APPENDIX B – ANALYSIS PROCESS

INTRODUCTION

Land and resource management planning requires that processes formerly used to make individual resource decisions be combined into integrated management decisions. It also requires that mathematical modeling techniques be used to identify the most economically efficient solution to meet the goals and objectives of any alternative. Appendix B presents a technical discussion of the analysis process and computer models used in the Revision planning effort. The appendix focuses on the quantitative methods used to perform the analysis and documents how the analysis was done. The results from the modeling processes are estimates of what can be expected if alternatives are implemented and facilitate comparison of alternatives.

The Forest's major analysis goal is to provide enough information to help decision-makers and the public determine which combination of goods, services, and land allocations will maximize Net Public Benefits (NPB). The regulations (36 CFR 219, 1982 regulations) developed under the National Forest Management Act (NFMA) provide the analytical framework within which these decisions are made.

The NFMA and its regulations also state that the requirements of the National Environmental Policy Act (NEPA) and its regulations (40 CFR 1500-1508) must be applied in this analytic process. The NEPA regulations require that the environmental effects of a proposed action and alternatives to that proposed action must be disclosed in an Environmental Impact Statement (EIS).

Information presented in this chapter supplements the broader and less technical descriptions included in the body of the EIS. This discussion includes basic assumptions, modeling components and inputs, rules, methods, and constraints. Additional information and documents used in the analysis process are contained in the planning process records. The planning record in its entirety is incorporated here by reference.

FRAMEWORK OF THE PLANNING PROCESS

The general planning process described in 36 CFR 219.12 (1982 regulations) was used to guide the revision of the George Washington National Forest Land and Resource Management Plan. This 10-Step process is described briefly below, followed by a more detailed discussion of Steps 2, 3, 4, and 6.

STEP 1, Identification of Purpose and Need: Issues, Concerns, and Opportunities. The Forest Interdisciplinary Team assessed changes in public issues, management concerns, and resource use and development opportunities since the Plan was initially developed and subsequently amended. To gain an understanding of public issues, 40 workshops were held for collaboration on issues and management options, as described in Appendix A of this EIS. In addition, information was reviewed and evaluated from numerous assessments, reports, action plans and initiatives from state and local government entities, such as the Virginia and West Virginia Statewide Forest Assessments, State Wildlife Action Plans, the Southern Appalachian Assessment, and County Comprehensive Plans for the counties with National Forest System lands.

STEP 2, Planning Criteria. Criteria are designed to guide the collection and use of inventory data and information; the analysis of the management situation; and the design, formulation, and evaluation of alternatives. This step establishes guidelines for accomplishing the next five steps. Planning criteria are based on:

- Laws, executive orders, regulations and agency policy as set forth in the Forest Service Manual
- Goals and objectives in the USDA Forest Service's Strategic Plan 2007-2012
- Recommendations and assumptions developed from public issues, management concerns, and resource use and development opportunities
- The plans and programs of other federal agencies, state and local governments, and Indian tribes
- Ecological, technical and other factors
- The resource integration and management requirements in 36 CFR 219.13 through 219.27

- Alternatives that are technically possible to implement
- Alternatives that meet management requirements or standards
- Various levels of multiple-use objectives and outputs achieved

STEP 3, Inventory Data and Information Collection - The kind of data and information needed is determined in Step 3 based on the issues, concerns, and opportunities identified and the resulting assessment of the management situation and determination of what needs to change. Data collection is part of normal Forest operations. Existing data is used whenever possible and supplemented with new data, when practicable. Data accuracy is continually evaluated. Much of this data and background documentation is on file in the planning records on file in the Supervisor's Office.

STEP 4, Analysis of the Management Situation - This step describes the existing situation on the Forest and determines if there is a need to change current management direction. It examines supply potentials and market assessments for goods and services, assesses demand for goods and services from National Forest lands, and determines suitability and feasibility for meeting needs. This information provides the basis for formulating an appropriate range of reasonable alternatives.

STEP 5, Formulation of Alternatives - A reasonable range of alternatives is formulated according to NEPA procedures. Alternatives are formulated to assist in identifying one that comes nearest to maximizing net public benefits (NPB). They provide for the resolution of significant issues and concerns identified in Step 1. Chapter 2 of the EIS describes the formulation of alternatives for the George Washington National Forest in more detail.

The alternatives reflect a range of resource management programs. Each identified major public issue and management concern is addressed in different ways in the alternatives. The programs and land allocations in each alternative represent the most cost-efficient way of attaining the goals and objectives for that alternative. Both priced and non-priced goods and services (outputs) are considered in formulating each alternative.

STEP 6, Estimated Effects of Alternatives - The physical, biological, economic and social effects of implementing each alternative are described in Chapter 3 of the EIS to evaluate how well each alternative responds to issues, concerns and opportunities and what the potential impacts to resources might be.

STEP 7, Evaluation of Alternatives - Physical, biological, economic and social effects of implementing alternatives are used to evaluate each alternative and compare them with one another. Typically, each alternative can be judged on how it addresses the significant issues identified in Chapter 1 of the EIS.

STEP 8, Preferred Alternative - The Forest Supervisor reviews the Interdisciplinary Team evaluation of each alternative and the public issues and concerns. The Forest Supervisor then recommends a preferred alternative to the Regional Forester. The Regional Forester either selects the Forest Supervisor's recommendation, another alternative, or modifies the alternative recommended by the Forest Supervisor. This alternative is described as the Selected Alternative in this EIS and is displayed as the Proposed Revised Forest Plan. Public comments are solicited and will be considered in the finalizing of the Revised Forest Plan and EIS.

STEP 9, Plan Approval and Implementation - After the Interdisciplinary Team has reviewed public comments and incorporated any necessary changes into the Final EIS and the Revised Forest Plan, the Regional Forester reviews and approves the Revised Forest Plan and Final Environmental Impact Statement. A Record of Decision documents this step.

STEP 10, Monitoring and Evaluation - The Revised Forest Plan establishes a system of measuring, on a sample basis, actual activities and their effects, and compares these results with projections contained in the Revised Forest Plan. Monitoring and evaluation comprises an essential feedback mechanism to ensure the Revised Forest Plan is dynamic and responsive to change. Chapter 5 of the Revised Forest Plan displays the Monitoring and Evaluation program.

PLANNING CRITERIA (STEP 2)

Laws

Alternatives should meet the intent of the Organic Administration Act and Weeks Law identifying the purpose of the National Forest to improve and protect the forest, to secure favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the U.S.

Alternatives should meet the intent of the Multiple-Use Sustained-Yield Act of 1960 to administer the National Forest for outdoor recreation, range, timber, watershed, and wildlife and fish purposes. These resources are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some land will be used for less than all of the resources; and harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output.

Alternatives should meet the intent of the Forest and Rangeland Renewable Resources Planning Act of 1974 as amended by the National Forest Management Act of 1976 including requirements to provide for multiple use and sustained yield of the products and services obtained therefrom in accordance with the Multiple-Use Sustained-Yield Act of 1960, and, in particular, include coordination of outdoor recreation, range, timber, watershed, wildlife and fish, and wilderness.

Alternatives should comply with the Clean Water Act, Endangered Species Act and other applicable laws. Protection of water quality to provide for current and future beneficial uses will be a high priority in all alternatives.

National Direction (formerly RPA Program)

The goals and objectives of the Forest Service Strategic Plan 2007-2012 will be addressed as applicable to the George Washington National Forest. These include:

Goal 1. Restore, Sustain, and Enhance the Nation's Forests and Grasslands
- Objective 1.1 Reduce the risk to communities and natural resources from wildfire
- Objective 1.2 Suppress wildfires efficiently and effectively
- Objective 1.3 Build community capacity to suppress and reduce losses from wildfires
- Objective 1.4 Reduce adverse impacts from invasive and native species, pests, and diseases
- Objective 1.5 Restore and maintain healthy watersheds and diverse habitats

Goal 2. Provide and Sustain Benefits to the American People
- Objective 2.1 Provide a reliable supply of forest products over time that (1) is consistent with achieving desired conditions on NFS lands and (2) helps maintain or create processing capacity and infrastructure in local communities
- Objective 2.3 Help meet energy resource needs

Goal 4. Sustain and Enhance Outdoor Recreation Opportunities
- Objective 4.1 Improve the quality and availability of outdoor recreation experiences
- Objective 4.2 Secure legal entry to national forest lands and waters
- Objective 4.3 Improve the management of off-highway vehicle use

Goal 5. Maintain Basic Management Capabilities of the Forest Service
- Objective 5.1 Improve accountability through effective strategic and land management planning and efficient use of data and technology in resource management
- Objective 5.2 Improve the administration of national forest lands and facilities in support of the agency's mission

Public Issues
The significant issues, as described in Chapter 1 of the EIS, will be addressed in the development and evaluation of alternatives.

Management Concerns and Resource Use and Opportunities
The Analysis of the Management Situation will identify management concerns, recommendations on the need to change the Forest Plan, and resource opportunities.

Plans and Programs of Other Agencies and Governments
Plans and programs of Federal agencies, State and local governments, and Indian tribes will be reviewed as required in 36 CFR 219.7(c). This will include county comprehensive plans, state wildlife action plans and state forest assessments.

Ecological Factors
The forest plan and alternatives will consider the effects of climate change on forest resources and the effects of forest activities on climate change. The management actions needed to restore, sustain, and/or enhance the composition, structure, and function of the ecological communities within the Forest will be evaluated.

Economic Factors
As addressed in 36 CFR 219.1(a), the plan shall provide for multiple use and sustained yield of goods and services from the National Forest System in a way that maximizes long-term net public benefits in an environmentally sound manner. Budget constraints based on past funding trends will be used in the development of desired conditions and objectives to provide meaningful measures that can reasonably be expected.

Resource Integration: Timber resource land suitability
During the forest planning process, lands which are not suited for timber production shall be identified in accordance with the criteria in 36 CFR 219.14.

Resource Integration: Vegetation management practices
When vegetation is altered by management, the methods, timing, and intensity of the practices determine the level of benefits that can be obtained from the affected resources. The vegetation management practices chosen for each vegetation type and circumstance shall be defined in the forest plan with applicable standards and guidelines and the reasons for the choices as identified in 36 CFR 219.15.

Resource Integration: Timber resource sale schedule
In a forest plan, the selected forest management alternative includes a sale schedule which provides the allowable sale quantity. The sale schedule of each alternative, including those which depart from base sale schedules, shall be formulated in compliance with 36 CFR 219.16.

Resource Integration: Evaluation of roadless areas
Unless otherwise provided by law, roadless areas within the National Forest System shall be evaluated and considered for recommendation as potential wilderness areas during the forest planning process, as provided in 36 CFR 219.17. The first step in the evaluation of potential wilderness is to identify and inventory all areas within National Forest System (NFS) lands that satisfy the definition of wilderness found in section 2(c) of the 1964 Wilderness Act. Areas of potential wilderness identified through this process are called potential wilderness areas. Follow the "Guidance on How to Conduct the Potential Wilderness Area Inventory for the Revision to the Revised George Washington National Forest Plan." Carefully evaluate potential wilderness areas as potential additions to the National Wilderness Preservation System to determine the mix of land and resource uses that best meet public needs. An area recommended as suitable for wilderness must meet the tests of capability, availability, and need. In addition to the inherent wilderness quality it possesses, an area must provide opportunities and experiences that are dependent upon or enhanced by a wilderness environment. Also consider the ability of the Forest Service to manage the area as wilderness. (FSH 1909.12 CHAPTER 70 - WILDERNESS EVALUATION)

Resource Integration: Wilderness management
Forest planning shall provide direction for the management of designated wilderness and primitive areas in accordance with the provisions 36 CFR 219.

Resource Integration: Fish and wildlife resource
Fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area. For planning purposes, a viable population shall be regarded as one which has the estimated numbers and distribution of reproductive individuals to insure its continued existence is well distributed in the planning area. In order to insure that viable populations will be maintained, habitat must be provided to support, at least, a minimum number of reproductive individuals and that habitat must be well distributed so that those individuals can interact with others in the planning area. Each alternative shall establish objectives for the maintenance and improvement of habitat for management indicator species as identified in 36 CFR 219.19.

Resource Integration: Grazing resource
Grazing may be used as a tool to meet habitat diversity objectives or recreation objectives.

Resource Integration: Recreation resource
To the degree consistent with needs and demands for all major resources, a broad spectrum of forest and rangeland related outdoor recreation opportunities shall be provided for in each alternative. Planning activities to achieve this shall be in accordance with 36 CFR 219.2. The identification of recreation opportunities will include an updated inventory of Recreation Opportunity Spectrum classification. The Scenery Management System will be used in planning to identify visual resources and guide management of these resources. The plan will provide a diversity of recreation opportunities on the Forest including motorized and non-motorized recreation.

Resource Integration: Mineral resource
Mineral exploration and development in the planning area shall be considered in the management of renewable resources as identified in 36 CFR 219.22. Private mineral rights will be considered in all decisions made in the planning process. The environmental analysis will evaluate alternatives for oil and gas leasing availability and the Record of Decision will include a decision on the designation of those lands administratively available for federal oil and gas leasing (36 CFR 228.102).

Resource Integration: Water and soil resource
Forest planning shall provide for protection and management of the water and soil resource as identified in 36 CFR 219.23. The identification of water uses will highlight public drinking water supplies on the Forest and nearby sources that rely on waters of the National Forest. It will also discuss the potential for future requests for water withdrawals.

Resource Integration: Cultural and historic resources
Forest planning shall provide for the identification, protection, interpretation, and management of significant cultural resources on National Forest System lands. Planning of the resource shall be governed by the requirements of Federal laws pertaining to historic preservation, and guided by 36 CFR 219.24.

Resource Integration: Research natural areas
There are no new Research Natural Areas (RNAs) currently being considered for identification.

Resource Integration: Diversity
Forest planning shall provide for diversity of plant and animal communities and tree species consistent with the overall multiple-use objectives of the planning area. Such diversity shall be considered throughout the planning process. Inventories shall include quantitative data making possible the evaluation of diversity in terms of its prior and present condition. For each planning alternative, the interdisciplinary team shall consider how diversity will be affected by various mixes of resource outputs and uses, including proposed management practices as identified in 36 CFR 219.26. The diversity analysis should be based on processes readily identifiable with other state or national systems, such as NatureServe. The analysis will address both ecosystem and species diversity. The diversity analysis will include karst.

Management Requirements

The minimum specific management requirements to be met in accomplishing goals and objectives for the National Forest System are set forth in this section. These requirements guide the development, analysis, approval, implementation, monitoring and evaluation of forest plans.

Resource protection. All management prescriptions shall--

(1) Conserve soil and water resources and not allow significant or permanent impairment of the productivity of the land;

(2) Conserve geologic resources to minimize geologic hazards and protect sensitive karst areas and their related groundwater and biodiversity resources;

(3) Consistent with the relative resource values involved, minimize serious or long-lasting hazards from flood, wind, wildfire, erosion, or other natural physical forces unless these are specifically excepted, as in wilderness;

(4) Consistent with the relative resource values involved, prevent or reduce serious, long lasting hazards and damage from pest organisms, utilizing principles of integrated pest management. Under this approach all aspects of a pest-host system should be weighed to determine situation-specific prescriptions which may utilize a combination of techniques including, as appropriate, natural controls, harvesting, use of resistant species, maintenance of diversity, removal of damaged trees, and judicious use of pesticides. The basic principle in the choice of strategy is that, in the long term, it be ecologically acceptable and compatible with the forest ecosystem and the multiple use objectives of the plan;

(5) Protect streams, streambanks, shorelines, lakes, wetlands, and other bodies of water as provided under paragraphs (d) and (e) of this section;

(6) Provide for and maintain diversity of plant and animal communities to meet overall multiple-use objectives, as provided in paragraph (g) of this section;

(7) Provide for adequate fish and wildlife habitat to maintain viable populations of existing native vertebrate species and provide that habitat for species chosen under 36 CFR 219.19 is maintained and improved to the degree consistent with multiple-use objectives established in the plan;

(8) Be assessed prior to project implementation for potential physical, biological, aesthetic, cultural, engineering, and economic impacts and for consistency with multiple uses planned for the general area;

(9) Include measures for preventing the destruction or adverse modification of critical habitat for threatened and endangered species;

(10) Provide that existing significant transportation and utility corridors and other significant right-of-ways that are capable and likely to be needed to accommodate the facility or use from an additional compatible right-of-way be designated as a right-of-way corridor. Subsequent right-of-way grants will, to the extent practicable, and as determined by the responsible line officer, use designated corridors;

(11) Provide for the acquisition, disposition and exchange of National Forest System lands to address access needs, trespass, fragmentation, and management needs;

(12) Ensure that any roads constructed through contracts, permits, or leases are designed according to standards appropriate to the planned uses, considering safety, cost of transportation, and effects upon lands and resources;

(13) Provide that all roads are planned and designed to re-establish vegetative cover on the disturbed area within a reasonable period of time, not to exceed 10 years after the termination of a contract, lease or permit, unless the road is determined necessary as a permanent addition to the National Forest Transportation System; and

(14) Be consistent with maintaining air quality at a level that is adequate for the protection and use of National Forest System resources and that meets or exceeds applicable Federal, State and/or local standards or regulations.

(15) Meet the (b) Vegetative manipulation; (c) Silvicultural practices; (d) Even-aged management; (e) Riparian area; (f) Soil and water; and (g) Diversity requirements of 36 CFR 219.27.

INVENTORY DATA AND INFORMATION COLLECTION (STEP 3)

Several Interdisciplinary Team meetings were held to evaluate what data were needed to address the significant issues, concerns and opportunities identified in Chapter 1 of the EIS. Existing inventories were reviewed and updated and new information needs were identified and collected, if available. Most of the information was stored in databases, spreadsheets and a geographic information system (GIS).

GIS Data Layers

A geographic information system (GIS) was used to develop the primary Forest Plan revision database. GIS links natural resource tabular information with spatial (map) information. This linkage enabled complex spatial analyses and rapid display for many different physical, biological or administrative resources. The resulting database was used to preliminarily map the allocation of the management area prescriptions, analyze suitable timber lands, build the forest planning model Spectrum analysis areas, and perform other analyses for the revision. To develop the database, the following layers were used in GIS:

1. **The Field Sampled Vegetation database (FSVEG, previously known as CISC)** – the Southern Region's primary forest vegetation and stand inventory information that relates to forest cover type, age, site index, and land classification. The mapping of the management prescriptions for each alternative and the identification of Spectrum analysis areas used FSVEG data from 2006 (the latest update).
2. **Land Status** – This layer contains information on Forest surface ownership and subsurface mineral rights. The latest update for mapping of management prescriptions and Spectrum analyses was the spring of 2010.
3. **Watersheds** – This layer included Hydrologic Unit Code (HUC) mapping at both the fifth and sixth levels.
4. **Riparian** – This layer is an approximation of the riparian habitat on the forest. It is impossible to map the true riparian corridor through the use of GIS due to the complexity of slope, vegetation and other factors that help define the corridor. This coverage was generated by buffering perennial streams, lakes and other water bodies by 100 feet and intermittent streams were buffered by 50 feet on each side.
5. **Potential Wilderness Areas** - Appendix C of the EIS incorporates all the data used in the potential wilderness area identification and evaluation.
6. **Developed Recreation Sites**
7. **Scenery Management System (SMS)** – This layer addressed the visual resources and included attributes related to scenic integrity, distance zone, scenic attractiveness, and concern level.
8. **Recreation Opportunity Spectrum (ROS)** – This layer represented the recreation experience expected in a particular area and included attributes such as rural, roaded natural, semi-primitive motorized and semi-primitive non-motorized. The ROS inventory was updated in 2009.
9. **Transportation** – This layer included state and Forest Service roads and trails within the Forest boundary.
10. **Special Biological Areas** – This layer included known areas with special biological or zoological resources or rare communities.
11. **Current Plan Management Areas** – This layer included all of the management areas and prescription areas from the 1993 George Washington National Forest Plan.
12. **Soils** – This layer included soil types and their characteristics.
13. **Geology -** This layer included geologic formations and lithology, such as limestone, shale, sandstone, granite, etc.
14. **Cultural Resources** – This layer included areas with special historical or cultural emphases.

15. **Streams and Watercourses** – This layer included intermittent and perennial streams, lakes, rivers and ponds.

16. **Special Uses** – This layer included existing special use permits and utility corridors.

17. **LANDFIRE -** (also known as Landscape Fire and Resource Management Planning Tools, www.landfire.gov) is an interagency vegetation, fire, and fuel characteristics mapping program, sponsored by the United States Department of the Interior (DOI) and the United States Department of Agriculture, Forest Service. LANDFIRE produces a comprehensive, consistent, scientifically credible suite of spatial data layers for the entire United States. LANDFIRE data products consist of over 50 spatial data layers in the form of maps and other data that support a range of land management analysis and modeling. Specific data layer products include: Existing Vegetation Type, Canopy, and Height; Biophysical Settings; Environmental Site Potential; Fire Behavior Fuel Models; Fire Regime Classes; and Fire Effects layers based on regional models and sample plot data. The original LANDFIRE Project was designed to use peer-reviewed, consistent, and repeatable scientific methods. Data products are developed through integrating a collection of advanced scientific procedures, including relational databases, georeferenced land-based plots and polygons representing field conditions, satellite-enabled remote sensing, systems ecology, gradient analysis, predictive landscape modeling, and vegetation and disturbance dynamics.

18. **Ecological Zones** – see following description.

Ecological Zones Mapping

Ecological Zones are units of land that can support a specific plant community or plant community group based upon environmental and terrain factors that control vegetation distribution. They may or may not represent existing vegetation, but instead, the vegetation that could occur on a specific site with historical disturbance regimes. They are basically equivalent to LANDFIRE's Biophysical Settings which "represent the vegetation that may have been dominant on the landscape prior to Euro-American settlement and are based on both the current biophysical environment and an approximation of the historical disturbance regime" (LANDFIRE 2009). Ecological Zones in the Southern Appalachian Mountains, identified from plant community composition and cover data, are associated with unique environmental variables and these variables can be characterized by digital models to predict distribution of ecological zones across the landscape (Simon et al. 2005).

Since 2001, Ecological Zones have been mapped in the Southern and Central Appalachian Mountains on over 10 million acres by applying logistic regression coefficients to digital terrain models within a geographic information system. These areas include portions of eastern Kentucky, western North Carolina, northeastern Tennessee, eastern West Virginia, and western Virginia. Much of this work was done in cooperation with The Nature Conservancy (TNC) under the Fire Learning Network (FLN) program. Using the same methodology and framework, ecological zone mapping of the GWNF was completed and reported in *Ecological Zones on the George Washington National Forest First Approximation Mapping* (Simon 2011). The results of that mapping have been included in the analysis for the EIS.

Mapping Methodology Ecological Zone Mapping

Development of the individual Ecological Zone models for the GWNF began with the creation of a spatial database that described the study area environment using landform and environmental variables. The following 25 landform/environmental models (DTMs) were used to characterize these variables:

- Elevation (10 meter DEM)
- Aspect (degrees)
- Aspect (cosine of slope direction)
- Surface curvature
- Surface curvature profile (direction of slope)
- Surface curvature planiform (perpendicular to slope)
- Slope steepness

- Solar radiation (yearly), Solar radiation (growing season)
- Relative slope position (from Wilds 1997)
- Terrain relative moisture index (from Iverson et al. 1997)
- Landform index (from McNab 1993)
- Distance to stream
- Distance to limestone lithology
- Distance to acidic shale lithology
- Distance to non-acidic shale lithology
- Distance to sandstone lithology
- Average annual precipitation
- Difference in elevation from nearest stream
- Local relief
- Valley position
- Surface curvature roughness
- Distance to high snowfall zones
- Distance to rivers
- Difference in elevation from nearest river
- River influence

Results

The relationships between Ecological Zone field plots and environmental variables were analyzed and predictive equations developed. Field plots (3,765) were used as reference data to evaluate the accuracy of the final Ecological Zone map. The relationship between plant community type and the environments in which they occur (and hence the Ecological Zone) can be evaluated by examining the relative importance of environmental variables found to be the best predictors of Ecological Zone location. Some of these relationships were fairly straight-forward, others were not. For example, elevation was the primary environmental factor to define the Spruce and Northern Hardwood distribution but for Shale barrens & Acidic woodlands, it was their association with acidic shale lithology primarily and secondarily with aspect (acidic woodlands) and rivers (shale barrens). Similarly, the primary environmental factor that drove the distribution of Pine-oak heath, on both sides of major ridges, is aspect but for Alluvial forests, it is the distance above streams and valley position. Geologic substrate strongly influenced the distribution of Rich cove and Dry-mesic calcareous forests, i.e., both are centered on limestone lithologies, while elevation and valley position explained nearly three-quarters of the variation in the High elevation red oak model. These relationships were all obvious in the field and from viewing digital terrain data in comparison to individual Ecological Zone models. Not so obvious in the field was the influence of high snowfall areas and the distribution of Northern hardwood coves or why multiple lithologic types contribute information for so many types.

Use of the Ecological Zones in the Forest Plan

Twenty-one different Ecological Zones were identified and mapped in the study area. This mapping was compared with ecological mapping from LANDFIRE, mapping of forest types from the FSVEG database, and mapping from the Virginia and West Virginia GAP datasets. Although the FSVEG database includes forest types as an attribute of stand delineation, there are several reasons why it is not always the best indicator of the ecosystem on the ground. Not all lands on the Forest have received the same level of inventory (e.g. land suitable for timber production versus Wilderness) and stand examinations do not cover as much area as they did in the past. Therefore, it was concluded that the ecological zone mapping was a more adequate representation of the current condition of ecosystems across all lands on the Forest, since it was based on field plots and models with high correlation from key terrain and environmental variables. However, the conditions predicted using the models were adjusted to reflect known on the ground conditions, such as areas planted to white pine, wildlife openings, other types of permanent openings, etc. It was also concluded that the ecological zone mapping did the best at identifying the ecosystem that could occur on a specific site, given historical disturbance regimes. The assumptions used in determining the existing conditions for the ecological indicators used in Chapter 3, Section B of the EIS are in the process paper "Process for Mapping the Existing Ecological Systems and Indicators for the GWNF Revision." The ecological zones were then crosswalked to NatureServe Ecological Systems and Virginia Natural Heritage Program Ecological Groups or Community Types. The NatureServe Ecological Systems were the basis for the models used in LANDFIRE for the Biophysical Settings. These models formed the basis for developing desired attributes and indicators for the GWNF ecosystems used in the Ecological Sustainability Evaluation (ESE) analysis tool, which were translated into the ecosystem plan components.

Transportation Analysis Process (TAP)

As defined in 36 CFR 212.5(b)(1), each national forest must identify the minimum road system needed for safe and efficient travel and for administration, utilization, and protection of National Forest System lands. The minimum system is the road system determined to be needed to meet resource and other management objectives adopted in the relevant land and resource management plan (36 CFR 219), to meet applicable statutory and regulatory requirements, to reflect long-term funding expectations, and to ensure that the identified system minimizes adverse environmental impacts associated with road construction, reconstruction, decommissioning, and maintenance. In 36 CFR 212.5(b)(2), it states that roads no longer needed to meet forest resource management objectives must be identified and therefore, should be considered for decommissioning or for other uses, such as for trails.

A Travel Analysis Process (TAP) was completed in April 2011 for the George Washington National Forest, concurrent with the Plan revision analysis, to identify the minimum road system. The TAP is intended to be a broad scale comprehensive look at the transportation network across the Forest. It is important to note that the TAP does not make any decisions related to roads or motorized trail systems, but it will be used to inform travel management decisions made for individual roads or motorized trails, which will be subject to site-specific environmental analysis through the NEPA process.

The TAP established Forest and District Interdisciplinary Teams (IDTs). The Forest IDT consisted of staff specialists who provided science-based evaluations and coordination with the development of the Revised Forest Plan. The Forest IDT accomplished the following:

- utilized a science based approach prescribed by 36 CFR 212.5(b)(1), addressing the questions at the forest level that are listed in Publication FS-643, "Roads Analysis: Informing Decisions About Managing the National Forest Transportation System;"
- identified indicators that are most relevant to the George Washington National Forest to help determine what risks and benefits should be used to analyze each road. Risks identified included impacts to, or from: 1) Wildlife, 2) Sediment Delivery, 3) Invasive Plants, 4) Aquatic Passage, 5) Public Safety, and 6) Law Enforcement. Benefits identified included: 1) Resource access; 2) Recreation access; 3) Fire/Emergency access; and 4) Wildlife/Plants;
- established criteria for each risk and benefit category based on a high, medium, or low metric. See the following example.

INDICATOR: INVASIVE SPECIES RISKS	
Risk assessment for new introduced populations of undesirable plant or animal species. Vehicles can carry and spread plant parts or seeds or animals into disturbed areas along roads or in the road bed.	HIGH RISK: Roads accessing or within Special Biological Areas Roads accessing/bordering Wilderness Roads along known infestations of highly invasive species which co-occur with known TES locations Roads accessing campgrounds and heavily used dispersed recreation areas MEDIUM RISK: Roads along known infestations (including fishing access in known locations of aquatic invasives) Roads in riparian areas for less than 500 feet (includes crossings) LOW RISK: Other Roads

The District IDTs evaluated each road as to its purpose and its rankings related to the risk and benefits metrics for each indicator. The purpose(s) for each road could include: future resource program needs; current resource program needs; dispersed recreation access; developed recreation access; private property access; arterial roads that are a major through road or highly used spur road that a joins with collector roads; long-term special use access; or could be a potential forest highway (arterial connecting state roads with adjacent private property, used for commuting or recurrent non-forest commercial traffic, etc.). Budget information, maintenance costs, and strategies to mitigate risks and reduce costs were evaluated as well.

Although the TAP identified a final score and recommendation for each road and motorized trail on the GWNF that led to a determination as to whether it should be part of the minimum road system, actual travel management decisions will be made on a project level with site-specific environmental analysis and public involvement. However, the cumulative results of the TAP were used to identify the minimum road system miles needed to implement each alternative, including the amount of new construction and the amount of decommissioning.

ANALYSIS OF THE MANAGEMENT SITUATION (STEP 4)

In addition to the emerging issues, the need for change was identified through the Analysis of the Management Situation for the George Washington National Forest (AMS). This analysis considered the results of monitoring and evaluation, other policy and direction since the previous Plan, the current condition of the resources, and supply and demand factors to determine the need for change in management direction, and the need to change from the 1993 Forest Plan, as well as the ability of the planning area covered by the Forest Plan to supply goods and services. It provided a basis for formulating a broad range of reasonable alternatives. The processes and results for the supply and demand analyses are briefly discussed below. The process records contain the full supply and demand analyses.

Determination of Demand Estimates

Recreation

Estimates for the demand of various recreation opportunities came from several sources, including the National Visitor Use Monitoring (NVUM) data collected in 2006 on the Forest, the 2000-2004 National Survey on Recreation and the Environment (NRSE), the outdoor Recreation participation projections 2010 to 2060 as provided in Outdoor Recreation Trends and Futures: Technical Document Supporting the Forest Service 2010 RPA Assessment, the *2007 Virginia Outdoors Plan* and the *2006 Virginia Outdoors Survey,* and the *2009 Statewide Comprehensive Outdoor Recreation Plan (SCORP) for West Virginia.* Results of the developed and dispersed recreation supply and demand analysis can be found in Appendix A of the Analysis of the Management Situation report.

Range

The range program on the George Washington NF is so small in scope that supply and demand conditions were not considered necessary.

Timber

Estimates for the demand for timber products came from Forest Product Directories for the counties included in the market area, the George Washington and Jefferson National Forests Appraisal Schedule, research done for the Jefferson National Forest, and Forest Inventory and Analysis (FIA) data. Results of the timber supply and demand analysis can be found in Appendix A of the Analysis of the Management Situation report.

Minerals

Future projections of the kind and amount of oil and gas activity that could be reasonably anticipated were identified in the Reasonable Foreseeable Development Scenario (RFD) report prepared by the Bureau of Land Management (BLM). The RFD is based on the assumption that all lands on the Forest would be available for oil and gas leasing under standard lease terms and conditions, except for those areas withdrawn from leasing by law (Wilderness and National Scenic Area). It covers a time period of 15 years and includes all lands within the boundaries of the George Washington National Forest (GWNF) regardless of mineral estate ownership. The RFD was revised by BLM after the Draft EIS and is found in Appendix K of the EIS.

Wilderness

Appendix C of the EIS contains the potential wilderness area inventory and evaluations. The criteria for identifying wilderness candidates for the inventory came from Forest Service Handbook 1909.12, Chapter 70, Amendment 1909.12-2007-1. The Forest’s application of these criteria are described in “Guidance on How to Conduct the ‘Potential Wilderness Area Inventory’ for the Revision to the Revised George Washington Forest Plan,” dated August 21, 2008.

Wildlife and Fisheries

Projections for hunting and fishing are included in the analysis for Recreation in Appendix A of the Analysis of the Management Situation Report.

Benchmark Analysis

Benchmark analysis is specified in the NFMA regulations in 36 CFR 219.12(e) as part of the Analysis of the Management Situation. This analysis is in Appendix B of that report. Benchmarks approximate maximum economic and biological resource production opportunities and are useful in evaluating the compatibilities and conflicts between individual resource objectives and in defining the range within which integrated alternatives can be developed.

Minimum Level of Management Benchmark - 36 CFR 219.12(e)(1)(i). This benchmark represents the minimum level of management needed to maintain and protect the GWNF as part of the National Forest System. This level of management does involve some activities and costs in order to meet the following minimum management requirements:

- Protect the life, health, and safety of incidental users;
- Prevent environmental damage to the land or resources of adjoining lands of other ownerships or downstream users;
- Conserve soil and water resources;
- Prevent significant or permanent impairment of the productivity of the land; and
- Administer unavoidable non-Forest Service special uses and mineral leases, licenses, permits, contracts, and operating plans.

Alternative C in the EIS embodies most of the elements of a minimum level of management; however some activities are allowed in this alternative to make it a more realistic and viable option. The activities in Alternative C that involve more than a minimum level of management include: the continued operation of three ATV use areas; more of an emphasis on non-motorized recreation that would include an increase in trail miles; and continued operation of some developed recreation sites.

Maximum Physical and Biological Production Potential Benchmarks - 36 CFR 219.12(e)(1)(ii). These benchmarks identify the maximum physical and biological production potentials of significant individual goods and services together with associated costs and benefits. For ecological systems, the maximum biological production is represented by the desired conditions for the Cove, Spruce, Northern Hardwood, Oak and Pine systems in Chapter 2 of the Plan.

Maximum Timber Benchmark. This benchmark is used to identify the maximum timber production potential of the Forest, subject to these specifications:

- The objective function maximizes timber volume in the first five decades, with a rollover to maximize present net value for 15 decades.
- All tentatively suitable acres are included, without any management prescription allocations, so every tentatively suitable acre is eligible for harvest.
- No successional habitat constraints are applied.

Several key results of the maximum timber benchmark are:

- 910,000 tentatively suitable acres are allocated to timber production
- Annual harvest is 19.68 MMCF (98.4 MMBF)
- Annual harvest is 10,331 acres
- Cumulative Present Net Value over five decades is $117,447,000
- Long-term sustained yield is 23.66 MMCF

Maximum Wilderness Benchmark. This benchmark is used to identify the maximum potential of the Forest to provide areas that meet the definition of wilderness according to the 1964 Wilderness Act. In Chapter 2 of the EIS, Alternative C represents this benchmark, with the recommendation for wilderness study all of the 37 areas in the Potential Wilderness Area inventory as well as Southern Massanutten Mountain and the Friars Inventoried Roadless Areas. This benchmark represents 386,800 acres recommended for wilderness study and 20,000 existing Wilderness acres.

Maximum Natural Gas Production Benchmark. This benchmark is used to identify the maximum potential for the Forest for natural gas production. This benchmark is represented by the Reasonably Foreseeable Development (RFD) prepared by the Bureau of Land Management that is based on the assumption that all lands on the Forest would be available for oil and gas leasing under standard lease terms and conditions, except for those areas withdrawn from leasing by law. The RFD is described in more detail in Chapter 3 of the EIS. This benchmark represents the construction of 20 vertical exploration/evaluation wells and 50 vertical and 249 horizontal development wells.

Present Net Value Benchmarks – The following benchmarks are described in the 36 CFR 219 regulations.

- 36 CFR 219.12(e)(1)(iii) Monetary benchmarks which estimate the maximum present net value of those resources having an established market value or an assigned value;
- 36 CFR 219.12(e)(1)(iii)(A) For forest planning areas with major resource outputs that have an established market price, monetary benchmarks shall include an estimate of the mix of resource uses, combined with a schedule of outputs and costs, which will maximize the present net value of those major outputs that have an established market price;
- 36 CFR 219.12(e)(1)(iii)(B) For all forest planning areas, monetary benchmarks shall include an estimate of the mix of resource uses, combined with a schedule of outputs and costs, which will maximize the present net value of those major outputs that have an established market price or are assigned a monetary value;

- 36 CFR 219.12(e)(1)(iii)(C) For forest planning areas with a significant timber resource, estimates for paragraphs (e)(1)(iii)(A) and (B) of this section shall be developed both with and without meeting the requirements for compliance with a base sale schedule of timber harvest, as described in s 219.16(a)(1), and with and without scheduling the harvest of even-aged stands generally at or beyond culmination of mean annual increment of growth, as described in s 219.16(a)(2)(iii). The George Washington NF does not have a significant timber resource.

Timber Maximum PNV Benchmark. This benchmark was established to estimate the schedule of outputs and costs that would maximize the present net value of timber production without any constraints, subject to these specifications:

- The objective function maximizes net present value over the entire planning horizon.
- All tentatively suitable acres are included, without any management prescription allocations.
- No successional habitat constraints are applied.

Several key results of the maximum timber benchmark are:

- 910,000 tentatively suitable acres are allocated to timber production
- Annual harvest is 17.66 MMCF (88.3 MMBF)
- Cumulative Present Net Value over five decades is $112,392,000
- Long-term sustained yield is 19.53 MMCF

Maximum Present Net Value Benchmarks were not modeled for resources other than timber since use of the Spectrum Model (linear programming model that determines the best mix of outputs and activities to maximize an objective function, such as present net value) was confined to timber harvest outputs and activities. There is no method to maximize the present net value of other resources but the present net values of several resource programs under each alternative that was evaluated in the EIS is presented in Chapter 3, Section C and also discussed later in this appendix.

Lands Suitable for Timber Production

During forest land and resource management planning, the Forest Service is required to identify lands unsuited for timber production (16 USC 1604(k); 36 CFR 219.14). This identification process involves three stages of analysis. Stage I analysis identifies lands tentatively suitable for timber production. Stage II analysis is designed to explore the financial aspect of varying intensities of timber management on lands identified as tentatively suitable for timber production from Stage I. Stage III analysis identifies lands as unsuited for timber production based upon the management objectives of the various alternatives.

Stage I: Physical Suitability

The first stage of the timber suitability analysis addresses the administrative and physical suitability of the land to be managed for the production of timber. Stage I lands unsuitable for timber production included:

- Lands that do not meet the definition of forest land.
- Lands that have been administratively or congressionally withdrawn from timber production by an act of Congress, the secretary of agriculture, or the chief of the Forest Service.
- Forest lands incapable of producing industrial wood.
- Lands where technology is not available to ensure timber production from the land without irreversible soil and water resource damage.
- Lands where there is no reasonable assurance that they can be adequately restocked.
- Lands where there is inadequate information, primarily due to recent acquisition.

The codes in Table B-1 from the Field Sampled Vegetation database (FSVEG) were used to define the five categories used to determine the Stage I tentatively suitable lands.

Table B-1. Stage I Acres Tentatively Suitable for Timber Production

Categories of Stage I Unsuitable Lands	Defining Information	Current Net Acres
Total National Forest System Lands:		1,065,000
1. Non Forest Land	FSVeg Land Class Codes: 110-Lake 120-Reservoir 140-River 210-Cemetery 220-Powerline 230 Road/Railroad 240-Special Use 250-Wildlife Clearing	(7,000)
2. Withdrawn	Designated Wilderness (1A) Mt. Pleasant National Scenic Area (4F) Research Natural Areas (4B)	(53,000)
3. Irreversible Damage	Land Class Code: 826 - Physical barriers AND Site Index < 70	(28,000)
4. Can't Restock	Forest Type: 99 – Brush AND Stand Condition Class: 15 – Non Stocked	(1,000)
5. Incapable of producing industrial wood	Land Class Code: 900 – Incapable of Industrial Wood OR Site Index < 40	(65,000)
Tentatively Suitable Forest Lands		**911,000**

Stage II: Financial Analysis

The second stage analysis is designed to explore the financial efficiency of different timber intensities on the lands identified as tentatively suitable for timber production in Stage I. It does not identify any lands as unsuitable for timber production. Stage III analysis considers the results of these financial efficiencies in making the final determination of lands suited for timber production.

The financial analysis identifies the present net value (PNV) for the different Spectrum analysis areas. For the purpose of this analysis, PNV is a measure of the discounted timber benefits less the discounted timber management costs, using a 4 percent discount rate. The actual PNV analysis consisted of a Spectrum run which examined all of the silvicultural prescriptions for all of the Spectrum analysis areas. There are many factors that determine the economic efficiency of a timber sale that cannot possibly be modeled using a landscape level planning model such as Spectrum. However, based on this financial analysis, the following primary conclusions were made:

- Clearcutting with natural regeneration has the highest PNV for all analysis areas.
- The analysis areas with the lowest PNV were site index 50 in yellow pine.
- All site index 40 lands were economically inefficient.
- Site index 50 lands that had slopes greater than 55%, with the exception of forest types 48, 53, 56 and 81 (northern red oak-hickory-yellow pine, white oak-northern red oak-hickory, yellow poplar-white oak-red oak, and sugar maple-beech-yellow birch) were economically inefficient.

Stage III: Identification of Suitable Acres

The third stage analysis is accomplished during the formulation of alternatives (Table B-2). Several criteria were used during this stage to identify lands as unsuitable for timber production:

- Based upon consideration of multiple-use objectives for an alternative, the land is proposed for resource uses that preclude timber production. However, in some management prescriptions that are classified as unsuitable for timber production, timber harvest may occur to meet the desired condition of other resources.
- Other management objectives for an alternative may limit timber production activities to the point where management requirements set forth in 36 CFR 219.27 cannot be met.
- The lands are not cost-efficient, over the planning horizon, in meeting forest objectives, which includes timber production.

Table B-2. Stage III Suitability for All Alternatives

Alternative	Acres Unsuitable for Production	Acres Suitable for Production	Percent Suitable for Production
A	715,000	350,000	33%
B	566,000	499,000	47%
C	1,065,000	0	0%
D	570,000	495,000	46%
E	698,000	367,000	34%
F	784,000	281,000	26%
G	616,000	449,000	42%
H and I	613,000	452,000	42%

ESTIMATED EFFECTS OF ALTERNATIVES (STEP 6)

Analysis Tools Used

The primary tools used to estimate the effects of alternatives include several established computer models, numerous spreadsheets and GIS.

Pre-Suppose

Pre-Suppose is a program used to query and sort Forest Inventory and Analysis (FIA) data for use in the growth and yield model. The program allows the user to evaluate, select or discard plots that fit desired criteria and create support files to directly be linked into the Suppose interface for the Forest Vegetation Simulator model.

Forest Vegetation Simulator Model

The primary tool for estimating growth and yield used in the Spectrum model is the Forest Vegetation Simulator (FVS) model. FVS is an individual-tree, distance-independent, growth and yield model. It has its structural roots in the Stand Prognosis Model developed by Albert Stage from the Intermountain Research Station. Staff at the USFS Forest Management Service Center in Fort Collins have now calibrated many variants of the model to specific geographic areas throughout the United States. Each variant used different species-specific growth and yield equations and assumptions. The Southern Variant was used for developing yield tables for the Spectrum model. The Southeastern and Northeastern Variants were also evaluated for use but the Southern Variant provided the best fit for tree species on the George Washington National Forest. The yield tables developed for the Jefferson Forest Plan were used for the GWNF.

FVS allows the user to calculate estimates of forest stand structure and species composition over time and quantify this information to: 1) describe current and future forest stand conditions; 2) simplify complex concepts of forest vegetation into user-defined indices, attributes, etc.; and 3) allow the manager to ask better questions about growth and yield of forested stands and complete analyses to answer those questions. For the purposes of the Southern Appalachian Forest Plan Revisions, Forest Inventory and Analysis (FIA) data for the Southern Region was converted into a format that FVS could use. This data is collected by the Forest Inventory and Analysis Unit of the Southern Research Station for each State on a 10 year cycle in order to provide unbiased, accurate, current, and relevant forest resource information that meets the diverse needs of land stewardship.

Stratification of FIA data was performed based on geological province, forest type, and site index. The dataset from which FIA data could potentially be selected was limited to the Blue Ridge, Ridge and Valley, and/or Cumberland Plateau provinces of Virginia, Kentucky, North Carolina, Tennessee, South Carolina, and Georgia. Forest Type was used to group the data into one of four working groups; upland oak, cove hardwoods, white pine/hemlock, and southern yellow pine. These working groups correspond to analysis area identifiers used in the Spectrum model. Three categories of site indices were used to further stratify the data within these working groups; 50 to 65, 66 to 85, and 86 t0 100. Whenever possible, data selected for a simulation was limited to FIA plots on National Forest System lands in Virginia to simulate conditions on the George Washington National Forest as closely as possible. For common working group/site index combinations (e.g. upland oak in the 66 to 85 site index group) this resulted in an adequate number of stands to provide statistically sound conclusions. However, in some cases (e.g. southern yellow pine on site index 86 to 100) very few FIA plots were found within those constraints. In such cases, selection criteria were broadened to include first, all of Virginia, then to all of the remaining States until an adequate number of FIA plots meeting the working group/site index criteria were selected.

The FVS model structure contains modules for growing trees, predicting mortality, simulating growth reductions due to stocking, calculating tree volumes, and producing reports. Extensions that simulate the effects of Oak Decline and the Southern Pine Beetle on forested stands are also available for use with the Southern Variant. These Pest Extensions predict the number of events, expected mortality, and residual stand structure and composition. In addition to providing input for the Spectrum model, FVS was used in combination with these pest extensions to disclose impacts to the Forest expected from Oak Decline and the Southern Pine Beetle.

Development of the Forest Planning Model (Spectrum)

Land management planning is the major mechanism for making large-scale and long-term forest land allocations and resource management decisions. Planning consists largely of exploring a national forest's productive potential and experimenting with various allocation choices. Modeling is an important planning tool because it permits studying the consequences of choices without actually committing valuable resources to experimentation or having to wait many years to observe an outcome. It can also evaluate whether desired future conditions are feasible when taking all resource management goals and objectives into consideration. However, decisions about land allocations, choosing and pursuing trade-offs, and accepting one result instead of another are made by people, not the model. The model is merely a device for organizing elements of the decision problem, discovering possible choices and identifying potential conflicts. The Spectrum model is an evolved version of FORPLAN, a linear programming model that solves for an overall objective, such as maximizing present net worth of benefits and costs or maximizing the amount of certain yields. It is an excellent tool for determining the most cost-efficient way to reach some objectives and for analyzing the impacts to vegetative conditions over time from various management activities.

In the past, this model has been used to make land allocation decisions; however, for this Forest Plan, those land allocations were essentially determined through the mapping of the management area prescriptions that varied for each alternative. Therefore, within Spectrum, the land allocation/management prescription assigned to every acre was already made in the model through the use of analysis areas. Because silvicultural treatments are one of the primary means of managing vegetation and wildlife habitat, and are easily modeled, the Spectrum model was constructed principally to examine how timber management could be used to achieve the goals and objectives for each alternative and for the individual management prescriptions. The George Washington Spectrum model was therefore constructed to be a timber harvest allocation model, i.e. it was used to model management constraints and determine the most efficient way of meeting management objectives through the use of silvicultural prescriptions. Only benefits and costs pertaining to the timber program were included in the model. The effects from other type treatments on vegetation and other resources, as well as other resource benefits and costs, were addressed outside of the model, based on the timber-related outputs from the Spectrum model.

Spectrum Model Overview

The model was designed and solved in the following steps:

- Model creation - Designing a Spectrum model was the most intensive of the four steps. In this step the modeler input resource data, specified resource interactions, set goals and objectives, outlined management actions, defined activities and outputs, set the planning horizon, stratified the landscape into similar response areas, and input economic data.
- Matrix Generation - Generating the matrix was the process of converting the input from step one to a matrix of rows and columns that the optimization software could solve.
- Optimization of the Solution - The commercial software C-Whiz was used to solve the matrix. The linear programming solver found the best mix of management actions to meet the management objectives.
- Interpretation of the Solution- The final step in the modeling process was to use the reports created in Spectrum and spreadsheets to interpret the results of the optimization and perform sensitivity analyses.

The eight basic components of the Spectrum model include the following and are discussed individually in this section:

1) the planning horizon;
2) land stratification;
3) silvicultural prescriptions;
4) activities and outputs and their associated costs and benefits;
5) rotation ages;
6) yield coefficients;
7) constraints;
8) the overall management objectives.

Planning Horizon

Each Spectrum model has a specified time frame called a 'planning horizon' that may be as short or long as desired and is broken into time periods of 10 years each. The George Washington Spectrum model used a planning horizon of 200 years, with 20 time periods, or decades. Activities and outputs are primarily represented in Spectrum on a decadal basis, occurring at the midpoint of the decade.

Land Stratification (Analysis Areas)

Analysis areas are defined as units of land, not necessarily contiguous, which can be considered to be homogeneous with respect to responses to treatment in terms of yields, costs, and values received for resource outputs. Management objectives or constraints are also expected to be relatively the same throughout an analysis area. In Spectrum, each analysis area is allowed up to six stratification categories to identify its unique responses to treatments, yields, costs, values and constraints. Table B-3 describes the six strata used to determine the analysis areas. The George Washington used a combination of Geographic Information System (GIS) data layers to construct its analysis areas. Initially, a polygon layer of stand information from the Field Sampled Vegetation database (FSVEG) was intersected with layers representing slope, the Recreational Opportunity Spectrum (ROS), the Scenery Management System (SMS), the Ecological Zones, and the allocation of the Forest Plan management prescriptions mapped for each alternative. A stratum may have two resource layers combined in order to keep the number of strata to six.

The Old Growth Community Type classification was used to define the forest cover types. This allowed tracking of changes in these vegetation groupings over time. Yield tables were developed for the four aggregate groupings of these community types. Site index was used to differentiate the growth and yield estimates and the appropriate silvicultural prescriptions allowed. Scenic class and the Recreation Opportunity Spectrum (ROS) were incorporated to apply constraints by management prescription. The beginning successional class of an analysis area was used to track the movement of acres, by community type, in the various successional classes over the planning horizon. Only the management prescriptions that are unsuitable for timber production were not included in the model.

Table B-3. Spectrum Analysis Areas

Stratum of Land	Description	Definition or Code
LEVEL 1 - Vegetation	SAA Old Growth Community Type	FSVeg Forest Type(s)
NH	Northern Hardwoods	81
CNH	Conifer-Northern Hardwoods	2, 3, 4, 5, 8, 9, 10
MMWM	Mixed Mesophytics and Western Mesophytics	41, 50, 56, 70, 71, 82
ERH	Eastern Riverfront and River Floodplain	58, 63, 69, 72, 73, 74, 75
DMO	Dry Mesic Oaks	51, 53, 54, 55
DXO	Dry Xeric Oaks	49, 52, 57, 60
XPPO	Xeric Pine and Pine-Oaks	11, 12, 15, 16, 20, 21, 31, 32, 33, 35, 38, 39, 88
DDMO	Dry and Dry Mesic Oak-Pines	42, 43, 44, 45, 46, 47, 48
MSF	Montane Spruce-Fir	6, 7, 17
SCOAK	Scarlet Oak	59
LEVEL 1 *AGGREGATES	Working groups for timber yield tables	Combinations of Community Types
*CVH	Cove Hardwoods	NH, MMWM, ERH
*UPH	Upland Hardwoods	DMO, DXO, DDMO, SCOAK
*YPN	Yellow Pines	XPPO, MSF

Stratum of Land	Description	Definition or Code
*WPN	White Pines	CNH
	Ecological system	Combinations of Community Types
* COVESYS	Cove Forests	CNH, MMWM
UPH	Oak Forests	DMO, DXO, DDMO
XPPO	Pine Forests	XPPO
NH	Hemlock-Northern Hardwoods	NH
MSF	Appalachian Spruce-Fir	MSF
LEVEL 2 – Site Productivity and Scenery	Site Index and Scenic Class	FSVeg and Scenery Mgmt System
SI4	Very low productivity	Site Index 40
SI5	Low to moderate productivity	Site Index 50-60
SI7	Moderate to high productivity	Site Index 70-80
SI9	High productivity	Site Index 90 and higher
SC1	Very high scenic class	Scenic Class 1
SC2	High scenic class	Scenic Class 2
SC37	Moderate to low scenic class	Scenic Classes 3 through 7
LEVEL 3 – Recreation Experience and Slope	Recreation Opportunity Spectrum and Slope	Recreation Opportunity Spectrum and Areas <= 25% Slope suitable for Group Selection
SPNM	Most primitive	Semi-primitive Non-motorized
SPM	Somewhat primitive	Semi-primitive Motorized
RN	Roaded	Roaded Natural
G	Gentle slopes and accessible, suitable for group selection	Slope <=25%, near existing roads
LEVEL 4 – Management Prescription that are Suitable for Timber Production	Primary Management Emphasis	Description
7A1	Scenic	Highlands Scenic Byway
7B	Scenic	Scenic Corridors and Viewsheds
7C	Recreation	OHV Use Areas
7E2	Recreation	Dispersed Recreation
7F	Scenic	Blue Ridge Parkway
8A1	Wildlife	Mid- to Late-Successional Habitat
8B	Wildlife	Early Successional Habitat
8C	Wildlife	Black Bear Habitat
8E4b	Wildlife	Indiana Bat Secondary Cave Areas
10B	Timber	High Quality Forest Products
13	Wildlife, Timber	Mosaics of Habitat
LEVEL 5 – Successional Stage	Successional Stage	Description
EARLY	Early Successional	Age 0-10, All community types

Stratum of Land	Description	Definition or Code
SAP1	Sapling/Pole Succ.	Age 11-40, Community types NH, CNH, MMWM, DMO, DXO, DDMO, MSF
SAP2	Sapling/Pole Succ.	Age 11-20, Community types ERH, XPPO, SCOAK
MID1	Mid Successional	Age 41-80, Community types NH, CNH, MMWM, DMO, DXO, DDMO, MSF
MID2	Mid Successional	Age 21-60, Community types ERH, XPPO, SCOAK
LATE1	Late Successional	Age 81-100, Community type NH
LATE2	Late Successional	Age 81-110, Community type DXO
LATE3	Late Successional	Age 81-120, Community types MMWM, DDMO, MSF
LATE4	Late Successional	Age 81-130, Community type DMO
LATE5	Late Successional	Age 81-140, Community type CNH
LATE6	Late Successional	Age 61-100, Community types ERH, XPPO, SCOAK
OLD1	Old Successional	Age 101+, Community types NH, ERH, XPPO, SCOAK
OLD2	Old Successional	Age 110+, Community type DXO
OLD3	Old Successional	Age 120+, Community types MMWM, DDMO, MSF
OLD4	Old Successional	Age 130+, Community type DMO
OLD5	Old Successional	Age 140+, Community type CNH
LEVEL 6 - ELEVATION	Description	
HIELEV	Elevation above 3,000 feet	

Silvicultural Prescriptions

The array of potential vegetative treatments applied to an analysis area is represented in the model by sets of actions known as management actions. Generally, a management action in Spectrum refers to a set of treatments or practices designed to develop or protect some combination of resources on a particular land type.

In addition to the ‘no action’ management action, the management actions incorporated in the George Washington’s Spectrum model were the various silvicultural treatments that could be used to meet vegetation manipulation objectives and are referred to as the *silvicultural prescriptions* in Table B-4. All lands were given the option of being assigned to a minimum level of management where no timber harvest would occur.

Table B-4. Spectrum Silvicultural Prescriptions

Management Prescription	Scenic Class	Minimum Level/No Action	Clearcut	SW-CWR	SW-2ST	SW-2A2	SW-2A4	Thin Only	GS
7A1 Scenic Byway	1-2	X			X	X	X	X	X
	3-7	X		X	X	X	X	X	X
7B Scenic Corridors and Sensitive Viewsheds	1-7	X				X	X	X	X
7C ATV Use Area	1	X			X	X	X	X	X
	2-7	X		X	X	X	X	X	X
7E2 Dispersed Recreation Areas - Suitable for Timber	1	X					X	X	X
	2	X				X	X	X	X
	3-7	X		X	X	X	X	X	X
7F Blue Ridge Parkway Corridor	1-2	X					X	X	X
	3-7	X		X	X	X	X	X	X
8A1 Mix of Successional Habitats	1-2	X		X	X	X	X	X	X
	3-7	X		X	X	X	X	X	X
8B Early-Successional Habitat Emphasis	1-2	X			X	X	X	X	X
	3-7	X	X	X	X	X	X	X	X
8C Black Bear /Remote Habitat	1-7	X		X	X	X	X	X	X
8E4b Indiana Bat Secondary Conservation Area	1	X					X	X	X
	2-7	X			X	X	X	X	X
9A1 Source Water Watershed Protection Area	1	X					X	X	X
	2-7	X			X	X	X	X	X
10B Timber Production	1	X		X	X	X	X	X	X
	2-7	X	X	X	X	X	X	X	X
13 Mosaics of Habitat	1	X		X	X	X	X	X	X
	2-7	X	X	X	X	X	X	X	X

- SW-CWR – Shelterwood Coppice with Reserves where the preparatory cut leaves 20 square feet of basal area of primarily non-commercial species which are later removed at a commercial thinning of the new stand or at the final rotation of the new stand.
- SW-2ST – Shelterwood 2-Step with a residual basal area of 40-50 square feet left after the preparatory cut. The overstory removal occurs 10-20 years later.
- SW-2A2 – Shelterwood 2–Aged with a residual basal area of 20 square feet left after the preparatory cut. The overstory removal occurs 30-40 years later.
- SW-2A4 – Shelterwood 2-Aged with a residual basal area of 40 square feet left leaving 8-14 inch trees after the preparatory cut. The overstory removal occurs 40-60 years later.
- GS – Group Selection, uneven-aged management.

Activity Costs and Output Benefits

Management of a national forest yields a variety of public goods and services, many of which can be assigned cost and benefit values, such as timber and minerals. Environmental settings and maintaining or protecting long-term biological productivity of forested lands are examples of public goods created through forest management that cannot be assigned monetary values. Table B-5 and Table B-6 show activity and output variables used in the George Washington Spectrum model and their assigned activity unit costs and priced output benefits. Since Spectrum was designed to model timber management, other resource activity costs and output values were estimated outside of the model.

Costs for timber activities were derived by examining historical budget costs and target attainment estimates and comparing these with the costs used in the Jefferson Plan Spectrum model. In 2004, the timber program was examined in detail during a realignment study and an effort was made to quantify the actual costs per timber activity. Because the relationship between budgets and targets can contain inconsistent variables, it was decided that the costs from the timber program realignment study were more accurate.

Table B-5. Spectrum Silvicultural Costs

Spectrum Activity	Unit of Measure	Range of Costs per Unit in the Model
Timber Sale Coordination with Other Resources	MCF (thousand cubic feet)	$309-$340
Harvest Administration	MCF	$31-40
Pre-commercial Thinning	Acre	$161
Timber Sale Preparation	MCF	$139-174
Site Preparation	Acre	$213-245
Timber Stand Improvement	Acre	$161-186

Timber revenues were estimated from a review of volume weighted average high bid values by species from 1997-2009. From this data, species were grouped into the following appraisal groups with similar revenues: high value hardwood sawtimber, moderate value hardwood sawtimber, low value hardwood sawtimber, white pine sawtimber, southern yellow pine sawtimber, hardwood pulpwood and softwood pulpwood. Examples of high value hardwood sawtimber included white oak, northern red oak, ash, and yellow poplar. Moderate value included hickory, chestnut oak, and birch.

Table B-6. Spectrum Revenues

Spectrum Output	Unit of Measure	Value per Unit in the Model
High Value Hardwood Sawtimber	MCF (thousand cubic feet)	$1,432
Moderate Value Hardwood Sawtimber	MCF	$926
Low Value Hardwood Sawtimber	MCF	$632
Southern Yellow Pine Sawtimber	MCF	$527
White Pine Sawtimber	MCF	$675
Hardwood Roundwood	MCF	$53
Pine Roundwood	MCF	$86

The amounts of road construction and reconstruction needed to access future timber harvests were not calculated in the Spectrum model for several reasons. Permanent road construction for the alternatives analyzed in the EIS ranged from 0 to 4.1 miles per year. Spectrum is not a spatial model; therefore it is difficult to address accessibility. However, costs of roads were included in the Present Net Value analysis in Chapter 3, Section C of the EIS.

Timber Yields

Since the yield tables that were developed for the Jefferson Forest Plan were used for this Forest Plan, the following describes the development of those tables. There were several steps in building the growth and yield tables. The first step was to select the Forest Inventory and Analysis (FIA) stands to be used in simulations in the Forest Vegetation Simulator (FVS model). Stratification of this data was performed based on geological province, forest type, and site index. The dataset from which FIA data could potentially be selected was limited to the Blue Ridge, Ridge and Valley, and/or Cumberland Plateau provinces of Virginia, Kentucky, North Carolina, Tennessee, South Carolina, and Georgia. Forest Type was used to group the data into one of four working groups: upland oak, cove hardwoods, white pine/hemlock, and southern yellow pine. These working groups correspond to analysis area identifiers used in the Spectrum model. Three categories of site indices were used to further stratify the data within these working groups: 50 to 60, 70 to 80, and 90 to 100.

Whenever possible, data selected for a simulation was limited to FIA plots on National Forest System lands in Virginia to simulate local conditions as closely as possible. For common working group/site index combinations (e.g. upland oak in the 70-80 site index group) this resulted in an adequate number of stands to provide statistically sound conclusions. However, in some cases (e.g. southern yellow pine on site index 90 to 100) very few FIA plots were found within those constraints. In such cases, selection criteria were broadened to include first, all of Virginia, then to all of the remaining southern states until an adequate number of FIA plots meeting the working group/site index criteria were selected.

The summary statistics for individual plots meeting the selection criteria were then reviewed for any obvious outliers. Stocking (basal area), trees per acre, and average diameter values were compared to published stocking charts (USDA Forest Service Agricultural Handbook 355) to identify selected FIA plots that were understocked. These understocked plots were eliminated from the simulation as needed.

The next step was to calibrate FVS to provide growth rates, volumes yielded, and mortality due to competition based on past and professional experience. Through a number of parameters, FVS can be customized to reflect local conditions. Based on volumes yielded from past harvesting data on the Forest coupled with professional experience with the average stand densities and diameters commonly found on the Forest, FVS was calibrated to simulate the forest stand dynamics that can be expected on the forests in this area.

The selected sets of FIA plots within these working group/site index combinations were then run through the calibrated FVS Southern Variant to show present volumes and predict growth and yield 150 years into the future. These were termed the “grow only” simulations. While the total volume output by FVS matched historical yield data from past timber harvests quite well, the allocation of that total volume between sawtimber and pulpwood volumes was not acceptable based on past harvest yield data. Therefore, the total volume output by FVS was then imported into a spreadsheet that allocated the division of pulpwood and sawtimber based on past harvest data considering working group and site index. For each of the four working groups, the spreadsheet also summarized the volume into the six appraisal groups that were modeled in Spectrum (high value hardwood sawtimber, moderate value hardwood sawtimber, low value hardwood sawtimber, white pine sawtimber, southern yellow pine sawtimber, hardwood pulpwood and softwood pulpwood). It also converted cubic feet, the unit output by FVS, into thousand cubic feet, the unit required by Spectrum. A comma-delimited file was then taken from the spreadsheet and imported into Spectrum.

The impact of some harvesting practices in growth and yield were also simulated using FVS. While the even-aged regeneration harvest methods (shelterwoods) were simulated simply by taking a percentage of the total standing volume from the grow only yield tables, partial harvests such as thinnings needed to be simulated in FVS. This is because thinning a stand significantly alters the growth and yield of the residual stems that would then be captured in a final harvest. While the same is true for shelterwood harvests, the length of time elapsing from the first entry to the final harvest is too small for this effect to be meaningful. In the case of the shelterwood with reserves and coppice with reserves treatments, so little standing volume is left and is not harvested in this rotation, that any growth accrued on those stems was deemed inconsequential. Three thinning regimes were modeled; a pre-commercial thinning at age 15, a commercial thinning at age 55, and a combination of both the pre-commercial and commercial thinning. Separate yield tables were produced following a similar process described above for each of these regimes. The plots selected for these simulations were further stratified by age; only stands less than 15 years old were selected for the pre-commercial and combined simulations and only stands less than 55 years old were used in the commercial thinning simulations. Uneven-aged management was also simulated for a subset of the working group/site index combinations in the form of group selection. When we compared these outputs to the grow only runs, it was apparent that simply taking a percentage (i.e. 10% of the volume for a 10 year entry cycle and 100 year rotation scenario) yielded results very close to those produced by FVS. Based on this comparison and in the interest of simplifying the modeling process, it was decided to simulate uneven-aged management by simply taking a percentage of the 'grow only' yield tables. The prescription of managing open woodland conditions was simulated by initiating a shelterwood harvest, including a pre-commercial thinning costs and eliminating the final overstory removal harvest.

Timber yields were also used to determine the culmination of mean annual increment (CMAI) for the working groups. CMAI is the age at which the average rate of annual tree growth stops increasing and begins to decline. Mean annual increment is expressed in cubic feet measure and is based on expected growth. The planning regulations at 36 CFR 219.16(a)(2)(iii) state that all even-aged stands scheduled to be harvested during the planning period will generally have reached the culmination of mean annual increment of growth. The CMAI for the working groups were determined as follows:

Working Groups CMAI Ages

Working Group	CMAI Age
White Pine	55
Cove Hardwoods	50
Upland Hardwoods	65
Southern Yellow Pine	45

Constraints

The land allocation mapping of management area prescriptions for each alternative essentially applied that alternative's overall goals, objectives and resource constraints to the land base. Therefore the Spectrum models constructed for each alternative were initially identical, with the exception of a new set of analysis areas for each alternative that resulted from a different mix of management prescriptions and a few constraints. The same set of silvicultural prescriptions, costs, benefits, yields, rotation ages and constraints related to successional stages, scenery and recreation opportunity spectrum were used for each alternative.

Constraints identified as "management requirements" (36 CFR 219.27) were applied to all alternatives. Additional constraints common to all alternatives were applied to insure an implementable solution. These common constraints fell into four categories: 1) constraints which assign congressionally and administratively designated areas to specific prescriptions, 2) constraints which ensure that the management requirements are met in each alternative, 3) timber scheduling constraints, and 4) operational constraints which constrain timber harvest to a realistic solution.

The following requirements, or constraints, were applied to all Spectrum model alternatives:

- Silvicultural prescriptions were not modeled within the riparian habitat within any of the management prescriptions.
- Although lands with a site index below 50 were represented in the model for growth and yield estimates, those lands were not allowed to be scheduled for harvest (financially inefficient).
- Group selection was prohibited from occurring in yellow pine stands and old successional stage stands.
- The Long-Term Sustained Yield (LTSY) constraint was used to ensure that the harvest of timber in the last decade is not greater that the long-term timber production capacity of the Forest. Long-term sustained yield capacity was computed using the acreage scheduled to each regeneration prescription applied in the model.

- The perpetual timber harvest constraint was used to ensure that the remaining timber inventory would allow achievement of non-declining harvest levels beyond the modeling horizon. To achieve this condition the constraint required that the Forest contain as much timber inventory volume at the end of the last period as the Forest would have, on the average, under the management intensities selected in the analysis. Without this constraint the Spectrum model would have no reason to leave enough inventory at the end of the planning period to sustain timber harvest levels into perpetuity.
- The non-declining yield constraint was used to ensure that the harvest of timber in a decade was greater than or equal to the harvest of timber in the previous period. This constraint indirectly limited the model to a lower present net value and reduced flow of timber in the early decades but also provided community economic and social stability through the controlled flow of timber.
- Timber harvests on lands classified as suitable for timber production were not scheduled for regeneration before the culmination of mean annual increment (CMAI). This constraint, indirectly applied through the harvest timing options allowed, ensured that relatively large sawtimber would be produced and ensured that smaller trees were not harvested before the site was completely utilized.
- The Allowable Sale Quantity (ASQ) was constrained to be no greater or less than 10 percent of that in the previous decade in order to provide a more even flow.
- The amount of clearcutting was constrained to a maximum of 5% of the total acres harvested.
- The proportion of harvest between the Oak, Pine and Cove hardwoods ecological systems was constrained to reflect the desired conditions and objectives for each of those systems.
- The amount of thinning was constrained between 200-400 acres per year to meet open canopy desired conditions.
- For each alternative Spectrum was constrained to be within the range of annual acres of regeneration by timber harvest according to the following alternative objectives. The Allowable Sale Quantity (ASQ) was determined from the model run at the highest end of the range since ASQ represents a ceiling of volume that may be sold.

Alternative						
A	B	D	E	F	G	H and I
2400	1800-3000	3000-5000	1800-3000	1000-1800	1800-3000	1800-3000

Objective Functions

The objective function allows specification of an overall objective of the alternative to be met in a given run of the model while all constraints otherwise specified are met. The objective function chosen for Alternative A was to maximize present net value. The objective function chosen for Alternative B, E, F, G, H and I was to maximize the amount of early successional habitat. The objective function chosen for Alternative D was to maximize volume.

Ecological Sustainability Evaluation Process and Tool (ESE)

The Forest Service developed a relational database, the Ecological Sustainability Evaluation (ESE) tool, based on the structure used by The Nature Conservancy (TNC) in their Conservation Action Planning Workbook (TNC 2005). The ESE tool served as the primary process record for ecological sustainability analysis. It included documentation of scientific and other sources consulted, uncertainties encountered, and strategic choices made during development of the database. In addition, the tool documented the many relationships among parts of the framework. For example, species were often related to one or more characteristics of ecosystems, and a given plan component frequently contributed to multiple ecological systems or species.

The following steps were used to build an ecological sustainability framework, with each step documented within the ESE tool. Although these steps are presented sequentially, the process required much iteration.

1. Identify and define ecological systems

To define terrestrial ecosystem diversity, all terrestrial ecological systems on the GWNF were identified using NatureServe's International Ecological Classification Standards (NatureServe 2004). Each system was defined in terms of existing Forest Service forest types and in terms of the LANDFIRE Vegetation Dynamic Models. Current acreage of each system was calculated using Forest Service GIS data. All identified terrestrial ecological systems were included in the ecological sustainability framework. These systems were also crosswalked with the Virginia Department of Conservation and Recreation Natural Heritage Program Vegetation Community types. The framework for diversity of aquatic ecological systems is described in the Aquatic Ecological Sustainability Analysis (Appendix G of the EIS).

2. Identify species

To assess species diversity, a comprehensive list of plant and animal species was compiled by combining species lists from a variety of sources. These sources included federally-listed threatened and endangered (T&E) species obtained from the U.S. Fish and Wildlife Service; species that are tracked by the Virginia Department of Conservation and Recreation Natural Heritage Program and the West Virginia Division of Natural Resources; species identified in the Virginia and West Virginia State Comprehensive Wildlife Conservation Strategies as species of conservation concern: the Birds of Conservation Concern list compiled by the U.S. Fish and Wildlife Service; and the Regional Forester's list of sensitive species for the Southern Region. Species were then screened for inclusion in the framework. The criteria and process for identifying, screening and grouping species are detailed in the Species Diversity Report (Appendix F of the EIS).

3. Identify and define characteristics of ecosystem diversity and related performance measures

To identify key characteristics and performance measures for terrestrial ecological systems, Forest Service biologists reviewed information in NatureServe, LANDFIRE, Virginia Department of Conservation and Recreation Natural Heritage Program community types, and other information.

4. Link species to the ecological systems and identify any additional needs of species

Species were then linked to terrestrial ecological systems. Where useful, species were grouped before linking them to systems. Where ecological conditions for these species were not covered by the ecosystem diversity framework, additional characteristics, performance measures, and rating criteria were added to the framework to cover these needs. All species have at least some of their needs covered by ecosystem diversity, but some species required additional plan components based on their major limiting factors. The ways in which individual species needs were addressed by ecosystem diversity components and additional Plan provisions are described in the Species Diversity Report.

5. Assess current condition of performance measures

Current values and ratings of all performance measures were estimated using a variety of methods. Many current values were derived through analysis of existing GIS databases. Assumptions and methods for determining current values and ratings are recorded in the ESE tool.

6. Develop plan components

In this step, plan components were proposed that would be expected to provide for characteristics of ecosystem diversity and ecological conditions for species. These plan components were then linked with characteristics and conditions within the ESE tool. In some cases, we identified where relevant provisions are made outside of plan components through other current requirements and processes. We ensured that all elements of the framework were addressed by appropriate management direction.

Aquatic Ecological Sustainability Analysis

The GWNF developed an aquatic habitat classification to facilitate the Aquatic Ecological Sustainability Analysis. The methods used in this classification follow the basic structure of The Nature Conservancy (TNC) aquatic community classification, and the Virginia and West Virginia Comprehensive Wildlife Action Plans, yet habitat classifications were focused on land managed by the GWNF.

As described in Appendix G of the EIS, this habitat classification is hierarchical and is based on an understanding of how habitat influences the composition and distribution of aquatic biological communities. It is based on four assumptions (Higgins et al. 1998):

1. Physiographic and climatic patterns influence the distribution of organisms, and can be used to predict the expected range of biological community types (Jackson and Harvey 1989; Tonn 1990; Maxwell et al. 1995; Angermeier and Winston 1998; Burnett et al. 1998).

2. The physical structure of aquatic habitats (or ecosystems) can be used to predict the distribution of aquatic communities (Gorman and Karr 1978; Schlosser 1982).

3. Aquatic habitats are continuous; however, generalizations about discrete patterns in habitat use can be made (Vannote et al. 1980; Schlosser 1982).

4. Using a nested classification system, (i.e. stream reach habitat types within species ranges), we can account for community diversity that is difficult to observe or to measure (taxonomic, genetic, or ecological) (Frissell et al. 1986; Angermeier and Schollsser 1995).

Sediment Effects Analysis

The most important soil resource issue/concern regarding the effects from the management activities proposed in the various alternatives of the Forest Plan Revision is soil productivity. The impacts to soil productivity are determined by estimates of areal extent (acres) that is affected. Some of the impacts will be short-term (<100 years) and some will be long-term.

A significant impact to soil productivity would be a fifteen percent reduction in productivity in areas that are actively managed. The threshold for allowable impacts to soil productivity has been identified by most regions of the Forest Service as 15 percent of an activity area. Long-term soil productivity must be maintained on at least 85 percent of an activity area. The activity area varies by alternative since each one has different levels of management on different areas of the Forest. When long-term soil productivity is reduced on fifteen percent or more of an area, then this would not be in compliance with the laws and policy guiding FS protection of soil productivity and ecosystem sustainability.

Table B-7. Activity Area for Sedimentation Analysis

	Alt A	Alt B	Alt C	Alt D	Alt E	Alt F	Alt G	Alts H and I
GW Acres included in Activity Area*	1,021,551	1,002,447	636,140	1,008,299	998,601	910,782	1,002,612	995,202

*Activity Area: The area on the Forest where soil disturbing management activity can occur.

By determining the acres of long-term effects to soil productivity for each alternative, we can compare the alternatives and show how extensive the effects are. Each alternative affects long-term soil productivity to some degree. Key indicators used for determining effects to the soil resource were:

- Acres of timber harvest
- Miles of road construction and decommissioning
- Acres of prescribed burning
- Miles of trail construction
- Acres of watershed improvement work
- Mineral development
- Acres of dispersed recreation use

Within each of the key indicators, the following activities were assumed to affect the long-term productivity of the soils for this effects analysis.

- Temporary roads - long-term effect is width of travel way, 12 feet.
- Skid roads have 10 feet of travel way with long-term effects.
- 25% of log landing areas are long-term impact to soil productivity due to blading.
- 75% of the total proposed and existing trail system is a long-term effect to soil productivity due to soil displacement and land use change.
- The acres of developed recreation that is cleaned and checked for trash is used for total existing acres of developed recreation which have long-term effects on soil productivity.
- Construction of oil and gas well sites - all acres are long-term impacts to soil productivity, due to blading.
- Access roads and parallel pipeline construction
- Long-term effects from oil and gas development are due to well pad and road construction.
- Existing oil and gas long-term effects resulting from existing well sites.
- Fire lines constructed with dozer have 8' width with long-term effects.
- Constructed road long-term effect is width of travel way and ditchline/cutslope, 19 feet
- New road right-of-way is 40 feet.

For each alternative a spreadsheet was prepared to show proposed management activities, types of effects, long and short-term effects, existing long-term effects, cumulative long-term effects and the percent of the GWNF area that would be affected long-term.

Other assumptions specific to each indicator include the following, where LT=long-term effect to soil productivity and ST=short-term effect to soil productivity:

Timber management assumptions

- Temp road LT is width of travel way= 12 feet.
- Temp road ST is ROW-12' travel way= 18 feet.
- Skid roads are bladed. Skid trails are not.
- Skid roads have 10 feet of travel way and 12 feet cleared right-of-way.
- Log landings are long-term impact to soil productivity due to blading.
- Skid trails are unbladed, 10 feet wide and are short-term impact due to compaction.
- Effects from a temporary timber road are the same as a FS system road.

Recreation management assumptions

- 100% of the total proposed and existing trail system is a long-term effect to soil productivity due to soil displacement and land use change.
- Existing new trail construction includes motorized and non-motorized trails.
- Long-term impact on 20 acres of dispersed recreation use per District assumed.
- Trails widths: motorized-6 feet, non-motorized-3 feet.

Mineral development assumptions

- Construction of well sites, all acres are long-term impacts to soil productivity, due to blading.
- Pipeline construction, short-term impact due to replacement of topsoil over pipe.
- Existing roads for oil and gas development are included in the effects of FS system roads.
- Long-term effects from oil and gas development are due to well pad and road construction.

Prescribed burning assumptions

- Fire lines constructed with dozer have 8' width, estimates based on 1998, 1999, 2000 on GW and JNFs.
- During a 10-year period, 50% P-burned acres are new and the rest is reburned using existing dozer fire lines.

Watershed improvement assumptions

- Existing soil improvement acres are calculated using 1993-2009 @ 40 per year.

Road management assumptions

- New road ROW is 40 feet. LT 15 feet, ST 25 feet.
- System road long-term effect is width of travel way and ditchline/cutslope= 19 feet
- System road short-term effect is ROW-19' travel way= 21 feet. (40'-19')
- Existing road system is 1818 miles.
- Roads decommissioned have 19 feet width for calculating acres of soil improvement.

Wildlife management assumptions

- Long-term effects from wildlife management are covered in skid road and log landing estimates.

Grazing management assumptions

- No long-term effects to soil productivity from grazing.

Present Net Value Analysis

The 1982 National Forest Management Act (NFMA) implementing regulations (36 CFR 219.1) state that forest plans must "...provide for multiple-use and sustained yield of goods and services from the National Forest System in a way that maximizes long-term net public benefits in an environmentally sound manner." Net public benefits is defined as the overall value to the Nation of all outputs and positive effects (benefits) less all associated inputs and negative effects (costs) whether they can be quantitatively valued or not. Present net value (PNV) is one of the criteria used to determine net public benefits (NPB) in benchmarks and alternatives. It is the difference between the discounted value of all outputs which were assigned a price in the revision and all Forest Service management and investment costs over the analysis period. The PNV converts all costs and benefits over a 50 year planning period to a common point in time. Other benefits of public land management cannot be measured using dollar values. These non-priced benefits are another criteria used to determine NPB. Each alternative was determined and analyzed to achieve its goals and objectives in a manner that produced the greatest PNV while meeting all specified costs and objectives for non-priced benefits. Thus, the PNV of each alternative estimated the highest value of priced benefits while accounting for the costs of producing priced benefits, non-priced benefits, and meeting management requirements. The PNV of each alternative can then be compared directly, even though the actual costs and benefits occur at different times. Two parameters were used in PNV analysis: Base year dollars – All monetary values entered into Spectrum and the PNV analysis were in 2010 dollars; Discount rate – A four percent discount rate was used. It approximates the return on long-range investments above the rate of inflation. All costs and benefits were discounted from the midpoint of each decade.

The output estimates for timber, minerals, recreation and wildlife under each alternative were identified in Chapter 3 of the EIS for the effects analysis and the PNV for each alternative is presented in Chapter 3, Section C. The benefit values for each of these resources came from different sources and are displayed in Table B-8.

Timber benefits were the same as used in Spectrum (from historical timber sale data). The mineral benefits were from market prices for minerals from the Minerals Management Agency. Recreation, hunting and fishing benefits were estimated from J. Michael Bowker et al. (2009), Estimating the Net Economic Value of National Forest Recreation: An Application of the National Visitor Use Monitoring Database, FS 09-02, September 2009, The University of Georgia.

Table B-8. Economic Benefits and Financial Revenue Values used in the PNV Analysis (year 2010 dollars)

Output	Unit	Value
Timber		
Sawtimber-Softwood Price	$/MCF	$650.64
Sawtimber-Hardwood-Price	$/MCF	$1,031.39
Roundwood-Softwood-Price	$/MCF	$52.60
Roundwood-Hardwood-Price	$/MCF	$85.50
Minerals		
Dimension Stone (Limestone)	$/Short Ton	$8.15
Natural Gas-Petroleum	$/Thousand Cubic Meter	$4.50
Recreation/Wilderness		
Camping	$/Visit	$51.26
Driving/Motorized	$/Visit	$43.84
General	$/Visit	$80.03
Hiking	$/Visit	$51.26
Nature/Historical	$/Visit	$51.26
Off-Highway Vehicles	$/Visit	$51.26
Primitive Camping	$/Visit	$76.10
Picnicking	$/Visit	$90.55
Trails (bicycling, horseback riding)	$/Visit	$205.34
Viewing Scenery	$/Visit	$60.01
Wilderness	$/Visit	$76.10
Wildlife Watching	$/Visit	$60.01
Hunting	$/Visit	$140.53
Fishing	$/Visit	$45.96

Socio-Economic Analysis

Much of the social and economic data presented in the Affected Environment section came from the Economic Profile System-Human Dimensions Toolkit (EPS-HDT at www.headwaterseconomics.org). EPS-HDT is a free software application that runs in Excel and accesses published statistics from multiple federal data sources, including the Bureau of Economic Analysis and Bureau of the Census, U.S. Department of Commerce; Bureau of Labor Statistics, U.S. Department of Labor; and others. It generates 14 reports for any part of the nation using any combination of states and counties. The program has been approved for agency use by the USDA Forest Service and the Bureau of Land Management.

IMPLAN

The Forest Service uses IMPLAN (impact for planning analysis) software and FEAST (forest economic analysis spreadsheet tool) to estimate socio-economic impacts and contributions. IMPLAN is an economic model originally developed by the Forest Service, Federal Emergency Management Agency and the Bureau of Land Management. IMPLAN has since been privatized and is now provided by Minnesota IMPLAN Group (MIG). IMPLAN uses a database of economic statistics obtained from major government sources such as the Regional Economic Information System (REIS), Bureau of Economic Analysis, Bureau of Labor Statistics and US Census Bureau. The database in IMPLAN represents 528 economic sub-sectors. The industries are defined by North American Industry Classification System (NAICS) Sectors. A Forest Service-developed spreadsheet known as FEAST was used to apply the IMPLAN results to each alternative, expressed in units of output. FEAST transformed the dollar impact for a given industry from IMPLAN to the various resource outputs by alternative into a specific employment and dollar output.

The input/output analysis is based on the interdependencies of the production and consumption elements of the economy within an impact area. The assumption used in this modeling process was that the impact area comprised the counties within the forest's designated county boundaries. Industries purchase from primary sources (raw materials) and other industries (manufactured goods) for use in their production process. These outputs are sold either to other industries for use in their production process or to final consumers. The structure of interdependencies between the individual sectors of the economy forms the basis of the input/output model. The flow of industrial inputs can be traced through the input/output accounts of the IMPLAN model to show the linkages in the impact area economy. This allows the determination of estimated economic effects (in terms of employment and income).

The IMPLAN model identifies direct, indirect and induced effects associated with an output activity. Direct effects are those economic effects associated with economic activity (e.g., amount of sawtimber sold or recreation use) that occurs in industries tied to forest outputs. Examples of direct industries are the local hotel, which provides lodging to recreationists or the local sawmill that processes National Forest timber. Indirect effects are economic effects associated with spending by industries that provide goods and services to the direct industries. An example is the utility company that provides electricity to the local hotel or sawmill. Induced effects are economic effects associated with household spending caused by changes in activity in the direct and indirect industries. Examples are the local grocery stores and restaurants that supply goods and services to the local economy.

Direct, indirect and induced impacts on jobs and income were estimated from six major Forest-level outputs on the GWNF: recreation use, hunting and fishing use, the amount of timber volume and type of product to be harvested, mineral extraction, payments to states (counties), and Forest Service expenditures (salaries, equipment, contracts). Due to substitution effects from competing non-government sources (such as volume of timber harvesting which may occur on private lands if national forest timber is not offered to the market to meet local demand), these jobs are characterized as being associated with local economic activity initiated by Forest Service programs and activities, rather than directly caused by these activities.

TIMBER PROGRAM ASSUMPTIONS. For Forest Service timber, we have looked at the sawmill and pulpwood industries where our timber goes as the first processing step in manufacturing. Impacts include all those industries initially impacted as well as those industries linked with supplying inputs to production, as well as workers in those industries who then spend wages in their households (known as direct, indirect and induced effects, respectively). Sales data was determined by using timber revenue values multiplied by estimated production levels for each alternative. Hardwood and softwood sawtimber were processed through the sawmill industry (about 70% of the sawtimber volume was processed in the study area). Hardwood and softwood roundwood were processed at the pulp mill (about 30% of the roundwood was processed in the study area). Impacts represent the economic activity occurring in all backward linking sectors associated with the final demand output of the timber industries described above.

RECREATION and WILDLIFE/FISH PROGRAMS ASSUMPTIONS. Recreation and Wildlife and Hunting trips were derived from the National Visitor Use and Monitoring survey, 2006 (NVUM). The resulting calculations yielded trips for Resident and Non-resident Day Use, On National Forest Overnight Use, and Off National Forest Overnight Use. These use metrics were entered into FEAST to link with IMPLAN impact response coefficients to yield an impact for recreation and wildlife resources. Local economic impacts from recreation, hunting and fishing use were determined using non-local use only because there may be substitution opportunities for local residents to spend their discretionary dollar. If some people choose not to recreate on national forest system lands, they may recreate in another manner such as go to sporting events or a movie. The dollars would still be spent in the local economy causing a similar impact, but the provider of recreation would be a different party. Local residents are defined as recreation users within 50 miles of the forest boundary.

Spending Segments

The spending that occurs on a recreation trip is greatly influenced by the type of recreation trip taken. For example, visitors on overnight trips away from home typically have to pay for some form of lodging (e.g., hotel/motel rooms, fees in a developed campground, etc.) while those on day trips do not. In addition, visitors on overnight trips will generally have to purchase more food during their trip (in restaurants or grocery stores) compared to day-use visitors. Visitors who have not traveled far from home to the recreation location usually spend less money than visitors traveling longer distances, especially on items such as fuel and food. Analysis of spending patterns has shown that a good way to construct segments of the visitor market with consistent spending patterns is to use the following seven groupings:

1. local visitors on day trips,
2. local visitors on overnight trips staying in lodging on the national forest,
3. local visitors on overnight trips staying in lodging off the national forest,
4. non-local visitors on day trips,
5. non-local visitors on overnight trips staying in lodging on the national forest,
6. non-local visitors on overnight trips staying in lodging off the forest, and
7. non-primary visitors (visits to the GWNF were not the primary destination for the visit).

The table below shows the distribution of visits by spending segment (data from the National Forests in GWNF NVUM Report 2006). A National Forest visit is defined as the entry of one person onto a national forest to participate in recreation activities for an unspecified period of time. A National Forest Visit can be composed of multiple site visits. The market segments shown here relate to the type of recreation trip taken. A recreation trip is defined as the duration of time beginning when the visitor left their home and ending when they got back to their home. “Non-local” trips are those where the individual(s) traveled greater than approximately 50 miles from home to the site visited. “Day” trips do not involve an overnight stay outside the home, “overnight on-forest” trips are those with an overnight stay outside the home on National Forest System (NFS) land, and “overnight off-forest” trips are those with an overnight stay outside the home off National Forest System land. “Non-primary” trips are those where the primary recreation destination of the trip was somewhere other than the national forest under consideration.

Table B-9. Distribution of Recreation Visits to GWNF by Spending Segment

	Non-local			Local			
	Day	Overnight on NF	Overnight Off NF	Day	Overnight on NF	Overnight Off NF	Total
Percent of NF Visits	5.7%	8.6%	2.7%	77.2%	4.4%	1.4%	100%

MINERAL PROGRAM ASSUMPTIONS. There are two outputs related to the minerals program that were used in the IMPLAN model and estimating present net values: dimension stone (limestone) and natural gas. The value/short ton for dimension stone is $8.15 and the value/million cubic feet (MMCF) for natural gas is $4500.00. The natural gas volumes include what would be developed on federal leases as well as on GWNF land with private mineral rights.

Table B-10. Mineral Program Outputs by Alternative

	Alt A	Alt B	Alts C and I	Alt D	Alt E	Alt F	Alt G	Alt H
Dimension Stone (short tons)								
Each Decade	5,236	4,090	0	4,090	3,671	3,197	3,770	3,770
Natural Gas (MMCF)								
1st Decade	380,060	282,685	70,255	282,685	90,720	232,190	91,330	225,415
2nd Decade	357,620	308,970	60,170	308,970	75,350	241,955	75,730	200,915
3rd Decade	49,320	48,345	7,575	48,345	8,930	36,855	8,940	26,670
Total Natural Gas	787,000	640,000	138,000	640,000	175,000	511,000	176,000	453,000

PAYMENTS TO STATES ASSUMPTIONS. The estimate for Payments to States/Counties was based on a three-year average from 2007-2009.

Projects Approved under the 1993 Forest Plan

Many decisions to conduct management actions were made before the effective date of the Revised Forest Plan, but will not be fully implemented before the Revised Forest Plan goes into effect. These "pre-existing actions" (made under the 1993 Amended Forest Plan) were treated as a part of the baseline for the Environmental Impact Statement and the Revised Forest Plan. The projected effects of these pre-existing actions are part of the cumulative effects analysis documented in the FEIS and Biological Assessment for the Revised Plan. A separate analysis (contained in the project records) was also conducted where it was confirmed that the continued implementation of these previously decided actions would not foreclose the ability to meet the desired conditions and objectives of the new Revised Forest Plan. One particular aspect of the transition between implementing the 1993 Plan and the new Revised Plan worth noting involves projects in watersheds that support the James spinymussel, which is a federally-listed endangered species. For these particular projects, the GWNF and the USFWS had previously agreed to incorporate the more restrictive riparian management requirements found in the Revised Jefferson Plan into those project decisions as mitigation measures. The riparian management directions of the Revised Jefferson Plan are now incorporated into the new Revised GWNF Plan. So in this particular instance, even though those decisions were made before the new Revised Plan goes into effect, they will, in effect, already be implementing the direction of the new Revised Plan.

Table B-11 provides a list of major project decisions containing timber harvest and other management activities that may not be completed until after the 2014 Revised Forest Plan goes into effect.

Table B-11. Projects Approved Under the 1993 Forest Plan That Will Continue to be Implemented

Ranger District	Project Name
Lee	Prescribed Burns (Catback, Church Rock, Indian Grave Ridge, Moody Tract, Second Mountain, Waonaze) Barb Timber Sale Church Rock Timber Sale Breakneck Timber Sale Trout Pond Trail Relocation Squirrel Gap Trail Relocation Gerhard Shelter Trail Relocation Trout Pond Recreation Area Rehabilitation
North River	Special Uses (Todd Lake dam, Briery Branch dam, Hone Quarry dam, Hearthstone dam) Prescribed burns (Augusta Springs, Buck Mountain, Dunkle Knob, Elkhorn, Evick Knob, Gate Ridge, Gauley Ridge, Grindstone, Gum Lick, Hall Springs, Heavener Mountain, Hone Quarry II, Little Fork, Marshall Tract, North New Road Run, North River, Rail Hollow, Slate Lick Fields, Slaty Lick, Turner Run, Walker Mountain, Wallace Tract) Timber Sales (Wallace Marshall, Moffat Creek, Rocky Spur, Back Draft, Sugar Run, Hodges Draft, Big Run, Grindstone, Chestnut Oak Knob, Sidling Hill, Falls Hollow, Tom Lee Draft) Rockingham Timber Stand Improvement Pendleton Timber Stand Improvement Road Maintenance North River Trails Enhancement Phase II Wallace Marshall Stewardship Project
James River & Warm Springs	Central Alleghany Project Humpback Project Back Creek Mountain Vegetation Management Project Warm Springs Mountain Restoration Project Tri County Vegetation Management Project Mares Run Vegetation Management Project Neals Run Prescribed Burn Peters Mountain Access Little Mountain/Mad Anne Vegetation Management Border Restoration Project Brattons Run
Pedlar	Big Bend Vegetation Project Robinson Hollow Vegetation Project Poplar Cove Vegetation Project Mill Creek Dam Rehabilitation Big Piney Vegetation Project Pedlar Timber Stand Improvement Coles Run Dam Rehabilitation and Waterline Replacement

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