	n23	n70	B
71	n24	n71	B
72	n25	n72	B
73	n26	n73	B
74	n27	n74	B
75	n28	n75	B
76	n29	n76	B
77	n30	n77	B
78	n31	n78	B
79	n32	n79	B
80	n33	n80	B
81	n34	n81	B
82	n35	n82	B
83	n36	n83	B
84	n37	n84	B
85	n38	n85	B
86	n39	n86	B
87	n40	n87	B
88	n41	n88	B
89	n42	n89	B
90	n43	n90	B
91	n44	n91	B
92	n45	n92	B
93	n46	n93	B
94	n47	n94	B
95	n48	n95	01
96	n49	n96	01
97	n50	n97	01
98	n51	n98	01
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100	n53	n100	01
101	n54	n101	01
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133	n86	n133	01
134	n87	n134	01
135	n88	n135	01
136	n89	n136	01
137	n90	n137	01
138	n91	n138	01
139	n92	n139	01
140	n93	n140	01
141	n94	n141	01

<u>Spray.add – RxB01 (Shelterwood)</u>

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Front and back cover photos provided by:

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