Appendix B

Modeling and Analyses

Planning Situation

The National Forest Management Act of 1976 (NFMA) directs each National Forest to prepare a comprehensive land and resource management plan. The Tongass National Forest produced its first comprehensive Plan in April 1979. The NFMA also directs that these management plans be revised at least every fifteen years. The Tongass began the Revision process in 1987, published a Draft Environmental Impact Statement (DEIS) in June 1990, and prepared the Supplement to the DEIS (SDEIS) as a result of the November 1990 Tongass Timber Reform Act (TTRA). The SDEIS was published in August 1991 and the Revised SDEIS (RSDEIS) was published in April 1996. This is the Final Environmental Impact Statement (FEIS) for the Tongass National Forest.

The purpose of this appendix is to present a discussion of the analytical processes and models used in the planning process. Due to the magnitude (17 million acres) and complexity (25 land use designations proposed) of the planning process, a number of analytical models are used. This discussion includes basic assumptions, modeling components and inputs, rules, methods, and constraints. The information supplements the broader, less technical descriptions included in the body of Chapter 2 and 3 of the FEIS. Additional information and documents used in the analysis process are contained in the planning record. The planning record in its entirety is incorporated here by reference.

Analysis-related Changes Between the 1996 Revised Supplement and the FEIS

As the assessment, development, and analysis of geographic information is a continuous process, aspects and attributes of existing databases are continually changing. These improvements and additions to the databases often have direct results on models, model results, and the assumptions used within the models themselves. The six months between the RSDEIS and FEIS saw a number of changes to resources inventories, coefficient development , and model assumptions, all of which played a role in the recalculation of alternative outputs. These changes are:

Recalculation of the Tentatively Suitable Land Base - The removal of the McGilvery soil filter and the correction of Ketchikan Area data resulted in a forest-wide increase of 100,000 acres to the tentatively suitable land base.

Recalculation of Culmination of Mean Annual Increment (CMAI) - Due to enhancements made to SEAPROG (the Tongass Growth and Yield Simulator), changes in second yield tables resulted in increases to some of the minimum rotation ages.

Changes to Visual Absorption Capability (VAC) model - Utilization of improved digital elevation models (DEMs) following a forest-wide review of the VAC GIS coverage resulted in a re-vamped scenery management inventory.

Land Transfers - During the summer of 1996 approximately 55,000 acres was transferred to private, State, or Native Corporation ownership. Of these, 22,000 acres were classified as tentatively suitable.

Modeling Implementation Reduction Factors (MIRF) - These factors, used to adjust model results to account for missing and known data inaccuracies, have been re-calculated for each alternative. The MIRF for the Chatham Area has been increased substantially due to the discovered shortcomings in identifying high-hazard soils through the use of the soils inventory and slope map.

Inventory Data and Information Collection

There are two general categories of data used in Tongass planning; spatial and tabular. A spatial data base is, for all practical purposes, a map or electronic representation of a map (often referred to as a GIS "coverage"). Tabular data is something like economic information or timber growth and yield tables. These attributes cannot be mapped unless linked to some spatially-known feature from a GIS coverage. The primary changes and updates to the inventory, data, and modeling include:

Inventory and Data

- Timber harvest map was updated to reflect timber harvested through June 1995.
- A new coverage was created to better estimate timber volumes. This cover was statistically derived using the timber type and common land unit (CLU) covers. For modeling and yield estimation purposes the old-growth strata is now broken into three rather than four groups.
- Inventoried roadless boundaries were changed to reflect new road construction and timber harvest that occurred through June 1995.
- New roads were added to the roads data base.
- Changes in land ownership due to conveyances to the State and Native Corporations as of August 1995 have been addressed in the data base.
- Improvements and updates have been made to most other resource databases, including tentatively suitable lands, logging operability, recreation places, visuals, and hunting data.
- Development of a new visual absorption capability (VAC) inventory.

Modeling Changes

- Analysis Area stratification (revised)
- Identification and incorporation of State and Native Encumbrances
- Further break-down and analysis of timber age-class groupings
- Updated dispersion coefficients
- Recalculation of all timber values
- Recalculation of all cost information
- Use of price trends on timber values (pond log)
- Creation of redefined management intensity regimes
- Incorporation of redefined watershed constraints
- Deferment of State and Native Corporation overselected lands from scheduled harvest
- Changes to model implementation reduction factors (MIRFs)

Overview. The inventory step of the planning process consists of the collection, development, and documentation of data to address the public issues, management concerns and resource opportunities, and planning criteria identified in Planning steps 1 and 2. Two basic types of information are needed to facilitate the analysis and development of alternatives. The first consists of information related to the classification of land into categories with unique properties. This classification can be based on any attribute significant to planning issues. This type of information is tied directly to the map base. In the case of the Tongass National Forest, this map base is its GIS data base.

The second type of information is not directly tied to a map base, but has more to do with the estimation of how land will respond to certain management activities. This type of information comes from many sources: Regional procedural handbooks, research studies, available literature, etc. The most up-to-date and verifiable information available was used for the FEIS.

Database Development. Starting in 1987, a computerized GIS was developed for the Tongass National Forest Plan Revision. A GIS links natural resource data with spatial (mapped) information. This linkage enables valuable spatial analysis and rapid display of resource information for forest planning.

Automating resource information for the Tongass' 17 million acres has taken several years. The data base is among the largest natural resource GIS data bases in the United States. To capture the information for rapid retrieval in tabular form, data is stored in 893,988 points. Spatially, each point represents about 20 acres. Most inventories are updated annually to reflect current conditions; verification of existing information is an ongoing effort. One aspect of the Tongass data base is the computer platforms on which the GIS data resides and where the majority of the analyses take place. The TLMP team as well as each of the three Administrative Areas has workstation hardware and the latest versions of Arc/Info and Oracle software (these programs are widely used for map making and data queries). This new system has enabled planners to develop better maps (i.e., depicting information in an easier to read form) and conduct more sophisticated analysis faster.

Major Uses of Inventory Data

Analysis Areas. The basic resource information and boundaries contained in the data layers of the mapping system are used to define the areas which are analyzed in the planning process. Analysis areas represent the aggregation of many individual resource polygons that have the same characteristics and similar responses to management activities. A linear programming model (FORPLAN) is then used to assign management prescriptions and schedule activities to these analysis areas (AAs). The analysis area formulation process is described, in detail, in the Forest Planning Model section of this appendix.

Production coefficients. Inventory data were combined with analytical models to develop production values (outputs) expected from various land units. An example of a coefficient may be the amount of sediment produced from one acre of ground following a harvest activity. This coefficient may vary by slope, harvest method, and soil type. There are many coefficients in the Tongass models used to estimate output and activity levels. The following list shows all outputs and activities used in the Tongass models and lists the source, dependent variables, and any assumptions used in its determination.

Model Activities

Sale Preparation and Administration
Information Sources: Region 10 Budget Office, 1992 Cost estimates based on a 470 mmbf/yr. program.

Occurs With or Varies By: Roaded condition, logging operability, and regulation class.

Assumptions: Costs in unroaded areas are 30% higher than preparation costs in roaded areas. If isolated operability and roaded then costs will be similar to unroaded costs. Harvest preparation costs on regulation class 3 are 35% greater than regulation class 1. This approximates the costs of administering an uneven-aged management sale.

Regeneration Certification
Information Source: Region 10 Budget Office, 6-year average certification costs, 1985-1990. Tongass regeneration certification results.

Occurs With or Varies By: Acres harvested.

Assumptions: Occurs for every acre harvested and the cost is incurred at time of harvest. This activity usually takes place from three to five years after harvest but since modeling is done on a decadal basis the cost is incurred at time of harvest. It also is assumed that all stands will be certified as regenerated by year five. This is based on the fact that fewer than 100 acres per year (on average) have required planting or other regeneration enhancement in order for certification.

Precommercial Thinning
Information Source: Region 10 Budget Office, 4-year average precommerical thinning costs, 1988-1991. Based on an approximately 6000-acre per year precommercial thinning program.

Occurs With or Varies By: Acres receiving a timber prescription permitting this activity.

Assumptions: Applied in the model at age 20 although, in reality, it is often applied between the ages of 12 and 30 years. Constrained at no more than 6,300 acres per year for estimated budgetary and personnel limitations.

Logging Costs
Information Source: Estimated using procedures in FSH 2409.22 -- Timber Appraisal Handbook.

Occurs With or Varies By: Regulation class, volume class, logging operability, administrative area, productivity group, stand age, and thinned or unthinned.

Assumptions: These costs include all temporary roads, felling, bucking, skidding and landing construction. Logging costs increase as regulation class becomes more restrictive. Due primarily to decreasing clearcut unit size and a greater number of system set-ups required to achieve similar volumes. The size of the logs influence logging costs. Volume class, productivity group, stand age, and the use of precommercial thinning is used to estimate the average log size and volume per acre for each unit. Typically, larger logs result in less logging cost per 1000 board feet. The logging operability classification of the area heavily influences the logging costs due primarily to the different harvest systems required. Helicopter logging is used in isolated stands while normal operable lands can utilize standard cable logging systems (although a proportion of normal operability does include a small helicopter component). The zone data required by the appraisal system is found by using an average strata characteristic by Administrative Area.

Road Construction, Maintenance, and Reconstruction
Information Source: Region 10 Engineering Office, 10-year average of costs, 1981-1990. Extent of Roading based on total projected road miles and total suitable land base. Costs required for regulation class 3 lands derived from Prince of Wales Island study for road from Thorne Bay to Coffman Cove (RATZ II).

Occurs With or Varies By: Regulation class, geographical location, current road development, and whether the harvest is existing old growth or a second growth stand.

Assumptions: All harvest requires some road construction and reconstruction. If the area is classified as roaded, then the majority of Roading activity is reconstruction. Otherwise, road construction is the primary activity. The amount of road construction or reconstruction required depends on the geographic location of the harvest area. Each value comparison unit (VCU) has a distinct roading requirement coefficient. This coefficient is in the terms of miles of roads required to access 1,000 acres of timber land. The average for the Tongass is approximately seven miles of road per 1,000 acres (this does not include temporary roads). Reconstruction is the only activity once timber harvest is comprised solely of regenerated timber stands. Road maintenance occurs annually on all roads that are anticipated to be used frequently. Roads used to access stands managed under regulation class 1 and 2 intensities are maintained.

Log Transfer Facilities
Information Source: The forest GIS coverage of existing and proposed LTFs. Costs and construction levels are based on a document prepared by the Stikine Area road planner in 1990.

Occurs With or Varies By: Acres harvested.

Assumptions: Each acre is assigned a proportion of the Area's total LTF cost potential. The cost is incurred at time of harvest. The LTF costs associated with the harvest of regenerated stands is one-half that of existing OG harvest. This assumes LTF reconstruction only.

Timber Hauling
Information Source: Costs and haul distances are based on a document prepared by the Stikine Area road planner in 1990.

Occurs With or Varies By: Value Comparison Unit (VCU).

Assumptions: Hauling cost includes all anticipated modes of transport likely used to transport logs from the landing to the mill. This may include truck, barge, and/or log raft. Both the sawlog and utility component of harvest incur this cost.

Outputs

Sawtimber (board feet and cubic feet)
Information Source: Economics derived from the Haynes and Brooks stumpage price projections and the Region 10 Appraisal Handbook. Merchantable volume of existing stands is derived from the 1980s timber inventories. Volume of regenerated stands is obtained from the growth and yield simulator, SEAPROG.

Occurs With or Varies By: At harvest, the volume of merchantable timber produced generates a per mbf revenue that varies based Administrative Area and volume class. Administrative Area effects this revenue due to the information from the Appraisal Handbook.

Assumptions: For existing stands, volume class provides estimates of piece size (diameter, etc.). For regenerated stands, age and productivity group (site index) is used to determine piece size. All revenues from timber are weighted to include the volume classified as utility. It is assumed that existing old growth volumes are constant (i.e., through time, growth equals mortality).

Utility Volume (board feet and cubic feet)
Information Source: Economics derived from the Haynes and Brooks stumpage price projections and the Region 10 Appraisal Handbook. Merchantable volume of existing stands is derived from the 1980s timber inventories. Volume of regenerated stands is obtained from the growth and yield simulator, SEAPROG.

Occurs With or Varies By: At harvest, the volume of merchantable timber produced generates a per mbf revenue that varies based Administrative area and volume class. Administrative Area effects this revenue due to the information from the Appraisal Handbook.

Assumptions: For existing stands, volume class provides estimates of piece size (diameter, etc.). For regenerated stands, age and productivity group (site index) is used to determine piece size. All revenues from timber are weighted to include the volume classified as utility. The utility volume from regenerated stands is only about five percent whereas the utility component of existing old growth stands averages 18 percent. This difference results from the mixed diameter distribution of old growth stands and the impact of defect to potential sawlogs.

Dispersion (impacted acres)
Information Source: The impacted acres output is used to model adjacency and visual constraints.

Occurs With or Varies By: Whenever an acre is harvested, that acre is considered impacted. The length of time that it remains in this state is determined by the level of timber management intensity in which it is managed.

Assumptions: The visual constraints are composed of an aggregation of clearcut size, adjacency, and maximum disturbance rules. The viewshed is assumed to be a VCU. The level of impact permitted by VCU is based on land use designation (LUD) and the visual resource inventories of distance zone, visual absorption capability, and visual quality objectives. When calculating total visual disturbance, the total viewshed is considered. This area includes all land within the view, including forested land, rock and ice, muskeg, and beach. Since, in FORPLAN, only suitable land is modeled, some adjustments to the visual constraints had to be made in order to properly account for visual disturbance. To do this, percent visual disturbance is based on the number of acres considered impacted in each VCU as compared to the total acres suitable for timber harvest in that VCU. As a proxy for modeling visual disturbance, this method seems to work quite well. The results were tested on each Administrative Area by comparing what the modeled timber schedule and what the area planners and landscape architects felt was appropriate given the visual quality objectives of the area. These field and map exercises resulted in a few adjustments to this process and the derivation of these constraints from the LUD standards and guidelines. The process for determining the allowable disturbance factors for each VCU is described in depth later in this appendix.

Alternative Development and Analysis. Public issues, resource opportunities, and management concerns were the major elements used to reassess the management situation and to identify what might need to change in the current plan. The need to reassess led to formulations of alternative themes to respond to the analysis of the management situation and public comment. In this FEIS there are ten alternatives. Each alternative represents a particular theme; from an emphasis on activities associated with non-development (Alternative 1) to one of maximum commodity development (Alternative 7).

All of the analysis and accounting for activities unrelated to timber harvest are taken care of within the Tongass GIS database. Ninety-five percent of the analytical processing concerns timber harvest and the effect of timber harvest on other resource outputs.

"Decision trees" (in the planning record) were developed such that the GIS could identify what land use designations would be best suited for specific areas on the Tongass in a way that would be most responsive to the theme of each alternative. Themes were generated to respond to the identified public issues. Except for Alternative 9, the Current Forest Plan and “No Action” alternative, land use designations for each alternative were assigned based on the "decision trees." The use of inventory data allows accurate reflection of the land base and provides the basis for scheduling activities and outputs. The forest’s data base was used to identify those areas in need of special consideration (e.g., high-hazard soils) as alternatives were being developed. This process is discussed further in the Formulation of Alternatives section of this appendix.

Implementation and Monitoring. The inventory data will aid in the implementation of site specific projects identified in the forest-wide plan. Also, the inventory data will continue to be updated as new information is obtained through monitoring. Data obtained from the evaluation of site-specific activities will be incorporated into the data base for future estimates and planning analysis. Changes in the data and analysis procedures and results and findings from monitoring will be reported annually.

Geographical Information System Data Layers. Many different physical, biological, and administrative layers of resource related information are contained in polygonal form in the GIS (4 gigabytes). These layers formed the basis for the resource data used for programmatic analysis. Some of the commonly used GIS coverages are:

1. Cultural Sites
2. Aspect
3. Slope
4. Elevation
5. Soils
6. Each Long Term Contract Sale Boundary
7. Existing Eagle Nests buffered 330 feet
8. The 141 Management Areas as modified by TTRA
9. Lakes
10. Land Status
11. Minerals (known and inferred)
12. Primary Base Series Shoreline
13. Each of the 228 USGS Quadrangles
14. Existing Recreation Places
15. Existing Recreation Sites
16. Roadless Areas
17. Existing Roads
18. Potential arterial road and transmission corridors
19. Cliffs
20. Special Uses
21. Streams by process group and stream class

22. Subsistence Ever Hunted Deer
23. Timber type map
24. Administrative sites
25. Structures
26. Tour ship and ferry routes
27. Trails
28. 894 Value Comparison Units (VCUs)
29. Visual Resource inventory (VAC, distance zone)
30. Forest watersheds
31. Wildlife Habitat
32. Research Natural Areas
33. Special Interest Areas
34. Estuaries
35. Riparian
36. Managed Timber Stands
37. Tentatively Suitable Forest Lands
38. Eligible Wild, Scenic, and Recreation Rivers
39. Wildlife Analysis Areas
40. Forest Habitat Integrity Program (FHIP) watersheds
41. Cave and Karst Vulnerability
42. Biogeographical Provinces

For a detailed description of the attributes available on these data layers, consult the Resources Information Management Data Dictionary, USFS, Region 10, August 1995.

Coefficient Development and Estimation of Effects. The GIS enables identification and stratification of land into logical groupings. The response of these groups to management activities was determined from a wide variety of existing data. All coefficients and assumptions made in the modeling process have been developed from the following information sources.

1. Codes and definitions for many of the activities, outputs, and effects come directly from the National Activity Structure Handbook (FSH 1309.16).

2. Timber values were determined using timber appraisal summaries for Southeast Alaska. The timber values where calculated using the quarterly Cut and Sold Reports for the Tongass, 1979-91.

3. The costs relating to timber harvest have been calculated using actual cost expenditure reports.

4. Old Growth timber yields are based on the timber type map, standing volume re-inventory, and the common land unit (CLU) inventory coverage.

5. Yields for regenerated second growth timber stands were derived from permanent study plots and the SEAPROG yield table generation program.

6. Average percent utility volume and defect by Administrative Area was determined from the Timber Sale Statement of Accounts reports.

7. Recreation values where calculated based in part on a Travel Cost study conducted by Data Decisions Group, Inc. and the Southeast Alaska Marketing Council, 1988.

8. The costs of providing and maintaining recreation opportunities on the Forest have been calculated using actual Forest Service cost information. Depending on the activity, costs from as far back as 1979 were used to determine average cost figures.

9. Recreation capacity figures were estimated by each administrative area using the procedures outlined in the Recreation Opportunity Spectrum Users Guide (ROS) (Forest Service Handbook (FSH) 2309.13).

10. Recreation use information and future human population estimates were used to calculate future recreation demand by ROS.

11. Alaska Department of Labor and the Forest Service IMPLAN Model were used to estimate future regional employment and income by resource.

12. Road construction and reconstruction costs are base on a three-year average (1984-87) of total road expenditures. Expenditures were re-calculated for 1991 and 1995.

13. Road densities are based on harvest-transportation paper plans for each TLMP Management Area (MA) containing tentatively suitable forest lands.

14. The cost of construction and reconstruction of Log Transfer Facilities is based on individual facility estimates and location.

15. Fish production models were used to estimate Forest-wide fish production. Production from fish enhancement projects is based on historic production data of similar projects.

16. Value of the commercial fish resource is based on ADF&G's Alaska Catch and Commercial Production Fisheries Statistics Leaflets (Nos. 29-38).

17. Benefits derived from wildlife are based on a study entitled Economic Value of Big Game Hunting in Southeast Alaska. Swanson, et al. (1989).

18. Implementation factors used within FORPLAN were obtained through field testing and GIS models.

19. RPA values were used except where Alaska-based study results existed for a particular resource or activity.

The Forest Planning Model (FORPLAN)

FORPLAN is the primary modeling tool used to ensure that land allocations and output schedules for alternatives are realistic and meet standards and guidelines in a cost-efficient manner. FORPLAN also used to conduct "benchmark" analysis of forest outputs. A benchmark is a set of values that indicate a maximum (or minimum) level of production capable under certain, often limited, constraints. Benchmark reports are available in the Analysis of the Management Situation (AMS). In addition to being used to formulate alternatives and benchmarks, FORPLAN is used to perform detailed accounting and generate summary reports of information needed to construct the display tables in the Final Plan.

FORPLAN is used to translate forest land, yield, and constraint information into a linear programming model. This model is read into a program designed to solve and optimize series of simultaneous mathematical equations. The Tongass uses C-WHIZ on a microcomputer for solving these models. The solution obtained from the optimization program is then read back into FORPLAN for interpretation and user-specified reporting.

Results from the modeling process are only approximations of what to expect when any given alternative is implemented. The objective of modeling is to aid planners in estimating likely future consequences of management actions (alternatives). A choice between alternatives can be made even though the model may lack precision in describing specific attributes of a given alternative. FORPLAN, very simply, does two things: 1) creates a linear programming (LP) model, and 2) puts the results of the model solution into a more readable form (i.e., interprets the linear programming results). FORPLAN enables planners to create an incredibly complex linear model through fairly simplistic data entries.

The Land Management Planning and Systems Analysis section of the US Forest Service (based in Fort Collins, Colorado) has developed the next generation of FORPLAN-type analysis tools. This new program is called SPECTRUM and is currently undergoing field tests. Although the Tongass has tested the beta-release of this program and Tongass models are currently being used to evaluate its robustness, we have used FORPLAN for the FEIS. Once SPECTRUM has been fully tested, and result-mapping features have been added, the Tongass will begin utilizing SPECTRUM for all long-term scheduling analysis.

An in-depth technical discussion of linear programming can be found in the 1991 SDEIS.

The Tongass FORPLAN models. The FORPLAN program has many internal limitations and parameters. These limitations must be adhered to when developing a model. For instance, the maximum number of constraints any one model can have is about 6,000 (this varies depending on constraint type). Initial size estimates of the Tongass model, given the desired level of detail, made it clear that three models would be needed; one model for each of the three Administrative Areas. The individual FORPLAN models were then constructed using information designed specifically for each Administrative Area.

Once the models were formulated, a number of tests were made to check for reasonableness and to make calibrations to those matrix coefficients whose development was not exactly straightforward. By this we are primarily referring to the visual constraints applied to each alternative. Since the standards by which the visual resource is measured are not easily put into a mathematical formulation, it is important that model outputs satisfy the demands (and intent) of Tongass landscape architects (and the Standards and Guidelines). This was done through a series of mapping exercises done to determine total feasible harvest acres on selected watersheds. This process led to a visual constraint that met the Standard and Guidelines of each alternative.

Management activities modeled in FORPLAN were determined by the interdisciplinary team (ID team). This pre-FORPLAN analysis included identifying:

1. The activities and outputs that would be modeled in FORPLAN. This is all activities and outputs directed associated with the harvest of timber.

2. The kinds of land to which each activity could be applied and the expected response.

3. The rules to which the activities must adhere. These rules are the Standards and Guidelines as proposed in the Forest Plan. Rules that would influence the amount, timing, and intensity of timber harvest activities were included in the FORPLAN models.

4. The costs and revenues resulting from the application of each activity to a specific type of land.

Since the Tongass models are primarily used to model timber harvest schedules, this process identified all attributes (land, activities, outputs, constraints) of the proposed alternatives that had some impact on or are influenced by timber harvest activities.

Developing the FORPLAN Model

Capability Areas. Capability areas are the smallest units of land (or water) for which data are collected in forest planning. They are discrete and recognizable units classified primarily according to physical (soil), biological (vegetation), and issue (wilderness status) factors. All land within a capability area is assumed to be homogeneous in its ability to produce resource outputs and in its production limitations.

The Tongass National Forest has 893,979 capability areas. Each capability area represents approximately 20 acres. A dot grid was developed by placing a point in the center of each 20 acre cell. The resource specialists then decided what information was needed for each capability area in order to assess resource opportunities and public issues. This information was collected and entered into the GIS. The point grid was then overlaid with the map information contained in the GIS. The map information under each point was then assigned as an attribute of the point. The map information from more than 50 different physical, biological, or administrative overlays was assigned to each point. An additional 60 attributes are added to each point as derived coverages (i.e., covers derived from processes involving multiple coverages and models). These attributes, as determined for each capability area, are stored in computer files to form the TLMP Revision data base. The Tongass uses the ORACLE Database Management system in conjunction with the ARC/INFO Geographic Information System (GIS). Once entered into the system, information on capability areas was retrieved, sorted, aggregated, and analyzed.

Stratification of the Land Base. A FORPLAN model has four main components: 1) the land base, 2) management prescriptions, 3) activities and outputs, and 4) constraints. The last three elements greatly influence how the first (the land base) will be defined. An additional element to any LP model is the objective function. The Tongass models are designed to analyze the activities and outputs associated with timber harvest scheduling; therefore the land base is defined only by those characteristics significant to the timber resource. Other resources are dealt with through the LUD allocation process and model constraints. Selecting these characteristics begins by scrutinizing what is known and what is needed. The management prescriptions applied to the forest differ mostly by rotation age and dispersion amount. The activities (costs) associated with timber harvesting are well documented as are the outputs (benefits) obtained from the wood fiber. The constraints differ by alternative but often refer to a particular timber classification, specific geographic area, activity or output volumes, and management allocation.

Identification of Analysis Areas. The 893,979 capability areas, could not be used as such in FORPLAN. Use of such a large number of land units would be cumbersome, expensive, and greatly exceed the parameters in FORPLAN and the optimization software. Analysis areas were created to handle this problem. An analysis area is a operational aggregation of capability areas that responds in a uniform way to management prescriptions.

Choosing Analysis Area Identifiers. Many forest attributes were analyzed for incorporation into the FORPLAN models. Since we are developing a timber scheduling model, we wanted to select level identifiers that provided the best description and categorization of our timber base. Of the 12 attributes tested, five were finally selected for input into the FORPLAN models. These five attributes are: 1) Value Comparison Units, 2) logging operability, 3) Productivity group, 4) roaded/unroaded classification, and 5) timber strata/volume class. A summary of each attribute and why it was selected follows.

Value Comparison Unit (VCU). In the current Plan, there are 926 unique VCUs. Each of the VCUs provide FORPLAN with a level of spatiality the other identifiers cannot. In previous FORPLAN models, the main spatial identifier was Management Area (MA). Moving to VCU as the spatial identifier increased the resolution of mapping by six times. This change was driven by the desire to improve the modeling of scenery and to provide TLMP team with the ability to map FORPLAN solutions at a more detailed level. In the 1979 Tongass Plan there were slightly fewer VCUs delineated on the Forest. The passage of TTRA and several land acquisitions resulted in some VCUs being split and/or added.

There are unique cost and constraint values attributed to each VCU and VCU aggregates. These include all dispersion and timber harvest constraints (see Formulation of Alternatives), log hauling cost, construction of log transfer facilities, road construction needs, and timber sale information.

Timber Harvest Operability. Operability defines the type of timber harvest methods necessary to move trees from stump to landing. There are three different classes of operability, normal (tractor and highlead cable), difficult (long span skyline), and isolated (helicopter). Harvest method is a very important factor when determining the profitability of timber harvest. Lands identified as difficult and isolated are rarely economically viable. Operability also correlates quite strongly with elevation and general accessibility.

Productivity Groups. This land classification is base on the site productivity as categorized in the Soil Mapping Unit (SMU) data base. There are three basic groups: 1, 2, and 3. The group indicates the regeneration potential for future timber stands. Group 1 is the highest productivity class with a minimum site index (SI) of 75. Group 2 are lands less than SI of 75. Group 3 is all lands in the following wetland soil types; Karheen, Kaikli, Maybeso, Kitkum, or lithic Cryosaprist. Group 3 has a SI of 40 (Chatham) to 50 (Ketchikan).

Roaded Classification. This identifier specifies whether an area is presently roaded or unroaded. The road/roadless condition of an area greatly influences the cost of harvesting the timber. Unroaded areas require road construction while those presently roaded require only road maintenance or road reconstruction. This identifier also enables better tracking of certain recreational opportunities and wildlife habitat.

Volume Class/Strata. This attribute was used as an identifier due to its relevance to many forest management considerations. Wildlife habitat and most recreational settings correlate with the vegetation types described by this feature. As vegetative cover changes (through growth and harvest) so do most of the activities and outputs associated with that area. There are four strata used as FORPLAN identifier: second growth stands (average age 23 years), low-volume old growth, medium-volume old growth, and high-volume old growth. The strata used for this identifier are obtained from a coverage derived from the timber-type inventory and the common land unit (CLU) coverages. The creation of this cover was in response to the problems occurring when using the timber-type alone to estimate volume.

With the selection of five level identifiers, the next step was to estimate the number of possible analysis area combinations. The maximum number possible is the product of the number of levels in each identifier:

894 VCUs x 3 Operability Classes x 2 road/unroaded x 3 productivity groups x 4 strata =

64,368 Potential Analysis Areas

Of course, all combinations are unlikely to occur so the actual number should be less than this estimate.

Modeling of Tentatively Suitable Forest Lands Only. It should be noted that the FORPLAN models for the Tongass will only analyze land classified as tentatively suitable for timber harvest. This means only those lands considered "suitable" for timber harvest will be entered into the models. Of the approximate 17 million acres of Tongass only 2.4 million are classified as tentatively suitable. The process for determining suitability can be found in Appendix A, "Timber Suitability Classification," of the Forest Plan.

Actual Total Analysis Areas. Once the identifiers were determined, the GIS data base was queried to calculate the actual number of unique analysis areas. This resulted in a forest-wide total of 6,100 unique analysis areas. Summary of these analysis areas showed almost one-fourth less than 100 acres in size. Because of rounding and other mathematical necessities within the FORPLAN model, small values tend to zero-out especially when very large values are in the same model. For this reason, all analysis areas less than 80 acres and within certain guidelines were aggregated into a larger analysis area. This meant that an identifier of the small analysis areas would have to be altered.

Aggregation of Analysis Areas. Analysis showed that the roaded/unroaded identifier had the least overall impact (i.e., minor contribution to uniqueness) and was responsible for the majority of small analysis areas (less than 50 acres).

The aggregation process: the small analysis areas were aggregated into the one that match all other level identifiers when the roaded condition identifier was ignored. If a match could not be found at that point then operability was ignored and a match found based on VCU and volume class (i.e., ignoring the roaded condition and operability identifiers). If still no match could be found then the last identifier to be aggregated was volume class. The need to aggregate over volume class occurred infrequently and only when a VCU had very few acres of suitable forest lands. The VCU identifier was never aggregated because of the spatial benefits provided by this identifier and the importance of this attribute to constraining and reporting. Further work with the analysis areas quickly revealed that Productivity Group could be represented by grouping analysis areas. Since this reduced the number of possible analysis areas by a factor of three it significantly reduced the size of the models. The final number of analysis areas for the Tongass is 4,290. The final FORPLAN level identifiers are shown in Table B-1.

Table B-1
FORPLAN Level Identifiers

Identifier	Possible Attributes
Value Comparison Unit (VCU)	00 through 3950 (Chatham)
	5270 through 8670 (Ketchikan)
	3980 through 5260 (Stikine)
Logging Operability	Tractor/Standard Highlead Cable
	Skyline/Suspension
	Isolated Stands (Helicopter)
Roaded Condition	Roaded
	Unroaded
Volume Class/Strata	Second Growth Stands
	Low Volume Old growth
	Medium Volume Old growth
	High Volume Old growth

Management Prescriptions

A prescription is a group of management practices applied to a specific land area. The planning process concerns the allocation of land to various prescriptions. The range of prescriptions describes the possible activities for a given analysis area. FORPLAN allocates land to prescriptions based on forest constraints, the given management alternative, and the objective function.

Prescriptions were developed by the ID team to represent the full range of possible management activities and outputs. Since the Tongass models are concerned primarily with timber harvest scheduling, only prescriptions related to timber harvest were modeled. The interdisciplinary team quantified the outputs, costs, and benefits that would occur when these timber prescriptions were applied to a given analysis area or land unit. This quantification process produced the output, cost, and benefit coefficients that are used in FORPLAN yield and economic tables. The ID team, during its development of standards and guidelines for all prescriptions, ensured that the specific management requirements set forth in 36 CFR 219.27 would be met in accomplishing the goals and objectives for the Tongass.

FORPLAN prescriptions were developed to allow consideration of a full range of management activities on the analysis areas. A minimum level or no-harvest prescription was created for each analysis area as well as several different harvest options. The only criterion used to eliminate timber options from the models was technical feasibility. For example, tractor logging was not considered on slopes greater than 60 percent. The development of timber options was not limited by economic efficiency. Available timber options were not eliminated from consideration because they produced a negative Present Net Value (PNV) or even a lesser PNV than some other timber option. A full range of timber options with varying levels of economic efficiency was available to the model. The FORPLAN prescriptions analyzed are briefly described below. Additional information about these prescriptions and the prescription development process is included in the FEIS Chapter 2.

FORPLAN Prescriptions Unique to Analysis Areas.

Minimum Level/Maintenance. Applies minimum custodial direction for the timber resource. There is no commercial timber harvest and no production of outputs related to timber harvest. This is the prescription assigned to lands not scheduled for timber harvest

Clearcut without precommercial thinning. Removal of all merchantable commercial trees within a stand in one operation. The regenerated stand receives no subsequent precommercial thinning.

Clearcut with precommercial thinning. Removal of all merchantable commercial trees within a stand in one operation. The regenerated stand receives a subsequent precommercial thin at 15 to 20 years of age.

Small group selection and uneven-aged harvesting. Cutting trees with the objective of producing uneven-aged stands with regeneration of desirable species. Trees are harvested individually or in small groups normally from 0.5 to 5 acres in size. Timber production is not the primary management emphasis in these areas (emphasis is recreation, scenery, fisheries, and/or wildlife).

Log Transfer Facility (LTF) construction. The construction or reconstruction of LTF's designed to permit transfer of harvested logs into saltwater for tow or barge to a mill site.

FORPLAN Constraints

There are two categories of constraints within a FORPLAN linear matrix: implicit and explicit. Implicit constraints are common to all FORPLAN models. For example, the acres allocated to a particular prescription can never exceed the total number of acres in the model. This type of equality constraint exists in every FORPLAN model and are underlying assumptions of linear programming.

Explicit constraints are those constraints added to FORPLAN models by planners. These constraints come in many forms and are applied to mimic the regulations and laws governing NFMA guidelines set forth in the forest plan and on-the-ground operating conditions. An example is the non-declining yield constraint. A constant flow (non-declining yield) of harvested timber volume is Forest Service policy. A constraint is added to the FORPLAN data set that forces all timber harvest volumes to be at least as great as the previous decade's harvest volume. Another example may be a constraint that forces a certain area to be managed specifically for wildlife habitat. There are many explicit constraints in the Tongass models. They vary by land attributes, geographic area, and by management alternative. The explicit constraints used in the FORPLAN models fall into two categories: Timber policy constraints and operational constraints. A detailed discussion of the intent of these constraints follows.

Timber policy constraints. These constraints are included in the FORPLAN models to represent legal or policy requirements of National Forest timber management. The primary requirements regarding timber management incorporated into Tongass FORPLAN models are:

Sustained Yield/Non-declining Flow. The Tongass models have a constraint that ensures harvest flow (in cubic feet) will not decline in any decade over the 160-year planning horizon per national policy. Harvest volumes may increase but all subsequent harvests must be at least as much as the previous decade’s harvest.

Culmination of Mean Annual Increment. The age at which a managed stand is harvested is called the rotation age. Agency policy is that rotation age can be no earlier than the age at which 95% of culmination of mean annual increment (CMAI) occurs. CMAI is the age at which the stand achieves its highest average volume. The FORPLAN models have constraints that allow timber harvest only when a stand has reached 95 percent of this CMAI age. On the Tongass, this translates to a range of rotation ages of about 60 to 170 years. CMAI varies by stand productivity, management prescription, and administrative area and is calculated using merchantible cubic foot volume.

Dispersion and Intensity of Harvest Units. To meet adopted visual quality and watershed objectives, dispersion and adjacency constraints are incorporated into the models. The dispersion limits are taken from proxies developed by Tongass landscape architects for each land use designation. These visual guidelines estimate how much of a viewshed can be "disturbed" at any one time and still meet the adopted visual quality objectives of the area. They also specify length of time before harvest of adjacent units and the maximum size of these harvest units. Modeling these guidelines necessitated the development of what are known as Regulation Classes in the FORPLAN models. The process of determining regulation class is described later in this appendix.

Operational Constraints. These constraints are added to FORPLAN models to ensure that the results fall within certain guidelines and objectives. These may not be legal requirements nor regional guidelines but are included to make sure the model is "well-behaved." The term well-behaved means that FORPLAN results are reviewed for any operationally impossible solutions and constraints are added to deal with these. An example may be the harvest of a 20-acre unit 30 miles from any existing road. The operational constraints used in the Tongass FORPLAN models vary slightly by alternative but are used primarily to control the spatial and volume components of timber management. These constraints are:

Strata Harvest Control Constraints. In order to ensure that the harvest acres included a mix of volume stratum, each model is constrained so that the proportion of the highest volume strata does not exceed the total forest-wide proportion of that stratum. This constraint is adjusted to account for the type of land (volume class mix) available in each alternative. Forest wide, this constraint limits the harvest of the high volume strata acres to less then 48-percent of the total harvest acreage.

Logging Operability Constraints. The forest has three classes of logging operability; normal, difficult, and isolated. In order to ensure that all harvesting does not come from the most economic normal operability areas, constraints were added to disperse harvest to the other classes. These percentages are based on historic averages of operability class timber harvest and occurrence. These constraints vary by alternative due to different LUD applications but, in general, limit harvest from normal operability areas to about 80-percent of total harvest acreage per decade.

Deferment of Overselected Lands. There are over 100,000 acres that have been identified (selected) by the State and Native Corporations for possible ownership. Of these, approximately 20,000 acres are classified as tentatively suitable and suitable for harvest in some or all alternatives. The general practice in dealing with these overselected lands is to defer any harvest until the final selections have been made even though not all the acres will transfer ownership. To account for this acreage deferment, FORPLAN is constrained from harvesting any overselected lands in the first decade of the planning horizon. It is assumed that final land transfers will have been carried out by this time. The number of suitable acres likely to be transferred to non-federal ownership are dealt with in the model implementation factors (discussed later) and permanently removed from the suitable base.

Watershed Entry Constraints. In order to minimize cumulative watershed impacts from harvest operations, constraints are included to restrict the number of acres that can be harvest in a certain time period. In general, these constraints limit total harvest acres in any 30-year period to less than 20-percent of the total watershed landbase. Since the Tongass models use VCU as the primary land attribute, these constraints are entered for each VCU. Some adjustment had to be done to the constraint coefficients in order to address the fact that the 20 percent for 30-year constraints actually applies to sub-VCU watersheds. The spreadsheets used to determine the VCU-specific coefficients are found in the planning record.

Precommercial Thinning Constraint. All alternatives are limited to a maximum precommercial thinning of 6300 acres per year. This is the amount that Region 10 considers feasible given budget and personnel limitations.

Roading Construction Constraint. Historically, for every two million board feet of timber harvested, a mile of road was constructed. During the optimization phase of a FORPLAN run, the same level of harvest can often be achieved with slightly fewer miles of road construction. This is discussed in the Results section of this appendix but has to do with the fact that VCU road coefficients deal only with roads within the VCU group boundaries. Because of this, constraints have been added to all alternatives to match historic road miles per volume harvested ratios. Over time, fewer roads are needed to access the same amount of timberland due to the establishment of the road network. For the first decade of all alternatives the constraint forces at least one mile of road construction for every two million board feet of timber harvested. Decade two requires at least one mile for every three million board feet harvested. These proportions are based on projections made by the Region 10 Engineering office. The need for new road construction decreases as the road network is developed. Although 90 percent of the road network is in place by seventh decade, corresponding with the harvest of most of the available old growth timber, road construction does take place throughout the planning horizon. This constraint deals primarily with the miles of road constructed (does not include temporary roads) and has no built-in assumption pertaining to whether the road is closed or remains open following use. This is a decision that is based on information and preferences beyond the scope of the modeling efforts.

Factors Affecting the Allowable Sale Quantity (ASQ). An ASQ is calculated using Forest, Area, and VCU-wide information. The level of accuracy and spatial specificity of these inputs vary based on the amount of information available and experience in field measurement. The inputs to models and anticipated effects are often estimates and averages of what is likely to be encountered during Plan implementation. Given the variability in these field estimates and the knowledge that reductions to estimated sale quantities are likely due to unforeseen land characteristics, factors have been established to adjust the ASQ estimates to a level more in tune with what is likely to be found during implementation. These factors are referred to as Modeled Implementation Reduction Factors, or MIRF. These factors are included in each model for each alternative. They are applied in order to address the reductions in lands available for timber harvest due to:

- Land selections (transfers to State and Native Corporations)
- Karst/caves (moderate vulnerability)
- Unmapped Class III streams
- Deer Standards and Guides
- Unmapped Bald Eagle/Osprey Nests
- 600-foot landscape linkages
- Goshawk nests
- Murrelet nests (600 feet)
- 600-foot buffer around active wolf dens
- Important mountain goat winter habitat and travel corridors
- Cost efficiency (low vol, difficult operability, isolated operability)
- Unmapped Class I and II stream buffers
- Unproductive Forestland (mapped as productive)
- Unmapped extreme high hazard soils
- Inoperable isolated stands created by Class III stream buffers

There are other factors that may also contribute to differences between ASQ and actual timber sale volume that are not included in the MIRF development. Some of these may include market fluctuations, timber demand, Forest Service budgets, timber planner preferences, and legal challenges.

In order to calculated the MIRFs for each alternative, FORPLAN outputs and on-the-ground sale layout plans were compared. This process identified the key factors resulting in ASQ and implementation differences and the extent of each. The table below shows the acreage reductions due to the factors listed above. These are then interpreted into FORPLAN constraints and/or GIS land adjustments for use in the models.

Table B-2
Acreage Reduction by MIRF Element (in 1000s of acres)

Model Implementation Reduction Factors	Alternative 1	2	3	4	5	6	7	9	10	11
Land Selections		24	18	23	21	21	31	29	18	15
Suitability Classification										
TTRA Stream Buffers		30	22	29	27	27	40	36	23	19
Non-Comm. Forest		25	20	25	23	23	33	32	20	16
Slope/Soil Hazards		145	100	142	135	135	183	174	104	88
Cost Efficiency	75	122	92	120	112	112	192	157	94	73
Standards and Guides										
Riparian Habitat			89	16	15	15			13	108
Karst/Caves - Moderate Vulnerability		26	20	26	23	23	32		21	18
Deer Habitat S&G's			15	47	27	27				
Remaining S&G's (see above)		12	9	12	11	11	16	14	9	8
Total Model Implementation Reduction Factor Acres	**75**	**384**	**384**	**440**	**394**	**394**	**527**	**442**	**301**	**345**

The MIRF acres are then subtracted from total acres initially deemed suitable for timber harvest (i.e., when considering land use designations and standards and guidelines alone). The impact to the land base due to these factors for each alternative is shown, in acres, in Table B-3.

Table B-3
Acres Removed to Account for Implementation Reductions (MIRF)

Alternative	Possible Harvest Acres (thousands of acres)	Acres Removed (thousands of acres)	Suitable Acres Remaining for Timber Harvest
1	75	75	0
2	1,611	384	1,227
3	1,236	384	852
4	1,581	440	1,141
5	1,581	394	1,077
6	1,471	394	1,077
7	2,111	527	1,584
9	1,940	442	1,499
10	1,277	301	977
11	1,095	345	750

The Regulation Class Process

In order to model the components of managing the timber resource, the regulation class concept was developed. These classes group lands that allow similar harvest unit size, visual disturbance, and re-entry times (adjacency). Every Land Use Designation, or LUD (map color), delineates a unique set of standards and guidelines that apply to that area. For instance, in the Timber Production LUD (TM) harvest intensity varies by the inventoried Visual Absorption Capability (VAC). The VAC is a measure of an area's ability to "absorb" ground disturbing activities (i.e., timber harvesting). The amount of timber harvesting also is affected by distance zone (DZ). Distance zone is the proximity of an area to a view-point. Distance zone varies from Foreground (within a 1/4 mile) to Not-Seen which is completely out-of-view from selected viewing points.

Tongass landscape architects developed some general timber harvesting guidelines, or proxies, for various VACs, Visual Quality Objectives (VQO), and LUDs. Although the exact harvest intensity an area receives is determined during the timber sale layout stages, estimates of allowable disturbance were needed in order to facilitate modeling. Each Land Use Designation has a series of adopted VQO and VAC objectives. Associated with these objectives are the estimated allowable disturbance factors. The proxies for each LUD and VQO/VAC setting were grouped by similar harvest method and unit size, cumulative visual disturbance, and height to adjacent stand criteria. Grouping the proxies of similar standards resulted in the creation of four distinct categories. These groups became the four regulation classes used in the FORPLAN modeling. These groups range from no harvest allowed to large clearcutting with minimal visual concerns. The GIS is then used to provide FORPLAN with the regulation class allocations by alternative for each Analysis Area. The following tables summarize the approximate harvest intensity and disturbance factors by LUD, VQO, distance zone, and VAC.

Table B-4
VQO from Scenery Standards and Guidelines

LUD	Foreground	Middle Ground	Background	Not Seen
Scenic Viewshed	Retention	Partial Retention	Partial Retention	Max Modification
Modified Landscape	Partial Retention	Modification	Modification	Max Modification
Timber Production	Modification	Max Modification	Max Modification	Max Modification

Table B-5
Maximum Unit Size based on Visual Absorption Capability (acres)

VQO	Low VAC	Interm. VAC	High VAC
Retention	< 2	5-15	15-30
Partial Retention	5-10	15-40	40-60
Modification	15-40	40-60	80-100
Max Modification	50-75	80-100	80-100

Table B-6
Percent Allowable Visual Disturbance

Land Use Designation	Distance Zone	VQO	Low VAC	Interm VAC	High VAC
Scenic Viewshed	Foreground	R	8	10	10
	Mid. Ground	PR	8	15	20
	Background	PR	20	20	20
	Not Seen	MM	20	20	20
Modified Landscape	Foreground	PR	8	15	20
	Mid. Ground	M	15	20	25
	Background	M	25	25	25
	Not Seen	MM	25	25	25
Timber Production	Foreground	M	15	20	25
	Mid. Ground	MM	50	50	50
	Background	MM	50	50	50
	Not Seen	MM	50	50	50

The above percentages are rough estimates intended to depict the possible level of disturbance one may encounter when viewing these areas. For modeling purposes, these visual disturbance zones were aggregated into groups with similar standards and economic response (e.g., logging costs). Since the percent of visual disturbance includes all visible terrain, tests had to be conducted to "recalculate" disturbance thresholds since only suitable lands are being modeled. These tests involve a series of iterative mapping exercises where varying levels disturbance factors were applied to the separate groups. The feasibility of the harvest level was then compared to the standards and guidelines and reviewed by Tongass National Forest landscape architects. This work was conducted under the following assumptions;

1. the items in the database (e.g., distance zone, visual absorption capability) are correct,
2. the standards and guidelines are modeled to their limits, and
3. the "viewshed" was a large area (e.g., as viewed from a boat).

This work did indicate a need to further review the scenery components of the database but in general the process worked well in terms of modeling the intent of the standards and guidelines. This work resulted in three distinct regulation classes that permit timber harvest activities. The final allocation of regulation classes to the various disturbance zones is shown in Table B-7.

Table B-7
Regulation Class Allocation

Land Use Designation	Distance Zone	VQO	Low VAC	Interm VAC	High VAC
Scenic Viewshed	Foreground	R	3	3	2
	Mid. Ground	PR	3	3	2
	Background	PR	3	2	1
	Not Seen	MM	1	1	1
Modified Landscape	Foreground	PR	3	3	1
	Mid. Ground	M	2	2	1
	Background	M	2	1	1
	Not Seen	MM	1	1	1
Timber Production	Foreground	M	2	2	1
	Mid. Ground	MM	2	1	1
	Background	MM	1	1	1
	Not Seen	MM	1	1	1

There are two main components of scenery constraints; the total visual disturbance and adjacency considerations. Total visual disturbance is the percent of land within a viewshed (VCU) that is classified as disturbed (see Table B-6). Adjacency refers to the amount of time required before a harvest unit can be placed immediately next to an existing harvest unit (often referred to as the "green-up" period). These constraints are shown in Table B-8.

Table B-8
Generalized Visual Constraints

Regulation Class	Visual Disturbance	Adjacency
1	40%	25 Years
2	30%	30 Years
3	20%	60 Years

There are several important things to remember regarding the above table:

1. Disturbance percent is based on suitable lands only, not the entire viewshed.
2. These values are entered into the models, as constraints, for each VCU.
3. The disturbance and adjacency factors for regulation class 3 are based on the use of very small patch cutting (less than 2 acres). Optimally, disturbance and adjacency would not be an issue with carefully planned uneven-aged management (i.e., partial stand removal).

Since Land Use Designation (LUD) is one factor in determining regulation class allocation, the breakdown of each of the nine alternatives into regulation class depends on the objectives of the alternative. Table B-9 shows how LUD impacts the determination regulation class. In some cases, the objectives of a particular alternative may require allocation of land to a management intensity that is less than that permitted under the regulation class process. For example, an eagle nest buffer area within a Timber Production LUD may have the general attributes that make it available for intense timber harvest but because it is an eagle buffer the initial allocation is "trumped" and it becomes regulation class 0. Regulation class 0 is a no-harvest allocation.

Depending on the alternative, the following items are some of the main resource and/or standard and guideline factors that may override (trump) a harvest-permissible regulation class to a no-harvest one (i.e., regulation class 0).

- Eagle nest buffers
- Beach buffer
- Estuarine area
- High vulnerability cave or karst area
- No-cut riparian prescription buffer

The final regulation class allocation percent by alternative is shown in Table B-9. This table shows how allocation of regulation class is proportioned by Land Use Designation (LUD). As can be seen, even the Timber Production LUD, has five to 15 percent of suitable lands allocated to regulation class 0 (no harvest). These acres are a direct result of the trumping process described above.

Table B-9
Allocation of LUD to Regulation Class by Alternative (percent)

Alt	Land Use Designation	Regulation Class 0	Regulation Class 1	Regulation Class 2	Regulation Class 3
1	Timber Production	6%	0%	0%	94%
2	Scenic Viewshed	17%	15%	1%	67%
	Modified Landscp	19%	31%	35%	14%
	Timber Production	10%	75%	13%	2%
3	Scenic Viewshed	21%	13%	1%	65%
	Modified Landscp	22%	25%	29%	24%
	Timber Production	15%	64%	10%	11%
4	Scenic Viewshed	18%	14%	1%	67%
	Modified Landscp	21%	28%	32%	19%
	Timber Production	12%	71%	11%	6%
5	Scenic Viewshed	19%	13%	1%	68%
	Modified Landscp	20%	28%	33%	20%
	Timber Production	11%	71%	12%	6%
6	Scenic Viewshed	19%	13%	1%	68%
	Modified Landscp	20%	28%	33%	20%
	Timber Production	11%	71%	12%	6%
7	Modified Landscp	6%	30%	46%	19%
	Timber Production	5%	72%	21%	1%
9	Scenic Viewshed	4%	30%	2%	64%
	Timber Production	6%	75%	18%	1%
10	Scenic Viewshed	19%	15%	1%	65%
	Modified Landscp	20%	29%	35%	17%
	Timber Production	12%	72%	12%	3%
11	Scenic Viewshed	27%	14%	1%	58%
	Modified Landscp	25%	27%	33%	15%
	Timber Production	15%	67%	10%	8%

Incorporation of Regulation Class into GIS and FORPLAN

In order to incorporate the regulation class values into the GIS (and FORPLAN), the components in the above tables used to determine regulation class had to be in the GIS database. The primary data elements of distance zone and visual absorption capability (VAC) exist in the TLMP database. In order to calculate visual quality objectives (VQOs) the land use designation (LUD) must be known. The LUD is obtained from the alternative map (i.e., map color). The incorporation of LUD (map color) is done by overlaying the alternative map onto the 900,000 Tongass data points. Then, using LUD and distance zone, VQOs can be determined (see table B-4). Once VQO is known, the standards and guidelines can be used to determine maximum clearcut size for each VAC rating (see table B-5). Then, using the information from table B-7, a regulation class allocation is given to every point in the database for each alternative.

The process for assigning the nine million regulation class values (ten alternatives times 900,000 data points) is done through the use of computer programs written specifically for the GIS data base system. These programs "ratchet' through the data points and evaluate the conditions responsible for regulation class determination. Once the appropriate regulation class is assigned, the program moves to the next point. When this process is complete, all analysis areas (AAs) have been tagged with up to four different regulation class assignments.

Incorporation of Unique Alternative Elements into GIS and FORPLAN

The process for creating the first round of regulation class allocations is described above. That process provides regulation classes based solely on LUD, VQO, distance zone, and VAC. Before the AA allocation data is supplied to FORPLAN, additional processing is required. This second step incorporates the unique components of each alternative by recalculation of regulation class. In some cases, these alternative components are addressed via FORPLAN constraints not by the recalculation of regulation class. The constraint limits applied to those are usually derived from the GIS data base. Table B-10 shows the primary unique components found in each alternative. Table B-11 indicates whether the component is modeled with a change in regulation class, a FORPLAN constraint, or both.

Table B-10
Unique Alternative Elements

Element	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 9	Alt 10	Alt 11
Reserves	no	no	all	no	4 prov	4 prov	no	no	all	all
VCU Threshold	no	no	no	25%	25%	50%	no	no	no	no
OG Retention	no	no	no	33%	33%	33%	no	no	no	no
FHIP 1	Opt 2	Opt 3	Opt 1	Opt 2	Opt 2	Opt 2	Opt 3	Opt 3	Opt 2	Opt 2a
FHIP 2,3	Opt 3	Opt 3	Opt 2	Opt 3	Opt 3	Opt 3	Opt 3	Opt 3	Opt 3	Opt 2a
Beach 500 Harvest	no	no	no	no	no	no	yes	yes	no	no
Beach 1000 Harvest[1]	UM	yes	UM	UM	UM	UM	yes	yes	yes	no
Estuary Harvest	no	no	no	no	no	no	yes	yes	no	no
Deer habitat	yes	no	yes	yes	yes	yes	no	no	no	no

[1] UM indicates Uneven-aged Management

Table B-11
Model Incorporation Method

Element	Method
Reserves	Both
VCU Thresholds	FORPLAN Constraints
OG Retention	FORPLAN Constraints
FHIP 1	GIS Reg Class Change
FHIP 2,3	GIS Reg Class Change
Beach 500 Harvest	GIS Reg Class Change
Beach 1000 Harvest	GIS Reg Class Change
Estuary Harvest	GIS Reg Class Change
Eagle Nests	GIS Reg Class Change
Deer habitat	Both

In general, any element that could be mapped (spatially explicit) was modeled by reallocation of regulation class. Elements that dealt with percentages and proportions of the land base and could not be mapped were modeled by FORPLAN constraints.

An in-depth discussion of these elements and their rationale exist in Chapter 2 of the FEIS and will only be summarized here. The discussion in this section will focus on how these components were represented in the data base and modeled in FORPLAN.

Reserves

Four of the nine alternatives have either all or some of the designated old growth habitat reserve areas. This element consists of three reserve sizes; small, medium, and large. The medium and large reserves are shown on the alternative maps thus regulation class allocation of zero is given for each in the first process. Due to their size and specificity small reserves are not mapped except on Alternative 11. To model the impact of small reserves on the remaining alternatives, the acres of suitable land required to meet the reserve specifications were determined through GIS queries and these were entered into the models through acreage constraints. The acres likely to fall within one of these no-cut small reserves is removed from the suitable base and given a no-harvest prescription. This procedure was used for each VCU.

VCU Thresholds

Three of the alternatives required that no more than 25% (or 50% for alternative 6) of the productive forest land be composed of regenerated stands in any 50-year period. The threshold concept then allows an additional 25% (or 50%) increase for the next 50-year period. This approach is intended to create a wider distribution of age classes than may be generated under an unconstrained harvest scheduling process. The threshold limits were determined for each VCU (through GIS queries) and acres available for harvest were limited in 50-year intervals.

Old-growth Retention

This series of constraints applied to three alternatives and limited the lands available for harvest to 33% of the remaining productive old-growth acreage. The right-hand side values for these constraints were determined for each VCU using the TLMP data base. This constraint did not impact regulation class allocation but forced a no-harvest intensity.

Riparian Habitat and Watershed Constraints (FHIP)

There are four different riparian prescriptions (options) being used in the FEIS. Each one has very specific protection levels (buffers) applied to various classifications of streams, soils, and wetlands. The first step in this process was to develop a GIS coverage for each of the options. These coverages were then overlaid onto the approximately 900,000 point database. This process assigned a value to every point indicating what level of riparian management was permissible depending on the alternative being considered. This same process was used to provide each point with a FHIP rating (1,2, or 3) using the FHIP watershed polygon coverage. FHIP watersheds refers to those watersheds with known higher value (FHIP 1) or lesser value (FHIP 2 or 3) as determined by a process defined in the current (1979) TLMP.

Using the alternative information, FHIP rating, and appropriate riparian option, the regulation class from the first step is compared to the maximum management intensity permitted by riparian option. If the primary allocation allows greater intensity then the regulation class is recalculated. The general rule of the algorithm is that the less intense regulation classes trump more intense regulation classes. This same type of process was used when determining regulation classes for Alternative 11 riparian prescriptions but FHIP rating was not used since this prescription is applied forest-wide.

500 and 1,000-Foot Beach Buffers

Using the buffering algorithms available in Arc Info, 500-foot and 500 to 1000-foot buffers where created and added to the database. Depending on the alternative, reallocations were made to the primary regulation classes. Again, if the alternative called for no-harvest in either or both of the beach buffers then all regulation class allocations that initially allowed timber harvest were trumped with no-cut (regulation class 0).

Estuary

The Revision database contains a polygon coverage of estuary areas. These were incorporated into the database using the same process as was used for beach buffers. The recalculation of regulation class was then conducted depending on the alternative and primary regulation class allocation. Again, if the alternative called for no-harvest in the estuarine area then all regulation class allocations that initially allowed timber harvest were trumped with no-cut (regulation class 0).

Eagle Nest Buffers

There are about 1,200 eagle nests whose location is stored in the Tongass database. Each of these is given a 330-foot (circular) no-harvest buffer. Each point that occurs within this buffer is assigned a regulation class of 0 (no harvest allowed) no matter what allocation it was given on the first pass.

Deer Habitat VCUs

Some of the alternatives applied a no-harvest (regulation class 0) prescription to certain VCUs due to estimated high importance as deer wintering habitat and where a certain amount of timber harvest has already occurred. Rather than using a coverage specific to these areas, a look-up table was used to select the necessary VCUs. Once the appropriate VCUs and alternatives were selected, all regulation class values greater than zero where recalculated to zero. All database queries, spreadsheets, and field notes that were used for the formulation of FORPLAN constraints and regulation class allocation (as described above) are available in the TLMP planning record.

Incorporating Regulation Class Allocations into the Models

After completing both steps of the regulation class process, AA information is now ready to use in the FORPLAN models. Using a series of programs, each AA is listed, by alternative, with the number of acres assigned to each regulation class. The listing obtained from the GIS following regulation class allocation looks like this:

Analysis Area	Regulation Class	Acres
A01	0	1,290.
A01	2	880.
A01	3	229.
A02	0	690.
A03	1	1,232.
A03	2	120.

The above information is delivered in ASCII format and converted by another program into the analysis area format used by FORPLAN. FORPLAN utilizes the prescription control feature to allocate the proper percentage of each AA to each regulation class. A look-up table is used to link the AA code (e.g., A01) with the appropriate level identifiers as needed by FORPLAN. The AAs are then grouped into productivity classes within the FORPLAN models.

Analysis Process Outside of FORPLAN

Recreation, hunting, and fish production were analyzed outside of FORPLAN for two reasons: 1) FORPLAN is unable to properly account for certain elements which drive demand for certain activities (e.g., population change, trends of usage), and 2) previous analysis may have shown little or no impacts from management activities so further analysis with the same data would have been redundant.

Recreation. The demand, and costs of recreation were modeled outside of FORPLAN. Recreation areas on the Forest have been delineated and these areas provide the recreation capacity and account for the management costs. Projected demand is equated to use as long as it is less than or equal to the amount of capacity. In the event that capacity is less than anticipated demand, use is assumed to equate to capacity. Also, some assumptions were made about certain areas and recreational settings once timber harvest activities had occurred.

First, recreation opportunities with similar settings were aggregated as follows:

Group 0 - Identified as not providing recreation opportunities
Group 1 - Primitive and Semi-primitive Nonmotorized
Group 2 - Semi-primitive Motorized
Group 3 - Roaded Natural and Roaded Modified

Next, assumptions were made as to what would happen if timber harvesting took place in the Recreation Group. The assumptions are:

1) Timber harvesting in Group 1 or Group 2 would remove any potential for recreation (becomes Group 0), unless;

2) The area is accessible by ferry or roads, in which case, the area would provide Roaded recreational opportunities (becomes Group 3).

3) If the area is of Group 3, then timber harvesting or any land disturbing activity would have no effect on the area's ability to provide Roaded recreational opportunities (stays Group 3).

Next, through a series of GIS queries, all identified recreation places (see Recreation Place map) allocated to a timber harvest prescription were placed in their recreation group and capacity was recalculated. This allowed planners to analyze not just the capacity of recreation opportunity, but the mix of different types of opportunities. The costs of maintaining and providing recreation opportunities is also analyzed outside the FORPLAN model.

Hunting. See the discussion in the Wildlife Demand section of Chapter 3 of the Revised Supplement for a detailed discussion of hunting habitat capability, hunter demand and habitat capability.

Fish. Fish production capacity and the economics of the fisheries resource is modeled outside of FORPLAN. Timber management, done in accordance with TTRA, assures the protection of riparian areas by maintaining at least a 100 foot no commercial harvest buffer along Class I streams and those Class II streams flowing directly into Class I streams. Use of Best Management Practices (BMP), along all streams, provides further assurance of maintaining water quality and stream habitat. In order to consider reduced risk to fish habitat, three levels of riparian protection were developed as discussed above.

Mathematical Models used outside of FORPLAN. Two models, IMPLAN and SEAPROG, are used to generate input data for FORPLAN. An input/output model was built using the IMPLAN system to estimate income and employment effects resulting from changes in Forest outputs and land allocations. Timber volumes for regenerated stands are developed through the SEAPROG growth and yield model. SEAPROG used bare-ground projection components to calculate these yields. Updates to the SEAPROG model were made for the RSDEIS. A more detailed description of each of these models can be found in the 1991 SDEIS.

Economic Efficiency

Net Public Benefits - Net public benefits are the "overall long-term value, to the nation, of all outputs and positive effects (benefits) less all associated Forest inputs and negative effects (costs) whether they can be quantitatively valued or not" (36 CFR 219.3). Net public benefits represents the sum of the net value of priced outputs plus the net value of non-priced outputs. The FEIS Chapter 3 explains and describes the elements of public benefits that may be a function of Forest planning and management activities. In the Tongass FORPLAN analyses, the only economic aspect directly considered was related to timber harvesting.

Costs used in the FORPLAN Analysis

All costs used in the FORPLAN analysis are adjusted to base year 1995, first quarter. Cost information was used from as early as 1978 through 1994, depending on the activity. When information for 1994 was unavailable, the National Producer Price Indices were used to convert to the desired time period. In order to reduce the number of numeric tables in this appendix, only average and summarized values are used in this section. The actual cost figures used in the analyses are available in the planning records.

Log Transfer Facility, Haul, and Roading Coefficients. These costs were calculated for over 100 different VCU aggregates (based originally on Management Area). Using the Log Transfer Facility map and data base, each LTF, existing or proposed, was assigned to the appropriate VCU. The cost of LTF construction or reconstruction and timber hauling was determined from existing information and engineering estimates. The hauling cost represents the cost to get one MBF of timber from the landing to the mill:

Administration Area	LTF Cost (ave$/acre)	Haul Cost (ave$/mbf)	Road Const. (miles/Macres)
Chatham	21.7	49.3	8.9
Ketchikan	13.6	38.9	8.7
Stikine	14.2	40.3	7.7

Timber Sale Preparation and Administration. This is the cost to the Forest Service of administering and laying out timber sale areas. In developing the costs for FORPLAN, attributes that affect sale preparation costs were identified: roaded vs. unroaded areas, higher costs in regulation class 3 (group selection/single tree selection) versus other regulation classes (clearcut), and higher costs in some operability classes. In general, sale preparation costs range from $48 to $160 per mbf.

Road Construction. The cost of local, arterial, and collector road construction costs vary due to the management emphasis of an area. Areas with an emphasis on visual quality (natural settings, etc.) will have higher road construction costs. Roads in these areas will require longer transportation of road bed material (due to fewer rock quarries per mile of road construction), increased engineering support costs (strategic placement of road), and road location (often constructed in a place that is less cost efficient). On the Tongass, the cost per mile of road ranges from $256,000 to $512,000.

Road Reconstruction Costs. Roads that have been constructed and only minimally maintained must be reconstructed to get the road up to standards suitable for timber hauling. The cost of reconstruction is determined by the amount of maintenance and time since last reconstruction or construction. Regulation class is used to estimate road reconstruction cost since the estimated time between harvest entries is tied to regulation class and this is a critical element in reconstruction costs calculations. The average cost of road reconstruction is $55,600 per mile.

Road Maintenance. Once roads are constructed there is often a certain amount of annual maintenance. Road maintenance depends on current road use and anticipated future logging activity. Again, road maintenance costs are based on regulation class allocation. Regulation class 1 and 2 roads, due to a greater use, will be maintained for light-use standards (maintenance levels 2 and 3). Average road maintenance cost is $161 per mile per year.

Reforestation Certification. The predominant form of forest regeneration following clearcut harvesting is natural regeneration. Very little planting or seeding is done on the Tongass National Forest. The soils and weather conditions of Southeast Alaska are very conducive to natural regeneration. The Forest Service certifies successful regeneration five years following clearcut harvesting. In the event of unsuccessful regeneration, more aggressive regeneration actions are undertaken. The average cost of certifying that regeneration has occurred has been $13.10 per acre.

Precommercial Thinning. The National Forest has an active program of precommercial thinning. This improves the health of the stand and permits greater understory development for wildlife. This thinning operation is termed "precommercial" because no revenues are derived from the sale of the harvested trees. The average cost for precommercial thinning on the Tongass is $500 per acre. This silvicultural activity is generally conducted when the stand is between ten and 20 years old.

Logging Costs. Logging cost is the amount of money a timber buyer spends to build temporary roads and fell, buck, and skid the trees to the landing. The logging cost estimates were determined using the procedures outlined in the Forest Service Handbook 2409.22 - Timber Appraisal Handbook. The costs include yarding, log sorting and loading, general logging overhead, felling and bucking, temporary road construction, camp mobilization, depreciation, and erosion control. The cost of this activity varies by regulation class (e.g., clearcut size), operability (type of harvesting system required), and size, or age, of the trees (big trees are less expensive on a board foot average):

Administration Area	RegClass 1&2 (ave$/mbf)	RegClass 3 (ave$/mbf)
Chatham	151	354
Ketchikan	135	366
Stikine	136	346

Benefits

The dollar values of outputs used to calculate PNV are the prices consumers would be willing to pay for Forest outputs, whether or not such prices are actually collected by the federal government. Generally many Forest outputs, particularly those with non-market values, are provided either at no charge to consumers or at a charge less than the willingness-to-pay price.

The evaluation of benefits from resource outputs requires a consistent concept of value, although value estimation techniques may vary from resource to resource. For example, timber may be valued using different techniques than minerals or fish, but the concept behind the techniques must be consistent. For further discussion on benefits and net willingness to pay, refer to the 1991 SDEIS.

Timber. The benefits derived from timber are based on appraised value. Value is based on tree size, species composition, amount of defect, and other factors. Timber benefits are measured as pond log value. Pond log values are the estimates of price a timber buyer would pay for a log at the mill site. To get the stumpage value of this log, all estimated costs that are incurred to get the log to the mill must be subtracted from the pond log value. The resulting stumpage price is assumed to be the price the timber buyer pays for the log (bid price). Bid price represents money to the U.S. treasury. The average pondlog value is $396 per mbf.

Hunting, Recreation and Fish. For complete discussion of these resources and the measure of economics and outputs, refer to the 1991 SDEIS and the economics section of the FEIS, Chapter 2.

Social And Economic Impacts. Social and economic impact analysis examines the consequences of different land management decisions on the people and communities in and around the Tongass National Forest. The effect of the alternatives on local communities are measured in terms of Forest Service payments to local governments, changes in job and personal income in a local area, and changes in lifestyle and community structure. Economic analysis identifies the consequences in terms of employment, personal income, and payments to governments while social analysis focuses on changes in lifestyles and structure of those communities in and around the National Forest.

Chapter 3 of the Revised Supplement, Social and Economic Environment section, contains a detailed discussion of the economic and social impacts of the alternatives.

Sources of Data. Refer the to the 1991 SDEIS.

Analysis Prior to the Development of Alternatives

Refer to the 1991 SDEIS.

Stage II Analysis

Prior to the formulation of alternatives, each acre classified as tentatively suitable for timber harvest was analyzed to determine the costs and benefits for a range of management intensities (36 CFR 219.14(b)). For the purpose of this analysis, the planning area was stratified into categories of land with similar costs and returns. The stratification also took into account those factors which influence costs and returns such as physical and biological conditions of the site and transportation requirements.

Stage II analysis is used to identify management intensities of timber production for each category of land which results in the largest amount of discounted net revenues. It also identifies those categories of land that are economically sensitive to even slight changes in management intensity. Stage II analysis provides insight into the overall economic condition of the tentatively suitable land base. This enables planners to evaluate and predict potential economic bottlenecks during the next step of the planning process; the formulation of alternatives.

Stage II analysis was conducted for all applicable management intensities: Intensive even-aged management (i.e., regulation class 1 areas) to very small clearcuts and group selection prescriptions (regulation class 3 areas). There are many economic factors that contribute to the calculation of net revenue. The table below shows average net revenue by category. These are not weighted averages (i.e., based on the number of acres in each category). Table B-12 is a summary of Tongass Stage II analysis.

Table B-12
Stage II Economic Summary by Regulation Class (Revenue per Acre)

Admin Area	Vol Class	Regulation Class 1 Normal (net$/acre)	Difficult (net$/acre)	Isolated (net$/acre)
Chatham	Low	-93	-979	-3,339
	Medium	977	-775	-3,941
	High	4,958	2,978	-2,294
Ketchikan	Low	80	-2,096	-3,011
	Medium	2,927	479	-2,433
	High	5,954	2,908	-890
Stikine	Low	1,440	-273	-2,483
	Medium	3,969	978	-1,948
	High	6,675	3,191	-282

Admin Area	Vol Class	Regulation Class 2 Normal (net$/acre)	Difficult (net$/acre)	Isolated (net$/acre)
Chatham	Low	-1,554	-3,028	-5,280
	Medium	-963	-3,289	-5,903
	High	2,054	-558	-4,566
Ketchikan	Low	-1,980	-3,959	-4,942
	Medium	350	-1,661	-4,577
	High	2,969	689	-3,190
Stikine	Low	-674	-2,358	-4,315
	Medium	1,540	-1,258	-3,945
	High	3,147	760	-2,433

Admin Area	Vol Class	Regulation Class 3 Normal (net$/acre)	Difficult (net$/acre)	Isolated (net$/acre)
Chatham	Low	-12,200	-14,227	-18,889
	Medium	-14,118	-15,848	-17,608
	High	-13,312	-13,465	-17,608
Ketchikan	Low	-14,163	-17,275	-17,693
	Medium	-13,342	-15,300	-16,570
	High	-12,088	-13,095	-14,684
Stikine	Low	-12,223	-13,774	-15,697
	Medium	-10,713	-11,938	-14,860
	High	-9,612	-10,230	-13,258

Formulation of Alternatives

A Forest Plan alternative is a mix of management prescriptions applied in specific amounts to areas of the Forest to achieve desired management objectives and goals. Each alternative within the range of alternatives was developed in accordance with the National Forest Management Act (NFMA). The alternative development process also follows National Environmental Policy Act (NEPA).

Alternative Development. The alternative development process began in 1988 with a review of Forest issues, concerns, opportunities, and resource inventories; resource production capabilities identified in the analysis of the management situation; and applicable planning direction. Based on a review of these items, resource management options were developed. These management options were designed to incorporate issues, reflect a particular level of management emphasis, and serve as a potential building block for Forest management alternatives.

Land Use Designations and Management Prescriptions. The identification of land areas which contribute to the goals and objectives of each alternative was an integral part of alternative development. Working from the management options developed earlier, areas of the Forest were identified and assigned a management strategy. These "Land Use Designations," or LUDs are portions of the forest managed for the same goals and objectives. They are physical units and can be delineated on a map.

The next phase was to develop a range of silvicultural activities that can occur within the LUD areas over the planning horizon. Silvicultural prescriptions represent the potential sets of timber management activities that can be implemented. These prescriptions are incorporated into the FORPLAN model, which seeks to schedule activities in a manner consistent with management constraints and objectives.

Iterative Process. The analysis began with a series of tests designed to calibrate and verify the operation of the models. Upon completion, analysis of individual alternatives began. Under their particular constraints, each model was then solved using an objective function to maximize timber harvest volume in the first decade of the planning horizon. Then, in order to maximize the economic present net value of the timber schedule, the model was constrained at the maximum harvest level and solve to maximize present net value. This process is commonly known as a “PNV rollover.”

Description of Standard Model Shell

A standard FORPLAN model shell was developed to ease the task of developing the individual models used to analyze alternatives. The shell has a standard set of identifiers, treatment types, activities, outputs, cost and value data, objective functions, prescriptions, and yield data. Constraints and analysis area allocations unique to each alternative are then added to customize the model to each alternative.

Description of Common Model Constraints

Constraints are used within a model in order to provide an accurate mathematical representation of the alternative. A set of common constraints were applied to the standard model shell during the analysis of alternatives. These common constraints fall into four categories: 1) Congressionally and Administratively removed, 2) Management Requirements, 3) timber policy constraints, and 4) operational constraints. Other constraint sets, such as wildlife, visual, and discretionary constraints, were modeled for all alternatives, but the amount and extent of the constraints varied by alternative.

Congressionally and Administratively removed areas. In FORPLAN, all lands identified as not suitable for timber harvest are assigned to non-timber prescriptions (i.e., regulation class 0). These lands include Congressionally (e.g., wilderness) or administratively withdrawn from timber harvest (see Revised Supplement Forest Plan, Appendix A, Timber Land Suitability).

Management Requirement (MR) constraints. These constraints are incorporated into the FORPLAN model so management requirements and standards are achieved. Procedures for defining the MR are established by the planning team. The MR are taken from 36 CFR 219.27 and generally represent requirements that are not expected to change. They are based on statutes and regulations in contrast to manual direction or agency policy. MR apply to all benchmarks and alternatives.

Timber Policy constraints. These are required to ensure that all timber harvest meets sustained yield, culmination of mean annual increment, and dispersion requirements. These constraints are in all benchmarks and alternatives.

Operational constraints. These constraints are needed to ensure that the results obtained from FORPLAN are acceptable and implementable on the ground. These constraints are within agency control, but there is little discretionary control regarding their application at the Forest level.

Development and Testing of Alternatives

This section describes the methods applied in the formulation and analysis of alternatives. Alternatives were developed to meet a variety of issues, concerns, and objectives. In all, nine alternatives were developed. These range from a non-market emphasis (Alternative 1) to a production emphasis (Alternative 7) to a representation of the current plan (Alternative 9). The alternative themes and corresponding land allocation patterns were developed by the Tongass Land Management Planning Team. The decisions were based on the analysis of the management situation, public comment, and other concerns generated from the DEIS or SDEIS.

Earlier in the appendix (“Development of regulation classes”) unique attributes of the nine alternatives were discussed. This discussion primarily dealt with the analytical methods by which these attributes were modeled.

Alternative Flowcharting

Once an alternative's theme, goals, resource objectives, and range of management intensities was determined, the process of allocating land to Land Use Designations (LUDs) was incorporated into a flowchart (i.e., a "decision tree"). Each of the almost 900,000, 20-acre capability areas flows through this decision structure until it is allocated to the appropriate LUD consistent with the theme, goals and resource objectives of each alternative.

The flowchart is made up of a series of "question" or decision nodes. Each node asks a yes-or-no question regarding an aspect of the land's attributes. This process continues until all capability areas have been allocated to a Land Use Designation. There is a separate flowchart for each alternative. Every acre passes through the flowchart for LUD allocation.

The flowchart is a symbolic representation of the LUD allocation process. These flowcharts also aid in the design of the computer program (in ARC-INFO) that formats the allocation decisions into FORPLAN inputs. Flowcharts for each alternative are available in the planning records. Due to their size, inclusion into this document was not possible.

The allocation patterns for each alternative generated by the flowcharts were then mapped and reviewed at the field level. Adjustments were made where necessary to account for local knowledge and concerns not addressed within the flowcharts. These additional considerations were made consistent with the theme of each alternative.

The FEIS Alternatives

Each of ten alternatives of the FEIS is based on an alternative or proposed alternative from previous Tongass planning efforts. The 1992 Alternative P is used for six of the alternatives, 1992 Alternative D for two, 1992 Alternative A for one, and one alternative is based on the current plan (1979 Plan as amended and 1992 Alternative C). Of course, most have been additionally modified to account for new information, public comment, and changes in resource management objective.

To develop the maps and models for each of the alternatives we began with the "base" alternative map and then added the features of the new FEIS alternative. The table showing the components of each alternative is found in Chapter 2 and will not be repeated here. The components of the alternatives, such as deer wintering habitat and VCU thresholds, will be discussed in this section.

Analysis Of Constraints on Alternatives

The purpose of identifying constraints and estimating their effects on alternatives was to find the most efficient and realistic means of addressing planning issues. Many constraints were considered for incorporation into the models. The purpose of these constraints is also to act as proxies to facilitate the developing of model results that are realistic, implementable, legal, and consistent with the intent of the standards and guidelines. Unless stated otherwise, all alternatives and sensitivity runs maximize timber harvest volume in the first decade then "rollover" and maximize present net value (PNV). This is the same procedure that was used in earlier TLMP efforts.

Sensitivity Analysis

Much of the information obtained from previous sensitivity runs are still applicable and relevant to FEIS alternative analysis. Sensitivity testing at the Forest Plan level primarily deals with changes in land base, economics, harvest volume attributes, and operational constraints. Although many functional aspects of the models and databases have changed, the results of the tests have varied little over the years (relatively speaking). Mechanically, the models of both the SDEIS and Revised Supplement are very similar to the FEIS models. The modeling provides similar results and are effected proportionally the same with the inclusion of like FORPLAN constraints. For these reasons, earlier sensitivity runs provide useful information for the examination and comparison of FEIS alternatives. The sensitivity run results printed in earlier documents will not be reprinted in this appendix.

One thing learned from the sensitivity tests was that the alternatives each responded similarly in regards to constraint addition and elimination. In other words, the results of a test on one alternative could often be proportionately applied to any other alternatives provided all other constraints were similar. With this knowledge, constraint testing could be applied to a few of the alternatives and the results could be used to estimate the impact on other alternatives. This was done through the use of regression analysis; the most commonly use independent variables were acres in regulation classes 1 and 2 and acres of normal operability lands. The need for this regression approach was to minimize the number of FORPLAN runs that had to be made. Each alternative is composed of three models. Having ten alternatives creates the need for 30 different simulations for each sensitivity test. Some of the larger models can take six or seven hours to complete.

The section below lists the outputs derived from the FORPLAN simulations under different constraint formulations. Since the Tongass models are primarily concerned with timber management, the outputs used for comparison will be the allowable sale quantity for each alternative. This is the volume of timber, measured in millions of board feet, that is scheduled in the model for harvest on a non-declining basis. This measure includes both sawlog and utility volume.

<u>Effect of a Positive Net Revenue Constraint.</u> Estimates of all timber harvest-related costs and revenues are included in the FORPLAN models. The alternatives are all subjected to a maximization of present net revenue objective function. Although FORPLAN may report a positive "net revenue" in some or all

decades, some alternatives do show that negative revenue decades will occur. To determine the impact of positive net revenue per decade, a constraint that forces positive revenues for each decade of the planning horizon was added to the FORPLAN models. Of course, this constraint does not truly indicate the amount of timber revenue expected but provides insight into effect of economics to volume of projected to be profitable timber. This sensitivity test simply allows planners to see the relative impact to harvest volume based on changes in economics. The resulting modeled allowable sale quantities (ASQ) are shown below.

Table B-13
Impact of a Positive Net Revenue Constraint

Alternative	Original ASQ	Sensitivity Run	Percent Change
1	0	0	0%
2	463	347	-25%
3	256	189	-26%
4	130	130	0%
5	122	122	0%
6	309	216	-30%
7	640	474	-26%
9	549	401	-27%
10	300	225	-25%
11	267	195	-27%

Results of this test vary most significantly between two general alternative forms: short rotation even-aged management and long rotation even-aged management. Alternatives 4 and 5 have minimum 200-year rotations for second growth. This being the case, the available old-growth must be “metered” out for the entire planning horizon. Since this volume is projected to be quite profitable, the model is able to maintain the same harvest level. The other alternatives are unable to do this due to the harvest of second growth. A portion of this second growth is projected to be unprofitable and must be “supplemented” with the harvest of old-growth to maintain profitability. This, in essence, spreads out the harvest of old growth over a longer period of time thus reducing first decade harvest volume.

In terms of economics, there are some interesting things about Tongass timber. For example, Tongass timber is very sensitive to changes in price. Stage II economic analysis has shown that a 20% increase in pond log value can increase the projected profitable acres by as much as 50%. Much of the available timber on the Tongass is on the economic margin. This situation not only makes supplying a consistent economic sale program challenging, it also makes constraining for timber economics in a 160-year model possibly unrealistic. Hence, ASQ are determined without a no-below cost constraint. In addition, a volume of timber less than the ASQ volume is shown as the projected probable economic portion of the ASQ. This volume is based on the volume of timber projected to be harvested of normal operable lands. This is approximately 80 percent of the ASQ volume and is termed the non-interchangeable component I (NIC I) volume. The remaining volume will be called the NIC II volume and is to be considered uneconomic for harvest in a decade of average timber economics and assuming constant logging technology and costs.

<u>Constraints on Logging Operability</u>. There are three categories of mapped logging operability on the Tongass; normal, difficult, and isolated. The rate at which timber is harvested from these three different classes has always been of interest. Too much volume off the easier-to-harvest normal operable areas could jeopardize the ability of the Tongass to supply economic future timber sales. There is a tendency for FORPLAN to harvest disproportionally from the three classes. In order to maximize Present Net Value (PNV), the more economic operable timber lands are harvested earlier in the planning horizon. A constraint was developed for all alternatives that requires each decadal harvest to be composed of no more than the forest-wide proportion of normal operability lands. This is approximately 79% of the tentatively suitable land base. Historic logging trends have shown that normal operable lands typically make up about 94% of the total harvest acres (difficult about 5% and isolated 1%). This 94-5-1 mix of operability is reflective of providing a timber sale program that is considered economically feasible. This proportion is based on 14 years of harvest data (1980-1994).

To test the impact of harvesting operability classes in their historic proportions, FORPLAN was constrained to mimic scheduling of the 94-5-1 mix. All other constraints remained in the model (limits on high volume old growth, for example). The results of this run are shown in Table B-14 and compared to the ASQ and NIC 1 components of each alternative. In addition to the historic proportion test, a test was conducted that permitted no harvest from difficult or isolated operability. This test, when compared to the results of the historic proportion run, will show the contribution of difficult and isolated stands to the ASQ. These results are also shown in Table B-14.

Table B-14
Impact of Constraining Operability: Historic and Normal Only

Alternative	ASQ (MMBF/yr.)	ASQ, NIC 1 Component	Historic Operability Constraint (MMBF/yr.)	Normal Operability Only (MMBF/yr.)
1	0	0	0	0
2	463	375	426	377
3	256	210	222	196
4	130	107	103	91
5	122	100	96	85
6	309	250	269	238
7	640	520	595	526
9	549	447	511	452
10	300	245	270	239
11	267	219	250	221

This information indicates that the harvest of operability classes is well represented by the use of the non-interchangeable component (NIC) concept. Only two of the alternatives indicate that constraints on the harvest of operability class reduce the ASQ below the calculated NIC 1 value. These alternatives, 4 and 5, have minimum rotation lengths of 200 years. This test indicates that a higher proportion of difficult and isolated operability stands may be required to achieve NIC 1 volumes than has been harvested historically.

<u>Impact of Precommercial Thinning.</u> In order to accurately assess the economics, effects, and requirements of precommercial thinning, all FORPLAN data sets included known benefits derived from thinned stands. The main timber-related benefits resulting from thinned areas, when final harvested, is reduced logging cost, increased value, and reduced minimum rotation age (in some cases). To determine the ASQ dependence on this activity, a run that did not allow precommercial thinning was compared to the original runs, which allowed precommercial thinning. The results are shown in Table B-15

Table B-15
Impact of No Precommercial Thinning

Alternative	Original ASQ	No Precom Thin	Percent Change
1	0	0	0%
2	463	440	-5%
3	256	248	-3%
4	130	130	0%
5	122	122	0%
6	309	297	-4%
7	640	595	-7%
9	549	522	-5%
10	300	285	-5%
11	267	254	-5%

FORPLAN schedules precommercial thinning to increase the ASQ and improve the economics of the second growth timber stands. These results demonstrate the need of precommercial thinning to achieve the ASQ and meet the non-declining yield constraints. Without adequate levels of precommercial thinning, the sustainability of first decade harvest volumes at the ASQ level is unlikely. Precommercial thinning has this effect due to the existing age class structure of the forest. The key factors in ASQ calculation are length of time before second growth timber is available for harvest and the volume that is harvested from these acres. Anything that reduces the "old-growth liquidation period" will tend to increase ASQ estimates. Other activities that may have similar effects would be a reduction in merchantability requirements or multiple thinnings.

The only benefits associated with precommercial thinning in this analysis are in terms of increased timber values. There are other benefits associated with precommercial thinning that have yet to be fully quantified. For instance, enhancement of wildlife habitat and improved vigor of the forest stand (which improves disease resistance) are benefits thought to be derived from thinning. When these values are finally quantified, precommercial thinning may show a higher economic return.

Factors Effecting the Allowable Sale Quantity Calculation. As discussed earlier in the appendix, constraints have been added to the FORPLAN models to account for a variety of missing, miscoded, and unaccounted for information that may reduce the feasibility of FORPLAN-generated results. These values are referred to as Model Implementation Reduction Factors (MIRFs). In order to estimate the impact these constraints have on the models, a series of runs were made without them. All other constraints were left in place.

Table B-16
Removing the MIRF Constraints

Alternative	Original ASQ	MIRF Removed	PercentChange
1	0	0	0%
2	463	574	24%
3	256	315	23%
4	130	144	11%
5	122	134	10%
6	309	355	15%
7	640	761	19%
9	549	659	20%
10	300	366	22%
11	267	332	18%

The impact of MIRFs vary due to the unique components of each alternative. In alternatives containing constraints for items such as small old growth reserves and harvest thresholds, the smallest increase occurs. While the proportions of MIRF constraints are similar among all alternatives, there is “overlap” between MIRF and other constraints, thus accounting for the above differences. For example, some of the MIRF constraint is achieved by using the same acres set aside for small old growth reserves.

Estimated Impacts of Three FORPLAN models. As discussed earlier, there are three separate FORPLAN models representing the Tongass National Forest. The main reason behind this is computer hardware and software limitations. The desired level of detail combined with size of the Tongass, made for very large FORPLAN models. The only option, other than reducing the level of detail, was to split the Forest into three separate FORPLAN models. Typically, as an area is disagreggated into additional models, levels of output, when summed, are different than that of the whole model. This is primarily due to limiting solution options as the model's land base is decreased. In order to assess possible resource production inefficiencies within the Tongass models, a test was conducted to estimate the effect of three models instead of one.

The best possible test would have been to put the three area models together and regenerate the solution. This is impossible. Instead, each of the three Forest models that make up one alternative were divided into three again. There are now nine different FORPLAN models that, when combined, represent the Tongass.

For this test, the land allocation for Alternative 7 was selected. Because we wanted each of the nine models to have land available for harvest, alternative 7 provided the best opportunity since it has the greatest suitable land base. Table B-17 shows the results of this test.

Table B-17
Impact on ASQ by Model Disaggregation

Area	Segment 1	Segment 2	Segment 3	Total
Chatham	41	59	35	135
Ketchikan	115	83	89	287
Stikine	73	63	67	203
Total				**625**

Comparing these results with the original Alternative 7 ASQ volume of 640 MMBF, we see that there is a decrease of 15 MMBF when using the disaggregated models. This represents an ASQ decline of slightly more than 2 percent when going from three models to nine. Assuming the same proportionate change when going from one model to three we can estimate the ASQ that would have resulted if we had the computer capabilities to make one large model instead of three. Table B-18 contains these estimates.

From the information obtained from this test, we conclude that splitting the Forest into three models is reasonable since the results do not vary significantly under further aggregation.

Results of Alternatives

The results of the alternatives under all congressional and administrative constraints, Management Requirement constraints, timber policy constraints, and operational constraints are shown below.

This section does not show all the outputs and activities associated with the alternatives. Many timber related outputs are found in other Revised Supplement documents. Results shown in this Appendix are selections of some of the key outputs and activities closely associated to the economic efficiency and harvest schedule of the models. FORPLAN reports are available in the Planning Record.

Table B-18
Alternative ASQ Estimated from One Model Instead of Three

Alternative	Original ASQ	One Model
1	0	0
2	463	474
3	256	262
4	130	133
5	122	125
6	309	316
7	640	655
9	549	562
10	300	307
11	267	273

Allowable Sale Quantity and Suitable Acres

The Allowable Sale Quantity (ASQ) and suitable acres are shown in Table B-19 for each alternative. The ASQ is shown here as the first decade harvest volume in board feet (sawlog and utility). This is the decadal volume possible under the constraints and land allocations represented by the various alternatives. The NIC 1 component represents a volume from the estimated ASQ from the most operable ground and based on historic harvest. This volume may more accurately project the likely timber sale program quantity than the ASQ, which is a maximum. The suitable acres are lands on which timber harvest is permitted based on LUD and alternative-specific management attributes and scheduled for harvest.

Table B-19
ASQ and Suitable Acres

Alternative	ASQ (MMBF/year)	ASQ-NIC 1 (MMBF/year)	Suitable Acres (1,000s)
1	0	0	0
2	463	375	1,180
3	256	210	795
4	130	107	845
5	122	100	786
6	309	250	1,024
7	640	520	1,575
9	549	447	1,390
10	300	245	924
11	267	219	680

A complete list of alternative outputs can be found in Chapters 2 and 3 of the FEIS and in the TLMP planning records.

Sensitivity Tests on Alternative 11

In this section, a variety of tests are made specifically to Alternative 11. Different aspects of the alternative will be tested in order to estimate likely effects and/or responses due to changes in assumptions and some additional investigation into some components of the alternative.

In order to model systems as complex as the timber management schedule of a National Forest it is a common, and necessary practice, to develop a series of assumptions in order to simplify the system to a level that makes modeling possible. Assumptions are made for a variety of reasons but the most common being:

1. So little is known about a topic that its response to varying levels of management must be completely estimated. Example: It is assumed that the volume of the existing old growth forests is constant over time (i.e., growth equals mortality).

2. The parameters in which the model is being developed cannot or does not perfectly adhere to the parameters of a particular attribute or the characteristics of a particular resource has not been or cannot be spatially quantified. Example: It is assumed that a VCU is a viewshed on which visual constraints will be modeled.

Since the primary purpose of the Tongass FORPLAN models is to estimate a harvest schedule that is sustainable and adheres to the proposed standards and guidelines, most of the assumptions relate to the activities and outputs associated with harvest. The sensitivity tests done in this section will concentrate primarily on forest-wide assumptions that would have a likely impact on ASQ if grossly inadequate.

Growth equals Mortality in Existing Old Growth Stands

For modeling purposes it is assumed that growth equals mortality in existing old growth stands. This is assumed since very little information exists on the dynamics of the old growth inventory over time. Expert opinion and a relatively uniform average harvest per acre for the last 30 years has led to this assumption. If this assumption proves false, then what are the likely impacts? A test was conducted to estimate likely changes in the ASQ under several different scenarios of declining and increasing volumes on existing old growth stands. The results are shown in Table B-20 and are based on alternative 11.

Table B-20
Impact to ASQ by Altered Old Growth Volumes

Scenario	ASQ (MMBF/yr)	Percent Change
Alternative 11, Current OG Yields	267	NA
1% Decadal Decline in OG Yields	261	-2.3%
2% Decadal Decline in OG Yields	256	-4.1%
1% Decadal Increase in OG Yields	271	+1.7%
2% Decadal Increase in OG Yields	277	+4.0%

The tests on old growth volume scenarios indicate that a relationship between merchantable inventory volume and ASQ certainly exists (as expected). But, it is also clear (from this test) that no “crisis” condition exists under the four scenarios tested. By “crisis” condition we are referring to an instance where major ASQ adjustments may result given a relatively small change in old growth volumes. For instance, if a 2-percent decadal decline in old growth volume resulted in a 20-percent decline in ASQ (i.e., 267 to 215) then addition work may be required to ensure that our assumption of growth equals mortality is correct or our ASQ estimates may be misleading. The results of this test reveal nothing that indicates that our old growth inventory assumptions are a major factor in ASQ estimation. The 2% decadal decline test is considered severe (i.e., major volume loss in a very short period) and yet it only results in a 4.1 percent decline in ASQ. This level of change in ASQ is considered to be within acceptable limits given the variability of information used in these estimates. This test was meant to depict decline (or increase) in old growth inventories based on natural stand and/or soil dynamics. In the event of a catastrophic event (e.g., volcanic eruption, massive windthrow, insect or disease, fire) that results in massive loss of merchantable old growth inventory, then the estimated ASq may, of course, no longer be appropriate.

Maximum Timber Potential over the Planning Horizon

To calculate the allowable sale quantity (ASQ), the model first maximizes timber harvest in the first decade of the 160-year planning horizon. This is done, of course, while adhering to all resource, legislative, and operational constraints. One of the constraints requires that the volume harvested in the first decade be sustained for the entire planning horizon. This is called non-declining yield (NDY) or sustainable harvest volume constraint. The model is then re-run, using this first decade harvest volume (from the maximum timber run) as a constraint and seeks to maximize the present net value (PNV) for the planning horizon. Under this scenario, there is little incentive for the harvest volume (or scheduled acres) to increase over time unless the revenues obtained from future harvests are highly profitable and would contribute greatly to the PNV objective function. This, in general, is not the case. The results for a typical alternative often show a slow and steady increase in harvest volume due to the eventual harvest of the more productive and merchantable second growth stands. These second growth stands on the Tongass typically contain twice the merchantable volume as an existing old growth stand on the same site.

To determine the total volume of timber possible over the entire planning horizon, a set of models were developed that maximize the cumulative timber volume over the entire planning horizon (not just the first decade). These models differ from the Alternative 11 models in that they will continue to schedule harvest throughout the planning horizon well above the first decade volume. These models must still adhere, though, to a non-declining yield constraint (i.e., harvest volume may increase or stay constant but never decrease).

We can then compare the average volume per decade for Alternative 11 and the test runs to give some insight into the actual timber potential of the land allocations of Alternative 11. The results of these tests are in Table B-21.

Table B-21
Timber Harvest over the Planning Horizon
(in MMbf/year)

	Max Timber Decade 1	Max Timber All Decades
Decade 1 Harvest (ASQ)	267	267
Average Harvest (15 decades)	285	325
Decade 15 Harvest	325	378
Long-term Sustained Yield	355	380

The column labeled as Max Timber Decade 1 is Alternative 11. Comparing this column with the max timber all decades column reveals several things. First, although the ASq are the same, the amount of timber harvested over the planning horizon is quite different. This tells us that the future harvest potential of Alternative 11 is quite higher than shown by the results of the model. From this we can safely assume that the number of second growth acres needed to maintain the ASQ is less than the number that will be actually managed for timber harvest. In fact, after the seventh or eighth decade, some of the second growth acreage could be given a non-timber management LUD (i.e., be removed from the suitable acre landbase). This test lends additional support to the assumption that the primary factor in ASQ determination is the number of existing old growth acres available for harvest.