Appendix B—Modeling Overview

Overview of Modeling Activities and Disturbances to Determine Outputs and Effects

Introduction

The final EIS essentially used the regional standard modeling and analysis systems that were used in the previous 2003 Monument planning process, the 2001 Sierra Nevada Forest Plan Amendment (USDA Forest Service 2001c), and the 2004 SNFPA Supplement (USDA Forest Service 2004e). The purpose of Appendix B is to provide an overview of the analysis process and models used to support the analysis of the alternatives and information used to support the evaluation of environmental consequences. Due to the complexity of management of the Monument and the number of analytical models and techniques utilized, analysis was facilitated by the development of an integrated analysis process. A detailed description of processes, models, specifications, and outputs can be found in the planning record. This appendix covers only the basic assumptions, modeling components, inputs, rules, and constraints and is meant to supplement the broader and less technical descriptions included in the body of the FEIS. Additional history on the evolution of the modeling approach can be gleaned in the modeling appendices of the other EISs mentioned previously, which are incorporated by reference. This analysis, like that used in the EISs mentioned above, was based on a multi-scale, multi-criteria, and hierarchical modeling approach to simulate the implementation of the various alternatives to support analysis of the alternatives by the interdisciplinary team (IDT).

The analysis process was based on the close integration of geographic information system (GIS) processes, forest inventory and plot data, traditional vegetation growth modeling and fire simulation and effects models in essentially a single process that allows GSNM managers to:

- Define spatially explicit management areas, treatment prescriptions, constraints (in the form of standards and guidelines), and priority units using GIS technology;
- Link these management areas to forest inventory information that contains vegetation attributes;
- Simulate and evaluate hundreds of thousands of possible combinations of management activities, while tracking several resource variables through time;
- Model an "optimal mix" of treatments to achieve the prioritized management goals and the desired future conditions of each alternative;
- Allow for adjustment of management strategies using simulation, mapping, reporting, and data visualization or rendering tools;
- Link various resource data and models into an integrated system, enabling analysis of attributes for both terrestrial and aquatic ecosystems.

Changes in Analysis, Assumptions, and Input Data

For the draft EIS, the following key items were addressed since the 2003 plan analysis:

- The GSNM forest inventory was updated to the 2006 inventory and then "grown" to 2009 by use of a Forest Vegetation Simulator, Gamma2.
- The GSNM forest inventory was updated to account for activities such as forest management activities and wildfires that occurred subsequent to the 2006 forest inventory.
- The GSNM updated management areas such as great gray owl, California spotted owl, and northern goshawk protected activity centers (PAC) and California spotted owl home range core areas (HRCA) maps.
- The GSNM updated wildland urban intermix (WUI) maps that are based on locally determined defense and threat zones.
- The GSNM updated the treatment costs and values derived for fuels and vegetation treatment activities to reflect current conditions.

Between the draft EIS and the final EIS, the following key items related to the analysis changed:

- The GSNM refined the treatment cost and values derived for fuels and vegetation treatment activities by subdividing the Monument into four zones (Groves in WUI Defense Zone; Groves outside WUI Defense Zone; Not Groves in WUI Defense Zone; Not Groves outside WUI Defense Zone) and estimating costs and values for each major treatment type (e.g. prescribed burning, mechanical treatment, hand treatment, etc.) within each zone.
- Alternative A was adjusted to better reflect the expected distribution of the amount of treatment between prescribed burning and other mechanical treatment methods.

Modeling of Alternatives

The alternatives were modeled using two different complementary processes before subjecting the alternatives to analysis. Although described here as a linear process of steps to more easily describe the process, the actual workload to conduct this analysis is not strictly linear. Spatial modeling of the alternatives was conducted with ESRI ArcGIS software. Most of the analysis was conducted with raster (GRID) layers at a 30-meter pixel resolution. The development and meta-data documentation of the individual layers used for alternative modeling are provided in detail in digital form in the project file as part of the planning record. A more detailed, technical description of the automated analysis process can be found in the administrative record.

The first step in the modeling process was developing a composite of the various land allocation and/or management area layers for each alternative. Since some land allocations could overlap other land allocations and each land allocation has a set of management direction and standards and guidelines, a composite map of unique combinations was created. Given that land allocations can overlap, the IDT developed a matrix showing which management direction would govern as shown in Table 63.

The second step in the modeling process required developing a list of potential treatment prescriptions that could be used to model the implementation of the alternatives. For this task, the list of general treatment prescriptions used in previous analyses such as the Sierra Nevada Forest Plan Amendment, the 2003 Monument planning effort, and other regional planning efforts were used as the initial source. The prescriptions also are built to approximate the implementation of applicable standards and guidelines. However, not all standards and guidelines could be easily modeled given the limitations of data and because the model does not simulate spatially explicit treatments. The prescriptions were reviewed and modified by the IDT to reflect a reasonable approximation of the intensity and effects expected from implementing the alternatives. Not all prescriptions are used in all alternatives. It should also be clarified that the final direction of the Land and Resource Management Plan will be specified in the Record of Decision based upon the direction provided in the description of the alternatives in Chapter 2 of the FEIS. The modeling used in this analysis in no way limits or expands the direction provided in Chapter 2 and as adopted in a Record of Decision. For modeling purposes these prescriptions are grouped by major treatment type and then ordered generally from least intensive change in vegetation to most intensive change. The list of treatment prescriptions used in the GSNM modeling is shown in Table 64.

The third step in the modeling process involved developing a rule-based treatment opportunity system to identify which treatment types would be permitted in each unique combination of land allocations (e.g. which treatments would generally be allowed in sequoia groves in the WUI defense zone versus in the WUI threat zone versus outside of the WUI?). In general, while the most restrictive maximum permissible prescription for areas of overlapping land allocations would govern, there are exceptions such as when WUI overlaps some land allocations and more intensive treatments are allowed. This general rule-set is used in modeling to select treatment types that are intended to be consistent with the intent of the alternative for Monument scale planning, while recognizing that site-specific conditions may differ for project-scale planning. The table showing the treatment prescriptions generally permissive within each land allocation or management area is shown in Table 65.

The fourth step in the modeling process involved combining the complex information from the first three steps with the updated vegetation inventory for the GSNM. This is done by taking each major vegetation strata (the combination of vegetation type, size, and density) in the vegetation inventory and modeling the expected change in vegetation condition from each of the permissive prescriptions and then "growing" the vegetation through the analysis timeframe. By pre-processing the data in this step, it allows quicker analysis in later steps and makes it easy to adjust parameters of the alternatives to ensure the model is reasonably reflective of expected outcomes from implementing the alternatives.

The fifth step in the modeling process involved using the scheduling model SPECTRUM (Version 3.0). SPECTRUM uses linear programming to select candidate areas for treatment while meeting the management direction of unique combinations of land allocations, the condition of the vegetation and suitability for different treatment types, and other base model limitations like treatment costs and the annual budget for treatments. The output from SPECTRUM are tables of data and reports that display the modeled optimized amounts and types of treatments that could occur within different vegetation conditions and different land allocations at different periods of time that meet the alternative goals and constraints and driven by priorities.

Modeling Limitations and Key Assumptions

The proposed Giant Sequoia Management Plan is in itself a model of land management through time. The plan attempts to simulate actions (for example, management activities such as fuels treatments, prescribed burning, restoration actions and road decommissioning) and estimate environmental consequences from these actions. Not all resources and factors can be considered and addressed in a plan. Plans and analyses attempt to mimic, in a simplified fashion, what might happen through time. Similarly, none of the models described below can perfectly represent the "real world" situation. Therefore, the results from these models are only approximations to the outcomes that can be expected if the alternatives are put into action.

While this analysis implies that outputs and treatments can be assigned to specific acres, in reality, they cannot be directly tied to spatially specific acres for two reasons. First, the analysis includes the effects from future projected stochastic disturbances such as wildfire, which cannot be accurately predicted to a specific acre or year; and second, the Forest Service planning process reserves to project-level planning the decision where, when, and how specific areas will be treated. What this model does is assign treatments to candidate areas and test to see if there are sufficient degrees of freedom to accomplish the treatments within the allocation and standard and guidelines developed for a specific area. The purpose of these models is to provide insight and clarify knowledge. These approximations are used to compare alternative strategies. A choice among alternatives can be made even though the models may lack the precision to describe the behavior of specific attributes of a given alternative. In other words, the models reveal relative differences among alternatives more reliably than absolute differences. These models make projection of future conditions under a given set of assumptions and not prediction of future conditions.

The models and analytical processes used have many internal limitations and parameters. These limitations must be considered when analyzing the outputs and effects projected by these models. Once the EIS models were formulated, a number of sensitivity tests were made to check for validity, "reasonableness," and to make calibrations to coefficients whose development was not based on empirical data or where development of coefficients was not exactly straightforward. Since many of the standards and guidelines are not easily put into a mathematical formulation or are too site-specific or contextual for generalization in modeling, it is important that model outputs satisfy the intent of the alternative so model outputs represent expected outcomes. This was done through an iterative process involving the interdisciplinary team, key management members, and those responsible for developing and running the models. The models used are not intended to provide precise information, especially at this scale in areas and time, but rather to provide indication of direction of change, estimates of the magnitude of change, and time frames surrounding such change.

Modeling Disturbance from Wildfire, Insects, and Other Pests

The purpose of disturbance prescriptions is to model disturbance and recovery from wildfire. To simulate fire, the tree-killing algorithms in the First Order Fire Effects Model (FOFEM) are used. The factors that affect tree mortality in FOFEM include scorch height and bark thickness. Gamma calculates a scorch height based on user-supplied flame length. Bark thickness is calculated using Region 5 species-specific equations found in the WESSIN variant of the Forest Vegetation Simulator source code. Three conditions of fire severity, with associated recovery options, are modeled in the internal disturbance prescriptions lethal fire, mixed lethal fire, and non-lethal fire.

California Wildlife Habitat Relationships (CWHR) System

The University of California, Berkeley, and the California Department of Fish and Game cooperatively developed the California Wildlife Habitat Relationships System (Airola 1988, Mayer and Laudenslayer 1988). The CWHR habitat system, like many other vegetation classification systems, uses the combination of vegetation types, average dominant vegetation size, and average canopy closure to classify habitats. CWHR habitat classification crosswalks are incorporated into the GAMMA model, allowing prediction of habitat changes over time associated vegetation growth and mortality and with different treatments in each alternative.

Key Assumptions for the Modeling

- While the modeling was done for 15 decades to evaluate long-term trends, the model effectively simulates treatments only for the first 2-3 decades. After the fourth decade, the model essentially simulates maintenance of the initial treatments plus vegetation growth and disturbance. It is assumed that this Plan will be amended as needed and revised within 15 years as directed by the National Forest Management Act.
- The GSNM budget for implementing treatments was assumed to be 2.0 million dollars per year.
- The rate and type of wildfire projected to occur into the future is based upon the real experience over the last decade.
- The modeling assumes that the assessment of potential treatments meeting the “Clear Need” criteria can only be made at the project scale, considering the specific context of the purpose and need for action. The modeling assesses the capacity of each alternative to provide areas potentially suitable for a “Clear Need” evaluation while meeting the intent and theme of the alternative.

Land Allocation/ Management Area Overlaps

This section provides a matrix that displays which direction applies when there are overlaps between land allocations or management areas. These overlays are used by the models to develop the unique combinations of overlays that must be considered and to assign the appropriate range of prescriptions that are permissive in each unique combination.

Table 67 Dominant Management Direction When Land Allocations/Management Areas Overlap

Land Allocations/ Management Areas	Southern Sierra Fisher Conserva-tion Area (SSFCA)	Old Forest Emphasis Area	Wildland Urban Intermix (WUI): Defense Zone	Wildland Urban Intermix (WUI): Threat Zone	Riparian Conserva-tion Areas (RCAs) and Critical Aquatic Ref-uges (CARs)	General Monument	Protected Activity Centers (PACs), Den Sites, Home Range Core Areas (HRCAs)	Giant Sequoia Groves	Tribal Fuels Emphasis Treatment Area (TFETA)
Southern Sierra Fisher Conservation Area (SSFCA)	N/A	Apply old forest	Apply SSFCA-except WUI fuels	Apply SSFCA-except WUI fuels	Apply both	Apply general Monument plus SSFCA-specific	Apply PACs, den sites, HRCAs	Apply groves	Apply general Monument plus SSFCA-specific
Old Forest Emphasis Area	Apply old forest	N/A	Apply old forest-except WUI fuels	Apply old forest-except WUI fuels	Apply both	N/A	Apply PACs, den sites, HRCAs	Apply groves	Apply old forest
Wildland Urban Intermix (WUI): Defense Zone	Apply SSFCA-except WUI fuels	Apply old forest-except WUI fuels	N/A	N/A	Apply both	Apply WUI	Apply special PACs and den sites[1]	Apply WUI	Apply SSFCA-except WUI fuels
Wildland Urban Intermix (WUI): Threat Zone	Apply SSFCA-except WUI fuels	Apply old forest-except WUI fuels	N/A	N/A	Apply both	Apply WUI	Apply PACs and den sites-WUI *usually* applied over HRCA	Apply WUI	Apply SSFCA-except WUI fuels
Riparian Conservation Areas (RCAs) and Critical Aquatic Refuges (CARs)	Apply both	Apply both	Apply both	Apply both	N/A	Apply both	Apply both except where PACs, den sites, and HRCAs are more restrictive	Apply both	Apply both
General Monument	Apply general Monument plus SSFCA-specific	N/A	Apply WUI	Apply WUI	Apply both	N/A	Apply PACs, den sites, HRCAs	Apply groves	Apply general Monument plus SSFCA-specific

1. See standards and guidelines for PACs and den sites located in defense zones.

Land Allocations/ Management Areas	Southern Sierra Fisher Conserva-tion Area (SSFCA)	Old Forest Emphasis Area	Wildland Urban Intermix (WUI): Defense Zone	Wildland Urban Intermix (WUI): Threat Zone	Riparian Conserva-tion Areas (RCAs) and Critical Aquatic Ref-uges (CARs)	General Monument	Protected Activity Centers (PACs), Den Sites, Home Range Core Areas (HRCAs)	Giant Sequoia Groves	Tribal Fuels Emphasis Treatment Area (TFETA)
Protected Activity Centers (PACs), Den Sites, Home Range Core Areas (HRCAs)	Apply PACs, den sites, HRCAs	Apply PACs, den sites, HRCAs	Apply special PACs and den sites[2]	Apply PACs and den sites-WUI *usually* applied over HRCA	Apply both except where PACs, den sites, and HRCAs are more restrictive	Apply PACs, den sites, HRCAs	N/A	Apply PACs, den sites, HRCAs	Apply PACs and den sites-WUI *usually* applied over HRCA
Giant Sequoia Groves	Apply groves	Apply groves	Apply WUI	Apply WUI	Apply both	Apply groves	Apply PACs, den sites, HRCAs	N/A	Apply groves
Tribal Fuels Emphasis Treatment Area (TFETA)	Apply general monument plus SSFCA-specific	Apply old forest	Apply SSFCA-except WUI fuels	Apply SSFCA-except WUI fuels	Apply both	Apply general Monument plus SSFCA-specific	Apply PACs and den sites-WUI *usually* applied over HRCA	Apply groves	N/A

1. See standards and guidelines for PACs and den sites located in defense zones.

Treatment Prescriptions

This section provides an overview of the prescriptions that were developed to model the general effects of treatments under Alternatives A through F of the final EIS. A prescription is a group of management practices or treatments applied to a specific land area.

Table 68 List of Treatment Prescriptions and Sequence Order Used In Modeling

Rx Code	Rx Name	Description
No Treatment		
01	letgrw	Let grow, no treatment planned. Only growth and inter-tree mortality. This is the default prescription for untreated areas.
Wildfire–Simulation Effects		
03	lethal	Simulates the effects of a lethal (high severity) wildfire. Modeled using FVS as 2/3 of the basal area of trees killed.
04	mxleth	Simulates the effects of a mixed-lethal (moderate severity) wildfire. Modeled using FVS as 1/3 to 2/3 of the basal area of trees killed.
05	nonlth	Simulates the effects of a non-lethal (low severity) wildfire. Modeled using FVS as less than 1/3 of the basal area of trees killed
06	brfire	Simulates the effects of wildfire in brush. Assumes high severity fire effects in shrubs.
07	grfire	Simulates the effects of wildfire in grass.
Insects and Disease–Simulation Effects		
08	b-leth	Simulates the effects of heavy mortality from insects or disease. Modeled using FVS as ¾ of the basal area of trees killed.
09	b-mxth	Simulates the effects of moderate mortality from insects or disease. Modeled using FVS as ¼ to ¾ of the basal area of trees killed.
10	b-nlth	Simulates the effects of light mortality from insects or disease. Modeled using FVS as less than ¼ of the basal area of trees killed.
Previous Treatments–Used to Update the Vegetation Data to Current Conditions		
11	ctreat	Lands previously treated or with existing conditions that meet the criteria of effectively meeting fuel or vegetation health specifications
12	ptreat	Lands previously treated for fuels or vegetation health but still needing a follow-up surface fuel reduction treatment. Used for projects in progress or past projects where vegetation structure is sufficient to meet objectives but surface fuels remain out of specifications.
13	pbrush	Lands with brush/shrub vegetation that was previously treated that meet the criteria of effectively meeting fuel specifications.
Brush/Shrubs		
16	brburn	Treatment of shrubs using prescribed fire. Simulates a mosaic burn that converts 60-80 percent of the areas to a younger age.
17	brmech	Treatment of shrubs using hand or mechanical methods. Usually limited to slopes <35 percent. Includes mastication methods.

Rx Code	Rx Name	Description
Prescribed Fire and Managed Wildfire		
21	unburn	Simulates an underburn. Primarily used for ecological purposes to reintroduce fire to the ecosystem. Low intensity fire with less than 2 foot flame lengths. Generally does not reduce larger material fuels and may not entirely meet desired fuel reduction specifications. Maintenance underburns occur on 30 year intervals.
25	rxburn	Simulates a prescribed fire designed to meet fuels objectives. Typically designed to simulate a 4-foot flame length. Within 5 years of the initial burn a repeat burn with 2-foot flame lengths occurs then maintenance burns occur every 20 years.
29	hotbrn	Simulates a prescribed fire specifically designed to reduce ladder fuels and alter stand structure, including creating small regeneration gaps. Usually applied where mechanical treatments are not allowed or possible. Also simulates burning used by the National Park Service. Typically designed to simulate a mixed-lethal fire that can kill larger diameter trees.
Tree Thinning to Approximate Changes from Prescribed Fire		
30	hand-6	Treatment that removes all material less than or equal to 6-inch diameter at breast height by hand treatment methods. Typically it involves hand piling cut material then prescribed burning the treated area within 3 years with a 2-foot flame length. May not meet desired fuel conditions if ladder fuels or crown fuels exist in larger diameter trees.
32	mecht3	Treatment that removes material similar to what would be removed with prescribed fire under a 4-foot flame length. Maximum dbh for removal is 12 inches. Includes a prescribed burn within 3 years with 2-foot flame lengths then maintenance burns occur every 20 years.
34	mecht1	Treatment that removes material similar to what would be removed with prescribed fire under a 5-foot flame length. Maximum dbh for removal is 20 inches. Includes a prescribed burn within 3 years with 2-foot flame lengths then maintenance burns occur every 20 years.
Regeneration of Wildfire Burned Areas		
ER	Regen-Mech	Areas affected by modeled wildfire that are then reforestedand then maintained with mechanical methods.
FR	Regen-RxFire	Areas affected by modeled wildfire that are then reforested and then maintained with prescribed fire.
61	defzon	Treatments in the Defense Zone of the WUI. Generally thins trees to 60 percent of normal basal area. Treatments can reduce canopy cover down to 40 percent.
63	Vigor1	Treatment that reduces stand density and focuses on retaining trees based upon characteristics of tree vigor (health) at the tree and stand level. Treatments can reduce canopy cover down to 35 percent. Thins from each canopy class starting with suppressed, then intermediate, then codominant trees. Within each canopy class, trees are thinned from the smallest crown ratio first.

Permissive Prescriptions by Land Allocation

The range of prescriptions describes the possible activities for a given analysis area. The SPECTRUM modeling allocates prescriptions to land based on forest constraints, the given management alternative, and the objective function. Each land area has a set of prescriptions that are applicable to that land allocation. Other prescriptions may also be applied if they are less impacting. For example, if an area allows prescribed burning it would also allow hand cutting of small trees. However it would not allow prescriptions that allow mechanical treatments or that remove larger trees. The exception to this is that the WUI Defense Zone can override some land allocations as shown in Table 63.

Table 69 Permissible Prescriptions by Land Allocation by Alternative Used in Modeling

Land Allocation	Alternative					
	A	B	C	D	E	F
Wilderness, existing	1	1	1	1	1	1
Wilderness, proposed	1	1	1	1	1	1
Wild and scenic rivers	1	1	1	1	1	1
Inventoried roadless areas	1-25	1-29	1-29	1-29	1-29	1-29
Research Natural Areas and other withdrawn	1	1	1	1	1	1
Admin/special uses sites	1	NA	NA	NA	NA	NA
Sequoia groves	1-25, 30	1-34	1-30	1-32	1-63	1-63
Sequoia grove buffer/Influence areas	1-25, 30	1-34	1-30	1-32	1-63	1-63
Sequoia stands (from vegetation data)	1-25, 30	1-34	1-30	1-32	1-63	1-63
CA spotted owl PACs	1-30	1-30	NA	1-30	1-30	1-30
CA spotted owl HRCA	1-32	1-34	NA	NA	NA	1-63
CA spotted owl nest cores	1-30	1-30	NA	1-30	1-30	1-30
Northern goshawk PACs	1-30	1-30	NA	1-30	1-30	1-30
Carnivore den sites	1	1	NA	1	1	1
Southern Sierra Fisher Conservation Area	1-32	1-34	1-30	1-30	1-63	1-63
Amphibians	1	1	1	1	1	1
Late-successional old growth (LSOG) Rank 4&5 areas	1-32	1-34	1-30	1-30	1-63	1-63
Old forest emphasis area (OFEA)	1-32	1-34	NA	NA	NA	1-63
Riparian zone [ephemerals]	1-32	1-32	1-30	1-30	1-32	1-32
WUI defense zone	1-61	1-34	1-30	1-32	1-61	1-63
WUI threat zone	1-34	1-34	NA	NA	1-34	1-63
Strategically placed area treatments	1-34	1-34	NA	NA	1-63	1-63
TFETA, inner	NA	1-34	NA	NA	NA	1-63
TFETA, outer	NA	1-34	NA	NA	NA	1-63
Plantations	1-34	1-34	1-30	1-25	1-63	1-34
Non-forest types [grass, water, barren]	1	1	1	1	1	1
CWHR classes 5M, 5D, 6	1-32	1-34	1-30	1-30	1-63	1-63

Land Allocation	Alternative					
	A	B	C	D	E	F
CWHR classes 4M, 4D	1-31	1-34	1-30	1-30	1-63	1-63
CWHR classes 4-5 with canopy closure between 40 percent–50 percent	1-30	1-30	1-30	1-30	1-63	1-63
Brush-shrubs >35 percent slope	1-16	1-16	1-16	1-16	1-16	1-16
Brush-shrubs <35 percent slope	1-32	1-32	1-32	1-32	1-32	1-32
Slopes >35 percent	1-30	1-30	1-30	1-30	1-30	1-30
Within 500 feet of a road	All mech	All mech	All mech	All mech	All mech	All mech
DEFAULT for untreated lands	1-32	1-34	1-30	1-32	1-63	1-63

Overview of Scheduling Model Process

Once the allocation maps are completed for each alternative, analysis areas are developed based on:

1. Vegetative types;
2. Management areas or zones which define where activities are permitted, modified, or restricted;
3. Constraints and/or desired conditions that control or affect activities; and
4. Other terrain or management designations where the same activity under the same prescription can be expected to produce significantly different output or where the full range of biologically possible management actions may not be appropriate.

Acres in each unique analysis area are assumed to respond in the same way to management activities and produce the same outputs and effects regardless of their location on the forest. This process allows the users to formulate and re-formulate alternative sets of management goals and desired resource conditions by creating new analysis areas, new management objective, and new standards and guidelines. Depending on alternative, from 1,400 to more than 2,000 unique analysis areas were generated.

All the alternatives have several management areas where different management directions in the form of land allocations, objectives or desired conditions, and standards and guidelines apply. In addition, for some of the alternatives, management direction includes prioritization of treatments depending on spatial patterns, existing conditions of wildlife habitat, vegetation, fuel hazard, or fire risk. When conflicts occur, allocations override standards and guidelines, which override objectives, which override priorities. Documentation of the GIS data used for the FEIS is found in the project file.

Forest inventory data are then linked to each strata type. The Region 5 Forest Service Forest Inventory and Analysis (FIA) inventories and databases provided sampling data to describe the various map strata. Data associated with a stratum type includes a tree list of species, dbh, height, live-crown ratio, tree sampling weight, etc. and plot location information. These data are the input used in the GAMMA forest vegetation simulator based on coefficients from the Forest Vegetation Simulator (FVS) model. The growth simulator grows the tree portion of FIA plots and applies various management treatments and a disturbance agent (fire, insects, disease, etc.) to these stands and calculates the effects on growth over time. Data output from the simulator includes tables that show how various attributes of the forest change over time based on growth, treatment, and disturbance. Also these data allow classification of the vegetation into classes such as wildlife habitat relationship categories. Many variables are tracked over time by prescription. Information on regeneration success in plantations (summarized in the Silvicultural Accomplishment Report), estimates of insect and disease activities based on change detection, and analysis of the past 25 years of fire history were used to develop the mortality model used in GAMMA and SPECTRUM.

A realistic vegetation simulation model is essential to predicting change in forest condition and assessing impacts of vegetation manipulation. For this planning effort, we used the GAMMA model developed by Wilson (1999), which is a variation of the Forest Service FVS model. GAMMA uses the FVS growth coefficients but manages the data and prescription scripts or key words differently. The GAMMA simulator permits the user to track inventory, growth, mortality, and removal through time. GAMMA options permit the tracking of derived variables such as habitat components, snags, dead and down wood, etc. GAMMA is an individual tree growth and yield model for the Sierra Nevada. The simulator processes stands of trees plot by plot and then aggregates the results as strata averages at the end of each time period. Prescription "scripts" are developed to simulate management through time. These strata-prescription regimes are written to simulate how vegetation manipulation could occur in these types. The simulator uses FIA plot data as input. The tree lists from inventory plots for each vegetation strata are run separately to develop yield streams particular to each vegetation strata. The results are stored in a relational database that is used by the SPECTRUM model. The GAMMA model defines the range of feasible activities that can be considered as management options throughout the planning process.

SPECTRUM Analysis

The linear programming (LP) model SPECTRUM (formerly known as FORPLAN) developed by K. Norman Johnson was selected as the primary analysis tool for national-forest-scale planning. SPECTRUM is used to analyze different management alternatives. It optimizes the attainment of desired future conditions (DFCs) by scheduling activities that move existing conditions toward the desired ones. This schedule is subject to meeting standards and guidelines, to imposed disturbance regimes, and to projected outputs and effects of time as a result of implementing the alternative. The major strength of this model is its ability to model the effects of constraints on outputs over time. The major limitations of this model, as related to this project, are that activities and projected effects are not spatially explicit (activities are assigned to analysis areas rather than specific places in the Monument) and that inputs and outputs are deterministic (do not consider variability and uncertainty in input data).

SPECTRUM was used to determine the most cost effective schedule of treatments that would produce desirable outputs and effects given the objectives (DFCs) and the constraints (standards and guidelines) of each alternative. A SPECTRUM analysis was made for each alternative. All the information needed for SPECTRUM analysis was entered into a set of data files. The SPECTRUM matrix generator then created a matrix of rows and columns that is then solved by linear programming software. A report is generated that is used to display modeled estimates of antivity and change for each alternative. Reports are generated for the entire planning area as well as for individual attributes and management prescriptions.

The range of permissive prescriptions is used in SPECTRUM to limit the kind of activities that could occur within a specific land allocation within a specific alternative. Constraints, in the form of modeled proxies for standards and guidelines, are parameters added to the linear programming model that limit the means of optimizing goals stated in the form of objective functions. In many cases these constraints are embedded the prescriptions, such as limits on diameters of trees that can be removed.

A number of different output reports can be generated from the SPECTRUM system. The major portion of the report contains information on scheduling of activities, the amount of outputs and changes in vegetation and attributes as a result of these activities, and financial costs and values produced. Examples of items reported include: acres of mortality by different fire severity classes, acres of the forest in various CWHR types, costs of different management activities, and the inventory, growth/mortality, and changes in various stand attributes such as snags, dead and down material, and large trees.

Outputs, Effects, and Products Generated by the Analysis Over the Planning Horizon

The following standard output reports from SPECTRUM were generated for consideration as background information during the analysis. These reports are included in the project record.

1. SWTB—MBF Scribner, for all commercial conifers >= 9.9” dbh to 6-inch top (that would exclude species like juniper, bristlecone pine, etc.). Net volume (minus defect) is determined using Levitan average defect equations.
2. BIOM–BDTs—calculate total stem cubic feet volume for all live trees, convert to bone dry tons [BDTs]
3. D&DW—cubic feet of all dead material (standing and down) > 3.0 inches; initialize from inventory, level based on interaction of decay rate and new mortality—reduced during treatment or fire by specified percentage...For trees with dbh > 3.0 inches, for larger material calculate a cone segment from lg diam = dbh to sm diam = 10 inches, assuming taper is 1 inch in 8 feet... this will be approximate wood volume (not including bark).. then convert to BDT...
4. %COV—Percent canopy cover (pcNetAvg) using regression equations to calibrate canopy cover estimations to values similar to what would be derived from photo interpreted crown cover and consistent with calibrations of map and field work. For more details on this methodology, see Appendix B of the 2004 Sierra Nevada Forest Plan Amendment SEIS.
5. SNAG—number of standing snags > 15 inches dbh and minimum height of 20 feet; initial levels from inventories, level at any period is balance of snag fall predicted by exponential decay model (with half-life specified by species and/or dbh classes) and new mortality.
6. HDWD—number of hardwood trees > 15 inches dbh
7. LGTR—number of large trees—minimum dbh is 30 inches westside, 21inches in alpine types (A and L)
8. VLTR—number of very large trees—minimum dbh is 50 inches westside, 32 inches alpine
9. CWHR—15 categories in three age-dependent tables. Uses pcNetAvg for percent cover. Measured in acres.