Appendix

B

MEDICINE BOW NATIONAL FOREST

Revised Land and Resource Management Plan

Final Environmental Impact Statement

Appendix B Description of the Analysis

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Appendix B

Framework of the Planning Process

The revision of a forest plan is guided by the general planning process described in 36 CFR 219.12. This section discusses ten steps which lead from the completion of a forest plan to the completion of a revised forest plan. These are not consecutive steps and some steps can be repeated. Due to the length of this planning process, most of the products of earlier steps have been updated.

Step 10 – Monitoring and Evaluation (Step 10 of the initial planning process)

The last step of the initial forest plan process is the first step in revising a forest plan. Annual monitoring and evaluation has been done since the forest plan was released in 1985. The monitoring reports have helped the Forest Supervisor identify several reasons to revise the forest plan.

Step 1 – Identifying the Purpose and Need

After the Forest Supervisor determined that a revision was needed, a series of public meetings were organized and held. At these meetings, the public was encouraged to comment on areas in the forest plan that needed revision. Local government officials were also involved at this stage. The feedback was screened into five possible categories of action:

1. Topics that required forest plan revision.
2. Other revision items that would not require a significant amendment but need to be addressed in the Revised Plan.
3. Topics that could be addressed through an amendment to the 1985 Plan.
4. Topics related to plan implementation.
5. Topics outside the scope of a plan revision.

As a result of this planning action, the Regional Forester determined in August 1993 that there were six major revision topics for the forest plan revision:

- Biological diversity
- Roadless areas/Wilderness
- Timber suitability and Allowable Sale Quantity (ASQ)
- Recreation/Travel management
- Wild and Scenic Rivers (Special Areas)
- Oil and Gas

As the planning process continued, other changes not specifically related to the six major topics were also considered, and these revision topics have been reaffirmed. However, the revision topics have become the primary focus of the forest plan revision effort.

Step 2 – Planning Criteria

During this step, the remainder of the process is outlined. As the revised plan was being prepared, several mid-course corrections were necessary, as models were not available or working properly, computer resources or assistance was not available, or public suggestions added additional considerations. In addition the Medicine Bow National Forest was combined with the Routt National Forest which resulted in three Forest Plan revisions. For these reasons, completion of the Revised Plan has taken longer than originally estimated.

Step 3 – Inventory Data and Information Collection

A Geographic Information System (GIS) was used to build the database used in the plan revision. The type of data and information needed for the revision process was based on the revision topics. The data was collected and assembled in a manner meaningful for addressing planning problems, as discussed later in this appendix.

Step 4 – Analysis of Management Situation (AMS)

This step determines the ability of the planning area to supply goods and services in response to society's demands. It provides background information for formulating a broad range of reasonable alternatives. The AMS focused on the revision topics and several of the models described in this appendix were initially developed during this step.

Step 5 – Formulation of Alternatives

Some initial ideas for alternatives were developed and discussed in the AMS. These were further formulated by the interdisciplinary team following NEPA procedures. Broad themes were developed in response to the revision topics. An in-depth review of the goals, objectives, standards, and guidelines in the 1985 Plan was made and possible changes identified. Additional changes were identified by the Rocky Mountain Regional Office to provide consistency across the Region. These changes were packaged together in compatible sets. The alternatives were presented to the public at a series of open-house public meetings during the fall of 2002. After reviewing the comments, the alternatives were further refined into the set that appears in the DEIS.

Step 6 – Estimated Effects of Alternatives

The physical, biological, economic, and social effects of implementing each alternative considered in detail were estimated and compared according to NEPA procedures.

Step 7 – Evaluation of Alternatives

Significant physical, biological, economic, and social effects of implementing alternatives were evaluated.

Step 8 – Preferred Alternative Recommendation

The Forest Supervisor, along with the entire Forest Leadership Team, and input from the cooperating agencies (BLM, State of Wyoming and Wyoming Conservation Districts), reviewed the interdisciplinary team's evaluation and recommended a preferred alternative to the Regional Forester. The Regional Forester selected the preferred alternative, Alternative D which is presented in the DEIS.

Step 9 – Plan Approval and Implementation

After receiving public comments on the DEIS, changes were made to the Plan and EIS. The Regional Forester has reviewed the documents and made a final decision as documented in the Record of Decision.

Inventory Data and Information Collection

A Geographic Information System (GIS) was used to develop the forest plan revision database. The resulting database was used to analyze suitable timber lands, build the forest planning model (FORPLAN) analysis areas, and perform other analyses for the revision. To develop the database the following layers were overlaid in GIS:

- Rocky Mountain Resource Information System (RMRIS) – this layer contain the RMRIS locations and sites (identifiers that link to the RMRIS database). RMRIS is an integrated resource database that was adopted by the Region in 1983. It is used for project implementation at the District level. The RMRIS data that was incorporated in the revision database was the location and site, vegetation cover type, tree size class, tree density, percent crown cover, elevation, plant association, habitat structural stage, and aspect.
- Land status – this layer contains information on Forest ownership, administering districts, and wilderness status.
- Slopes – This layer was derived from Digital Elevation Models (DEMs) provided by the Geometronics Service Center in Salt Lake City, Utah. The slope maps were generated with the following classes: 0-20%, 20-30%, 30-40%, 40-60%, and 60%.
- Soil – this layer contains the soil types from a level 3 soil inventory. The soil inventory was completed from 1980 to 1983.
- Geologic hazard – this layer gives the geologic composition of an area. Potential geologic hazards are identified.
- Watershed – this layer contains the boundaries for the 6th-level watersheds on the Forest.
- Riparian - this layer contains riparian polygons on the Forest. It includes the vegetation type and location inside or outside a stream channel. Riparian areas too small to be delineated as polygons were stored a line data. These lines were buffered by the 100 feet and combined with the riparian polygon layer. Lakes or ponds are also included in this layer.
- Management area prescription by alternative – these layers contain the management area prescriptions allocated for each alternative. There is one layer for each alternative. The information in this layer is shown on the management area prescription maps accompanying this document.

- Inventoried roadless areas – this layer contains the agency inventoried roadless areas on the Forest. (FSH 1909.12 Chpt 7)
- Recreation areas and cultural sites – this layer contains developed recreation sites, such as picnic grounds, campgrounds, summer home sites, and ski areas. The layer also contains the areas that are known to be highly sensitive to cultural resources over large areas.

Timber Suitability Analysis

Changes between Draft and Final

- The US Fish and Wildlife wetland GIS coverage was added to Alternative D FEIS where available. This coverage did not include information for the Laramie Peaks and Pole Mountain units. When combined with the existing Forest Service Riparian GIS coverages, there was an approximate net increase of 9,000 acres which was not taken out of suitability in the Draft EIS. Because tabulation of suitable acres is based on a sequential subtraction of these areas, this does not equate to a simple reduction to suitable acres of 9,000 acres. In many cases these areas overlap with other items such as non-forest land, Wilderness, or other areas which are removed prior to arriving at the tentatively suitable acre section of the analysis.
- In the DEIS, the riparian polygon coverage which includes lakes and large ponds was not buffered. This has been corrected for Alternative D FEIS. Because these changes are minor in nature they were not removed from Alternatives A-F, only Alternative D FEIS. If added to the other alternatives considered, it would not result in a significant change in the ranking of alternative effects for timber suitability.
- Suitable acres for Alternative D FEIS have been added to the summary table in this document.
- A discussion describing sites with less than 20 cubic foot/acre/year growth was added.

Process to Determine Timber Suitability

Requirements to perform analysis of timber suitability are found in 36 CFR 219.14[1982], and FSH 2409.13, chapter 20. The "Region 2 – Process to Determine Timber Suitability and Standards for Display" was the procedure used with minor variations based on local factors.

Lands Tentatively Suitable for Timber Production

Required Data

- Ownership (from RMRIS data base and ALP data base)
- Cover Type (from RMRIS data base)
- Designated Wilderness Areas (from CFF layer)
- Existing Research Natural Areas (RNA, from RMRIS)
- Soil Map Unit (from soil inventory)
- Elevation (from Digital Elevation Models (DEM))
- Aspect (from DEMs)
- Geology (from Soil and Landslides Coverage)
- Roads (Infra Travel Routes and TIS coverage)
- Lakes and Streams (from CFF polygon-hydrology and line-hydrology layers)

Process

Use GIS to identify areas that meet the following criteria:

1. Begin with lands that are in National Forest System (NFS), i.e. the ownership coverage.
2. Subtract non-forested cover types (cover type that is not a tree type) [36 CFR 219.14(a)(1)[1982], and FSH 2409.13, 21.1]; also buffer roads by 8 feet on either side of the center line. *Perennial streams were not buffered 3 feet either side of center line, as they will emerge from the riparian layer in timber suitability section. Also, Wilderness and RNA's were excluded from the non-forested cover type selection.*
3. Subtract Wilderness Areas and RNAs that were designated prior to July, 1993; also subtract any other areas that have been designated by Congress, the Secretary, or the Chief for purposes that preclude timber production. [36 CFR 219.14 (a) (4)[1982], and FSH 2409.13, 21.2] *Sheep Mountain Game Refuge area was not removed, timber production <u>is not</u> precluded in its designation*.
4. Subtract lands not capable of producing industrial wood. Cover types of pinyon-juniper, Rocky Mountain juniper, limber pine, and cottonwood. [FSH 2409.13, 21.3;] *Gambel oak was also included by the Silviculturist as non-industrial wood.*
5. Subtract lands with potential for irreversible soil or watershed damage. [36 CFR 219.14 (a) (4)[1982], and FSH 2409.13, 21.41] To identify, used geology coverage in combination with slope. The following codes from the landslide coverage were identified by the Soil Scientist as unstable soils, <u>mdf</u>, <u>mf</u> or <u>mrff</u> regardless of slope, <u>av</u>, <u>dav</u> <u>df</u>, <u>dlef</u>, <u>ef</u>, <u>f</u>, <u>rs</u>, <u>ms</u> with slopes between 40-

60%, and blstrm, bs, ds, ef, frf, mblsl, mrs, rf, rff, rg, rga, rgi, s, solif, tf with slopes greater than 60%.

6. Subtract lands where restocking within 5 years is not assured. [36 CFR 219.14 (a) (3)[1982], and FSH 2409.13, 21.42] The following were used to identify these lands:
   - Snowy Range and Sierra Madres

     Soil codes identified by the Soil Scientist as 045, 100, 101, 102, 103, 113, and 114. Also selected areas with soil codes 105 and 108, and the cover type is spruce/fir and the elevation is 10,000 feet or higher.

     Sherman Mtn (Pole Mtn)

     Soil codes identified by the Soil Scientist as 505, 506, and 601.
   - Laramie Peak

     Soil codes identified by the Soil Scientist as 707bk and 709ck. Also removed most of codes 227ck, 291ck and 291bk, with exceptions as identified by District Specialist.

     Plant Association – Were not used based on the inconsistency of classification in the RMRIS database as judged by the Silviculturist, Analyst and District specialists.

     Restocking – A review of the last 15 years of monitoring reports indicates that 95% of all regeneration harvests have been restocked within 5 years. Occasionally natural regeneration does not occur within five years for a variety of reasons such as climatic conditions, or inadequate site preparation. In these cases the Forest Service has the option of seeding or planting

     Soils types were primarily identified based on severity of seedling mortality rates.

Subtract lands with inadequate response information. [FSH 2409.13, 21.5;. No reference to this occurs in CFRs[1982]]. FSH 2409.13, 21.5 states:
"Identify forest land as unsuitable for timber production if there is not adequate information available, based on current research and experience, to project responses to timber management practices.

Until such time as adequate response data are available, identify these lands as needing further inventory, research, or information and do not consider them as part of the tentatively suitable land base. These lands may include forest types, such as pinyon-juniper, mesquite, and so forth which occupy low sites.

Give special attention to lands classified as incapable of producing 20 cubic feet/acre/year if they formerly met this criterion and were previously part of the timber base. In those situations involving significant acreages, consider the lands as tentatively suitable for timber production. Where response data to intensive management practices is inadequate, limit the yield projections for these lands to regeneration harvest practices during the development of management prescriptions in accordance with FSH 2409.13-22."

Removed cover type of limber pine. Limber pine is removed at this step due to lack of information, research on how it responds to silvicultural treatments, not because of industrial wood viability. Limber pine was removed during non-industrial wood, but not recorded as removed till this step.

Sites with less than 20 cuft/ac/year growth were reviewed. Approximately 81,000 acres in this category exist on the forest. Most of these acres occur in aspen stands, Pole Mountain and Laramie Peak areas which are generally not suited for timber production for other reasons. For Alternative D FEIS, 32,305 acres occur on lands identified as producing less than 20cuft/ac/year. Since the 20 cuft/ac/year growth is not a required minimum level set by law, policy or regulation, and since these areas are generally small isolated patches on the forest, and since site specific evaluation of potential harvest stands ocurrs prior to project development, and because productivity is closely associated with soil types of low productivity already removed from the suitable base, it was determined that it would be more practical to utilize the SPECTRUM model and the growth & yield calculations developed by the Forest Silviculturist to address areas of low productivity. Use of the model will ensure that low productivity sites are adequately accounted for in calculating an ASQ and allow appropriate harvest methods to be evaluated during development of management prescriptions as specified in FSH 2409.13

All lands were reviewed by District specialists and other staff with local knowledge and past harvest and road construction experience. Some areas were restored as being tentatively suitable, some areas were removed from tentatively suitable due to any of the above criteria.

The resulting lands are tentatively suitable for timber production.

Lands Suitable and Appropriate for Timber Production

Required Data

- Lands Tentatively Suitable for Timber Production (see above)
- Riparian Areas (from a separate riparian layer)
- Roads and trails (from Travel Routes and INFRA database)
- Developed Recreation Sites, Administrative Sites (RMRIS)
- Heritage Resource Sites (determined from coarse delineations by archeologists)
- Management Area Prescription Allocation for each alternative

Process

Use GIS to identify areas that meet the following criteria:

1. Start with lands tentatively suitable for timber production from the above steps.
2. Subtract areas where other management objectives limit timber production activities to the point where minimum specific management requirements of 36 CFR 219.27 cannot be met. [36CFR 219.14(c)(2) [1982],FSH 2409.13, 23.1] Subtract the following:
   - Riparian areas. All areas including riparian vegetation were identified and buffered by 100 feet. GIS coverages of these areas included: rip_poly, rip_point, and rip_line. The rip_point was buffered 1 acre around the point. Rip_line was buffered 100 feet on either side of the line (to match direciton in WCP Handbook 2509.25, standard 12.1). All three riparian covers were unioned into one cover.
   - Heritage resource sites – optional. The forest archeologists identified the following areas to exclude:

     Pole Mountain (Sherman): The prehistoric site density is so great it is often looked at as one large site with varying levels of artifact concentration. There have been prehistoric artifacts found at every existing Forest Service improvement and permitted improvement. Recent inventories indicate that the density of military sites and extent of military activity is greater than historically believed. Military activities appear to take place in all but the far western edge.

     Douglas Creek Area: The artifact density is so high, further logging activities could result in permanent loss of site context and association with its historic setting.

     Deep Creek Stock Driveway: Further logging activities would result in fragmentation of the driveway. Logging activities along the corridor could result in the permanent loss of contributing aspen carvings associated with the driveway.

     Centennial Mining District: The entire district is filled with legally filed and wildcat mining developments. Further logging activities could result in the permanent loss of these features and irreparable damage to the historic landscape of the district.

- Threatened, Endangered, and Sensitive (TE&S) species habitat - optional *Potential Threatened, Endangered, and Sensitive species habitat was reviewed by the forest biologist. Because habitats can change frequently based on natural processes, and because the Forest Plan includes specific standards and guidelines designed to identify and protect TE&S species during site specific project development, and because removal of TE&S habitat from suitable timberlands is not a requirement by law, regulation or policy, it was determined to not be practical to remove these areas at the programmatic Forest Plan level..*

3. Subtract areas where, based on a consideration of multiple-use objectives for the alternative, the land is proposed for resource uses that preclude timber production. [36 CFR 219.14(c)(1) [1982], FSH 2409.13, 23.2, no tie to CFR's [2000]] Subtract the following:

- Developed recreation sites

  Developed recreation sites are in a coverage called suit_recadm which were derived from RMRIS and edited by hand.

- Administrative sites

  Administrative sites are in a coverage called suit_recadm which were derived from RMRIS and edited by hand

  Allocation of management area prescription that does not allow timber production which contributes towards the ASQ. In other words, timber production with the goal of producing wood fiber is not allowed in the management area. This may vary as alternatives are developed, but at a minimum, management area prescriptions 5.11 and 5.13 <u>do</u> contribute towards the ASQ.

  The following management areas <u>DO</u> contribute to ASQ: 3.32 (excluding Pole Mountain area), 4.22, 4.31, 5.11, 5.13, 5.15, 5.21, & 5.4. All other management areas <u>DO NOT</u> contribute towards ASQ *(These Management Areas are utilized to reflect the 1985 Forest Plan).*

- Primary roads and trails buffered by 100 feet to protect visuals. **Not Used**. Determined to be inappropriate at the suitability level due to variance in site-specific conditions. For consideration in estimating ASQ, visuals were addressed in the SPECTRUM model and in standards and guidelines.

4. Subtract areas that are financially inefficient. [36 CFR 219.14(c)(3) [1982], FSH 2409.13, 23.3] *The following areas were identified:*
   - Not accessible (no right-of-way is available); or area is so isolated a potential timber harvest is not manageable.
   - Inaccessibility; (have right-of-way), but site is an isolated island or a small inclusion in nonsuitable or nonforested areas, potential timber harvest is not manageable.
   - Road construction limitations prevent access to area.
   - All aspen areas are excluded due to lack of viable market. Exclusion from the suitable base does not preclude harvesting aspen. Harvest treatments may occur, but are not scheduled for contribution to ASQ. Treatments are usually completed for resource values other than timber production.

   All lands were again reviewed by District specialists and other staff with local knowledge and past harvest and road construction experience. Some areas were restored as being suitable, some areas were removed from the suitable base due to any of the above criteria.

Remaining lands are **suitable and appropriate for timber production**. The suitable acres will vary between alternatives based on allocation of management areas which contribute to the ASQ.

Display of Timber Suitability in the EIS

The following table compares the timber suitability analysis from the Medicine Bow Forest Plan of 1985 to the analysis from alternatives chosen for revision. Detailed maps of the suitable timberlands on the forest are available.

Benchmark Alternative T represents the maximum timber benchmark suitability coverage used for the AMS benchmark analysis.

Table B-1. Final summary of lands suited for timber production in GIS acres by alternative.

Classification	1985 Forest Plan[1]	Alt A (No Action)	Alt B	Alt C	Alt D DEIS	Alt D FEIS	Alt E	Alt F
Net National Forest System Land	1,093,342	1,084,614	1,084,614	1,084,614	1,084,614	1,084,390	1,084,614	1,084,614
Non-Forest Land	-235,057	-211,665	-211,665	-211,665	-211,665	-215,476	-211,665	-211,665
Forested Land	**833,285**	**872,949**	**872,949**	**872,949**	**872,949**	**868,914**	**872,949**	**872,949**
Not Available – Wilderness (Encampment River, Huston Park, Platte River, Savage Run) (* = Published Acres)[3]	-79,323	-78,856 (78,388*)	-78,856 (78,388*)	-78,856 (78,388*)	-78,856 (78,388*)	-78,908	-78,856 (78,388*)	-78,856 (78,388*)
Not Available -- Research Natural Area (Snowy Range RNA) (* = Published Acres)[3]	-771	-749 (771*)	-749 (771*)	-749 (771*)	-749 (771*)	-734 (771*)	-749 (771*)	-749 (771*)
List any other areas withdrawn by Congress, the Sec., or the Chief ...	-0	-0	-0	-0	-0	-0	-0	-0
Not Capable of Producing Industrial Wood (pinyon-juniper,Rocky Mtn juniper, cottonwood & gambel oak)[2]	-0	-519	-519	-519	-519	-514	-519	-519
Potential for Irreversible Soil/Watershed Damage (Unstable soils types based on various slope classes)[2]	-0	-6,672	-6,672	-6,672	-6,672	-6,587	-6,672	-6,672
Restocking in Five Years not Assured (Soil types with limited productivity and Spruce/fir over 10,000 ft elevation on certain soil types)[2]	-0	-23,994	-23,994	-23,994	-23,994	-23,584	-23,994	-23,994
Inadequate Response Information (Limber Pine removed)[2]	-142,143	-11,410	-11,410	-11,410	-11,410	-11,387	-11,410	-11,410
Tentatively Suitable	**636,048**	**750,749**	**750,749**	**750,749**	**750,749**	**747,200**	**750,749**	**750,749**
Not Suitable due to Minimum Management Requirements for other Resources								
Riparian Areas		-61,459	-61,459	-61,459	-61,459	-58,921	-61,459	-61,459
Areas with large Heritage Resource Sites		-22,761	-22,761	-22,761	-22,761	-22,658	-22,761	-22,761
Habitat for Threatened, Endangered, or Sensitive Species[7]	-0	-0	-0	-0	-0	-0	-0	-0

Classification	1985 Forest Plan[1]	Alt A (No Action)	Alt B	Alt C	Alt D DEIS	Alt D FEIS	Alt E	Alt F
Not Suitable due to Management that Precludes Timber								
Administrative and Developed Recreation Sites[4]	-8,720	-2,972	-2,972	-2,972	-2,972	-2,866	-2,972	-2,972
Tentatively Suitable and Common to All Alternatives	**627,864**	**663,557**	**663,557**	**663,557**	**663,557**	**662,756**	**663,557**	**663,557**
Not Suitable due to Management that Precludes Timber								
Management Area Prescription does not allow Timber Production which contributes to ASQ[5]	-180,309	-88,830	-189,751	-226,144	-265812	-201,424	-305,630	-411,770
Not Suitable due to Financially Inefficient[6]	-0	-99,899	-66,003	-67,341	-67,184	-140,578	-67,770	-79,332
Suitable and Appropriate for Timber Production	**447,555**	**474,828**	**407,803**	**370,072**	**330,561**	**320,754**	**290,157**	**172,455**

[1] Data available during development of the 1985 Plan was different than current data sources. In several cases, specific data used in the Revision was not available in 1985. The Forest Service used the most current data available.

[2] Data derived from databases, RMRIS & INFRA, and GIS covers, including, but not limited to, RMRIS, hydrology, soils and geologic hazard covers.

[3] The "published" acres are from several source documents, including the 1985 Forest Plan & EIS, current files, and other sources.

[4] The 1985 Plan includes all administrative, recreation, known electronic and other special use sites. Only administrative and developed recreation sites included in Alt A-F.

[5]The 1985 Plan has an undetermined, unspecified number of acres removed from suitability for old growth retention.

[6] The 1985 Plan did not estimate lands not suitable due to Financial inefficiency.

[7]Habitat for TES species is not static nor are all locations of nest sites known. As such, it is not appropriate to remove during a suitability analysis. Forest Plan Standards and Guidelines are developed to protect species and their habitats when they are identified at the site-specific project level. Spectrum modeling constraints for old growth, and other management areas not suitable for timber production are adequate adjustments for TES species and their habitats in determining Forest ASQ.

Forest Planning Model - SPECTRUM

Changes between Draft and Final

Based on public comments and questions about the SPECTRUM model and the methodology used in applying some of the constraints, the SPECTRUM model used in the DEIS was sent to an expert independent contractor for detailed evaluation and updating. Primary changes included:

1. Improvements to the model to more accurately implement management constraints.
2. Additional reporting variables to provide more detailed tracking of growth and yield and habitat structural stages.

These modifications resulted in increased levels of harvest throughout all alternatives except alternative F which decreased as a result of corrections in constraints specific to that alternative. The ASQ for Alternative D-FEIS is a 29% (5.1mmbf) increase from Alternative D as modeled in the DEIS.

While the modeled outputs increased as a result of these updates, the overall alternative theme, distribution of management areas, and standards and guidelines are similar to those published in the DEIS. The modeled output for Alternative D-FEIS is within the range of ASQ analyzed in the DEIS.

The key findings and changes resulting from the detailed independent review are summarized below. Detailed findings are available as Appendix 1 of the SPECTRUM specialist report which is located in the administrative record.

Watershed Constraint – The constraint which limits timber harvest to 25% ECA per 6^{th} level watershed was modified. The constraint is intended to provide a maximum level of disturbance which is allowed to occur in a 6^{th} level watershed. The underlying principle is that in order to protect long-term stream health from damage by increased runoff (Forest-wide watershed Standard 2), disturbances (both natural and managed) should be limited to maintain runoff within a range which will not risk potentially damaging levels.

It was found that this constraint in calculating Equivalent Clearcut Acres (ECA), was based on the suitable acres within a watershed grouping as opposed to evaluating the vegetation condition on the entire watershed grouping. Changing this constraint to consider all acres (suitable and non-suitable) within a watershed resulted in an increase in areas available for harvest within the model

Scenery Constraint – This constraint is designed to ensure that the model considers potential limitations resulting from implementation of scenic integrity objectives. This constraint is difficult to model because it is based on spatial conditions and the SPECTRUM model is not a spatial model.

Similar to the watershed constraint described above, the scenery constraint was found to only be evaluating suitable acres. Changing this constraint to evaluate all acres resulted in an increase in areas available for harvest within the model.

Age Constraint (Alternative F Only) – Alternative F includes a Forest-wide standard requiring that at least 50% of each watershed be maintained in late successional age classes. The independent review identified that this constraint had been omitted in the DEIS. Including this constraint resulted in a reduction of analysis units available for harvest in Alternative F.

Management Area 5.15 Constraint – The DEIS included a constraint intended to reflect the emphasis on ecological conditions in this management area. In the DEIS this constraint set 53% of the MA 5.15 acres to a no harvest condition. The 53% level included old growth, security areas and unharvested islands remaining in harvested units. Because of the variability in site specific conditions, this variable was modified to reflect only the increased levels of unharvested islands within clearcuts. Security areas were not specifically modeled because most of these areas will be provided through areas managed for old growth and areas unsuitable for timber harvest. This level is estimated to be 20% of clear cut acres. The modeling level was set to 16% for all alternatives with MA 5.15 to account for the 4% of snag retention already accounted for in the model.

Old Growth Constraint – The old growth constraint for Alternative D FEIS was modified to increase lodgepole from 10% to 15% and spruce/fir from 20% to 25%. This change was made to address the need to account for recruitment old growth.

Tracking Variables – The model output reports were updated to provide detailed outputs on growth and yield. These are summarized in the Timber section of the FEIS.

The model used in the DEIS only tracked habitat structural stages 1-4. In addition, the reporting variable was found to incorrectly account for changes in habitat structural stages after harvest. These reporting variables were updated to track all five habitat structural stages and corrected to accurately calculate habitat structural stages after harvest in the output report.

Adjustments to D FEIS – Constraints for Alternative D FEIS were the same as Alternative D DEIS except that the constraint for old-growth was increased to 15% for lodgepole pine, and 25% for spruce/fir.

Additionally, Alternative D FEIS was developed using an updated suitability layer which included adjustments to riparian buffers (lakes were omitted in the DEIS), and incorporation of an updated wetland coverage provided from the Fish and Wildlife Service. Because these changes were minimal from a Forest-wide perspective (approximately 9,000 acres) only Alternative D FEIS was remodeled with the updated information. This was necessitated due to time and cost limitations required to incorporate these minor changes which would not result in a change in the ranking of alternatives nor a significant change in overall suitability since a portion of these acres are removed from suitability for other reasons such as Wilderness, or non-forested lands.

Costs and Revenues: All costs utilized in the SPECTRUM model were reviewed and determined to be reasonable estimates of current averages on the forest. Timber values were also reviewed. Current average values were reduced from $252.10/mbf to $211.96/mbf. These values are based on combined averages of actual sales on the Medicine Bow National Forest. Although spruce/fir species have a slightly higher value than lodgepole, separating the values was not determined to be necessary since the majority of timber existing and harvested on the forest is lodgepole, and since the value used in SPECTRUM is a combined average that accurately reflects conditions on the Medicine Bow National Forest.

Variance of costs between MA 5.15 and 5.13 were considered and determined to be insignificant for Forest-wide modeling purposes. Sale layout costs could be higher in some cases for MA 5.15 due to more complicated direction, but will vary based on site-specific conditions and objectives which are impossible to predict at the programmatic Plan level.

Post modeling adjustments –Goshawk and small diameter volume adjustments were estimated after modeling and applied to the final SPECTRUM outputs. These variables could not be accurately modeled (goshawk nest sites are not all identified and may change, and small diameter outputs are not within our ability to incorporate in the model due to time and complexity) As a result, estimates were applied to the SPECTRUM ASQ outputs which reduced the ASQ as follows:

Table B-2. Post modeling reduction of ASQ for goshawk and small diameter estimates.

	A	**B**	**C**	**D DEIS**	**D FEIS**	**E**	**F***
Goshawk	2.0	1.8	1.6	1.3	1.4	1.3	
Small Diameter Trees	0	.5	1.3	2	2	2	
Total Reduction	-2.5	-2.3	-2.9	-3.3	-3.4	-3.3	
SPECTRUM ESTIMATED ASQ 50 year annualized average	30.9	29.5	28.7	27.5	26.2	24.0	.5
Reduced ASQ	28.8	27.2	25.8	24.2	22.8	20.7	3.0

** Because of the high degree of limited management prescriptions in Alternative F, it is not anticipated that there would be any potential for a needed reduction in ASQ.*

Model Overview

Spectrum is a specialized matrix generator and report writer to a standard linear programming optimizer. The Forest used C-WHIZ as the linear programming optimizer. C-WHIZ is available for PCs and is a product of the Ketron Division of the Bionetics Corporation. Linear programming is a standard mathematical technique for solving simultaneous linear equations subject to constraints and an objective function. Spectrum is used to build a linear program matrix that is then solved by C-WHIZ. The solution from C-WHIZ is then interpreted by Spectrum, which generates a report and produces a data file containing the results. The data file can then be imported to Microsoft Access for further analysis.

Spectrum Version 2.6 was the model used to schedule timber harvest and determine ASQ for each alternative.

For the Medicine Bow, Spectrum was used as a timber harvest scheduling tool, reporting timber outputs and timber costs and benefits, while tracking wildlife habitat structural stages and water yields. Spectrum was not used to make land allocation decisions. Those decisions were made by the districts, based on knowledge of the land. Acres assigned to management area prescriptions were transferred to the model. Given the management emphasis and constraints to meet standards and guidelines, the model then determined whether or not to harvest timber on a particular area, when to harvest, and the type of timber harvest.

Spectrum was used to schedule timber harvests by decade for the next 20 decades. This long planning horizon assures a sustainable yield into the future. Only the first five decades were carried forward into other analysis.

Land Stratification/Analysis Areas

Land stratification is the process of identifying a set of attributes, or strata, to use in defining the land base. This is done to organize the forest land base into logical subunits that respond similarly to management actions. In Spectrum, each strata is called a "layer" and combining these layers results in an "analysis area." Spectrum layers 1 through 6 are used to describe analysis areas. Analysis areas are usually homogenous, but not contiguous. The attributes used in developing analysis areas are based on the issues to be addressed by the model, differences in resource response, and the reliability of the data. Table 1 shows the land stratification and analysis area composition.

Analysis areas are developed by combining the six layers shown in the following table and calculating the amount of acreage for each combination that is present. Activities and outputs that are associated with analysis areas are on a per acre basis.

Table B-3. Spectrum land stratification.

Layer	Layer Description	Code	Code Description
1	Roading Economics	RDLSH	roadless area that can be helicopter logged
		RDLSN	roadless area not able to helicopter log
		ROADED	not a roadless area; low local roading costs
		UNSUIT	unsuitable lands
2	Sensitive Watershed	WTR0	watershed group 0
		WTR10	watershed group 10
		WTR16	watershed group 16
		WTR22	watershed group 22
		WTR25	watershed group 25
3	Allocation of Timber Management Area Prescription	MRX332	Management Area Prescription 3.32 - backcountry rec
		MRX422	Management Area Prescription 4.22 - scenic areas
		MRX431	Management Area Prescription 4.31 - dispersed rec with low use
		MRX511	Management Area Rx 5.11 - General Forest
		MRX513	Management Area Prescription 5.13 - Forest Products
		MRX515	Management Area Prescription 5.15 – Ecological Maint/Restoration
		MRX521	Management Area Prescription 5.21 – Water Yield
		MRX54	Management Area Prescription 5.4 - forested flora and fauna habita
		UNSUIT	unsuitable lands
4	SMS Scenic Integrity Objective	LOW	SIO of Low
		MODERA	SIO of Moderate
		UNSUIT	Unsuitable
5	Species, Productivity Area, Size Class and Density	L6	Lodgepole pine nonstocked/seedlin, eastern productivity area
		L7	Lodgepole pine sapling
		L8EA	Lodgepole pine poles, east productivity area, low density
		L8EB	Lodgepole pine poles, eastern productivity area, medium density
		L8EC	Lodgepole pine poles, eastern productivity area, high density
		L8NA	Lodgepole pine poles, north productivity area, low density
		L8NB	Lodegpole pine poles, north productivity area, medium density

Layer	Layer Description	Code	Code Description
		L8NC	Lodepole pine poles, north productivity area, high density
		L8WA	Lodgepole pine poles, west productivity area, low density
		L8WB	Lodgepole pine poles, west productivity area, medium density
		L8WC	Lodgepole pine poles, west productivity area, high density
		L9EA	Lodgepole pine mature, eastern productivity area, low density
		L9EB	Lodgepole pine mature, eastern productivity area, medium density
		L9EC	Lodgepole pine mature, eastern productivity area, high density
		L9NA	Lodgepole pine mature, north productivity area, low density
		L9NB	Lodgepole pine mature, north productivity area, medium density
		L9NC	Lodgepole pine mature, north productivity area, high density
		L9WA	Lodgepole pine mature, west productivity area, low density
		L9WB	Lodgepole pine mature, west productivity area, medium density
		L9WC	Lodgepole pine mature, west productivity area, high density
		P6	Ponderosa pine nonstocked/seedling
		P7	Ponderosa pine sapline
		P8	Ponderosa pine poles
		P9A	Ponderosa pine mature, low density
		P9B	Ponderosa pine mature, medium density
		P9C	Ponderosa pine mature, high density
		S6	Spruce/fir nonstocked/seedling
		S7	Spruce/fir sapling
		S8A	Spruce/fir poles, low density, all productivity zones
		S8B	Spruce/fir poles, medium density, all productivity zones
		S8C	Spruce/fir poles, high density, all productivity zones
		S9CA	Spruce/fir mature, central productivity area, low density
		S9CB	Spruce/fir mature, central productivity area, medium density
		S9CC	Spruce/fir mature, central productivity area, high density

Layer	Layer Description	Code	Code Description
		S9HA	Spruce/fir mature, Hayden productivity area, low density
		S9HB	Spruce/fir mature, Hayden productivity area, medium density
		S9HC	Spruce/fir mature, Hayden productivity area, high density
		S9SA	Spruce/fir mature, south productivity area, low density
		S9SB	Spruce/fir mature, south productivity area, medium density
		S9SC	Spruce/fir mature, south productivity area, high density
		UNSFOR	unsuitable forested lands
		UNSNF	unsuitable, non-forested
6	+/- 40 percent slope, access	<40%SL	<40% slopes
		>40%SL	>40% slopes
		INACC	Inaccessible -- helicopter logging only (RDLSH & ROADED)
		UNSUIT	unsuitable land

The analysis areas were generated using ARC Info. The database reflects conditions as they exist in October 2001. Without adjustment to the database, Spectrum could schedule stands for future harvest which have actually been cut between 2001 and the implementation of the Revised Plan. To correct this, districts identified areas that were currently under a timber contract or would be sold by the end of fiscal year 2002. This information was incorporated into layer 5.

Although the analysis areas were generated using GIS and the RIS database, there is not a direct spatial link for these areas. This is due in part to the analysis unit limitations of SPECTRUM. The model will go infeasible and not run if there are too many analysis units. This required some analysis units to be dissolved into larger units to limit the total number. As such, it is not possible to accurately map model solutions.

FVS Calibration For Yield Modeling (SPECTRUM)

The following procedure was developed for calibrating the Forest Vegetation Simulation Model for the Medicine Bow Forest Plan Revision. This is the same procedure that was used in calibrating the Routt Forest - Forest Vegetation Simulation Model.

Based upon the outcome of a meeting (January 5, 1994 Phil Krueger, Silviculturist on the Medicine Bow National Forest, Fred Winkler and Dennis Donnelly from the Washington office detached group), it was determined that FVS should be calibrated for the Medicine Bow Forest Plan Revision using the following:

1. Model Selection and Scale Factors: Use the large tree diameter scale factors from the FVS calibration statistics output files for cover types.
2. Utilization Standards: Use standards for the Forest and adjust FVS to use these.
3. Mortality adjustments: Adjust FVS using the Maximum density functions in FVS until the outputs match the averages of the Forest data.
4. Defect factors: Use woods and mill defect factors to determine differences between gross and net sold volumes to mills.

Stands were selected from the respective district databases that were needed to fully represent the Forest. Datasets (from the rmstand database) were constructed for each of four cover types (lodgepole pine, spruce/fir, ponderosa pine, and aspen). These datasets contained all the tree information for the sawtimber and poletimber sites within each cover type.

Model Selection And The Use Of Large Tree Diameter Scale Factors

Within the submittal system for the Central Rockies Variant of FVS there were at the time of modeling for SPECTRUM (12/28/93) five cover type model types available for use. They were:

1. Southwest mixed conifer (SWMC)
2. Southwest mixed ponderosa pine (SWPP)
3. Black hills ponderosa pine (BHPP)
4. Spruce-fir (SF)
5. Lodgepole pine (LP)

For a naming convention the cover type was combined with the model being used. The first two letters refer to the covertype (AA=aspen, LP=lodgepole pine, PP=ponderosa pine, and SF=spruce/fir). The third letter refers to the model being used. The fourth letter if used refers to the size class of the dataset. The following prefixes were used for the modeling:

Table B-4. Prefixes used for modeling.

Prefix	Cover Type / Size Class	Model Type
AAL	Aspen	Southwest Mixed Conifer
AAM	Aspen	Southwest Mixed Conifer
LP8L	Lodgepole/poletimber	Lodgepole pine
LP9L	Lodgpole/sawtimber	Lodgepole pine
LPL	Lodgepole/poletimber & sawtimber	Lodgepole Pine
PPB	Ponderosa pine	Black Hills Ponderosa pine
PPC	Ponderosa pine	Southwest mixed conifer
PPM	Ponderosa pine	Southwest mixed conifer
SFS	Spruce/fir	Spruce/Fir

The following scale factors were used for various strata:

For all LP8 (lodgepole poletimber) strata use 1.317 for lodgepole.

For all LP9 (lodgepole sawtimber) strata use 1.49 for lodgepole.

For all SF (spruce/fir) strata use 1.474 for lodgepole, 1.375 for spruce, 1.055 for fir.

For all PP strata use 1.909 for ponderosa pine.

For all AA strata use1.107 for aspen.

Standard reports such as summary tables of trees per acre, basal area, cubic foot volume, etc., as well as stand structure and species composition tables, were developed for all stands used in the predictions. Values from these tables were then used to build the yield tables used in the FORPLAN model.

Silvicultural Prescriptions in the Spectrum Model

Spectrum layers 7 and 8 are used to define the analysis area management prescription. Several timing choices were applied to these options. Timing choices are defined by specifying in the model the range of ages in which an existing stand and a regenerated stand may be harvested. Based on constraints and the objective, the Spectrum model determines the management prescription to apply to an analysis area and the timing of implementation.

The following table displays the management prescriptions defined in the Spectrum model. All analysis areas were given the option of no management (level 7 of minimum level and level 8 of minimum level). For analysis areas that were suitable for timber management (level 3 identifier of MRX332, MRX422, MRX431, MRX511, MRX513, MRX521, MRX515, or MRX54), several timber prescriptions were available. The timber prescriptions that are available vary based on management area prescription allocation, species, size class, and density.

Table B-5. Spectrum management prescriptions.

Layer	Layer Description	Code	Code Description
7	Emphasis	COMTIM	Commercial Timber Management
		MINLVL	No Timber Management
8	Intensity	CLRCT	Clearcut - for LP and PP
		GROUPN	First group selection entry already complete
		GRPSEL	Group Selection
		INDTSL	Individual Tree Selection
		MINLVL	Mimum level management
		PCTCC	Precommercial thin existing; clearcut - LP only
		PCTSW2	Precommercial thin existing; 2 step shelterwood - LP only
		SW_SW2	finish 2-step shelterwood existing; 2-step sw regen
		SW_SW3	finish 3-step shelterwood existing; 3-step shelterwood regen
		SW2SW2	2-step shelterwood - for LP, SF, PP
		SW3SW3	3-step shelterwood - SF only

The table below displays the timber prescription options based on these factors. No mature or pole size conifer stands have an option for pre-commercial thin in the existing stand. Spruce/fir regenerated stands have no pre-commercial thin in the model.

Table B-6. Timber prescription options.

Mgmt Area Rx	Species	Size Class/ Stocking	SPECTRUM Level 8	Timber Rx Description
3.32, 4.22, 4.31, 5.13, 5.15, 5.21,or 5.4	Lodgepole Pine	All/All	CC	Clearcut Existing Stand, Clearcut Regen Stand
		All/All except L8NA	S2	2-step Shelterwood Existing Stand, 2-step Shelterwood Regen
3.32, 4.22, 4.31, 5.13, 5.15, 5.21, or 5.4	Spruce/Fir	All/All except S8A	S2	2-step Shelterwood Existing Stand, 2-step Shelterwood Regen Stand
		All/All except S8A, S8B, S9SB, any mature/poor	S3	3-step Shelterwood Existing Stand, 3-step Shelterwood Regen Stand
		Mature/All or Pole/Good	G1, G2, or G3	Group Selection starting in Decade 1, 2, or 3 with 20 year cycle
		Pole/Medium	G2, G3, or G4	Group Selection starting in Decade 2, 3, or 4 with 20 year cycle
		Pole/Poor	G3, G4, or G5	Group Selection starting in Decade 3, 4, or 5 with 20 year cycle
		Mature/Good Medium or Pole/Good	T1, T2, or T3	Individual Tree Selection starting 1, 2, or 3 with 20 year cycle
		Pole/Medium	T2, T3, or T4	Individual Tree Selection starting

Mgmt Area Rx	Species	Size Class/ Stocking	SPECTRUM Level 8	Timber Rx Description
				Dec. 2, 3, or 4 with 20 year cycle
Any Suit Rx	Ponderosa Pine	All/All	CC	Clearcut Existing Stand, Clearcut Regen Stand
		All/All except P9A	S2	2-step Shelterwood Existing Stand, 2-step Shelterwood Regen
5.11	Lodgepole Pine	All/All	CC	Clearcut Existing Stand, Clearcut Regen Stand
		All/All except L8NA	S2	2-step Shelterwood Existing Stand, 2-step Shelterwood Regen
		Mature/All or Pole/Good or Pole/Medium	G1, G2, or G3	Group Selection starting in Decade 1, 2, or 3 with 20 year cycle
		Pole/Poor	G2, G3, or G4	Group Selection starting in Decade 2, 3, or 4 with 20 year cycle
5.11	Spruce/Fir	All/All except S8A	S2	2-step Shelterwood Existing Stand, 2-step Shelterwood Regen Stand
		All/All except S8A, S8B, S9SB, any mature/poor	S3	3-step Shelterwood Existing Stand, 3-step Shelterwood Regen Stand
		Mature/All or Pole/Good	G1, G2, or G3	Group Selection starting in Decade 1, 2, or 3 with 30 year cycle
		Pole/Medium	G2, G3, or G4	Group Selection starting in Decade 2, 3, or 4 with 30 year cycle
		Pole/Poor	G3, G4, or G5	Group Selection starting in Decade 3, 4, or 5 with 30 year cycle
		Mature/Good Medium or Pole/Good	T1, T2, or T3	Individual Tree Selection starting 1, 2, or 3 with 30 year cycle
		Pole/Medium	T2, T3, or T4	Individual Tree Selection starting Dec. 2, 3, or 4 with 30 year cycle

For management area prescriptions 3.32, 4.22, 4.31, 5.13, 5.15, 5.21, and 5.4 timing choices were based on culmination of mean annual increment (CMAI) with merchantability specifications of 8" DBH to a 5" top DIB. The age at which CMAI is reached was determined by FVS for the existing mature and pole sized strata. The CMAI age for seedlings, saplings, and regenerated stands was developed from queries of RMSTAND data. For all species, mature and pole sized existing stands have already reached CMAI. For seedlings, saplings and the regenerated stand, CMAI is at age 120 for lodgepole pine, 110 for spruce/fir, and 100 for ponderosa pine.

For seedlings, saplings and the regenerated stand, CMAI is at age 120 for lodgepole pine, and 100 for ponderosa pine. CMAI for spruce/fir is generally higher than other species (130-140 years). However, the model was set to age 110 to allow the first step of a two or three step shelterwood to occur prior to the regeneration harvest which would occur after CMAI is reached.

For management area prescription 5.11, timing choices were based on a rotation age that is longer than CMAI and closer to a biological rotation. The rotation age is 200 years for lodgepole pine, spruce/fir and ponderosa pine.

Costs and Revenues in the Spectrum Model

Sawtimber revenue figures reflect a 5-year average of harvest values (revenues actually paid) for sawtimber on the Medicine Bow National Forest. The average conifer sawtimber harvest value is $211.96/thousand board-feet (MBF). Differences in stumpage values between species is generally limited and most of the volume harvested on the Medicine Bow is lodgepole pine. Since the average value was calculated based on actual sawtimber sales on the Medicine Bow National Forest, it was determined that splitting out separate values for individual species would not provide a more accurate estimate of ASQ.

All harvest on the Medicine Bow has been tractor logged. To determine a value for cable logged timber, the additional cost of this harvest method was estimated. The additional cost of yarding, felling and bucking, and overhead in cable logging was determined to be $124/MBF. The additional cost was included in Spectrum as an activity found only on steep slopes.

Helicopter logging was also considered for those areas that are difficult to access or in roadless areas but have good stands of timber. The Regional Logging Engineer performed an analysis of the additional cost of helicopter logging from costs associated with the Routt Divide Blowdown. The analysis indicated that helicopter logging costs are $166/MBF above tractor logging. The additional cost was included in Spectrum as an activity found only for inaccessible areas.

All costs associated with timber and their production functions were developed by the interdisciplinary team and district timber staffs. The basis for the costs was a 5-year historic average, with changes based on the updated standards and guidelines. After the model was run, costs were reviewed to determine if they were realistic.

The production function for miles of road reconstruction and construction was developed based on the historic amount constructed/reconstructed for the amount of timber harvested. The production function for road construction and reconstruction was varied based on whether the area was already roaded or not.

A summary of all costs in the Spectrum model is shown in the following table.

Table B-7. Summary of activity costs.

Activity	Spectrum Code	Cost/Unit	Production Relationship
Silvicultural Exams & Planning	EXAM		
First Entry		$5.50/ac	10 ac exam/1 ac harv
Second Entry		$5.50/ac	1.5 ac exam/1 ac harv
Sale Prep	PREP		
Clear Cut		$30.00/mbf	1 mbf prep/1 mbf harv
Shelterwood, Group Selection		$40.40/mbf	1 mbf prep/1 mbf harv
Individual Tree Selection		$56.10/mbf	1 mbf prep/1 mbf harv
Clear Cut in Rdls Area		$36.00/mbf	1 mbf prep/1 mbf harv
Shltrwd, Group Sel in Rdls area		$46.40/mbf	1 mbf prep/1 mbf harv
Individual Tree Sel in Rdls area		$62.10/mbf	1 mbf prep/1 mbf harv
Heritage Resource Inventory	ARCH		
First Entry		$15.20/ac	1.5 ac/1 ac harv
Second Entry		$2.00/ac	1.5 ac/1 ac harv
Sale Administration	ADMN		
Clear Cut		$18.50/mbf	1 mbf admin/1 mbf harv
All others		$21.50/mbf	1 mbf admin/1 mbf harv
Site Prep for Natural Regen	SIPR		
Clear Cut		$135.00/ac	0.25 ac prep/1 ac harv
Shelterwood (seed cut)		$135.00/ac	0.05 ac prep/1 ac harv
Litigation and Appeals	ALIT	$2.00/mbf	1 mbf litigation/1 mbf harv
Planting - Clear Cut only	PLNT	$500.00/ac	0.01 ac plant/1 ac harv
Seeding - Clear Cut only	SEED	$180.00/ac	0.13 ac plant/1 ac harv
Certification of Natural Regen	CERT		
Clear Cut		$9.50/ac	0.61 ac cert/1 ac harv
Shelterwood		$9.50/ac	0.95 ac cert/1 ac harv
Group or Individual Tree Sel.		$9.50/ac	1.0 ac cert/1 ac harv
Pre-commercial Thin			
Regen Stand	PCT	$150.00/ac	1 ac thin/1 ac regen age 20 LP
Exist Stand - CC, SW	0PCT	$150.00/ac	1 ac thin/1 ac size 7 w/ PCT
Exist Stand - Group Sel 2nd Entry	8PCT	$90.00/ac	1 ac thin/1 ac harv
Exist Stand - Individual Tree Sel	8PCT	$90.00/ac	1 ac thin/1 ac harv
Common Services/Overhead	TGOH	$22.50/mbf	1 $ overhead/1 mbf harv
Local Roads - Purchaser Road Const	CONS		
First Entry		$21,000/mile	0.0019 mile/1 ac harv
First Entry in Rdls		$22,000/mile	0.0116 mile/1 ac harv
Local Roads - Purchaser Road Reconst	RCNS		
First Entry		$6,700/mile	0.0042 mile/1 ac harv
First Entry in Rdls		$6,700/mile	0.0016 mile/1 ac harv
Local Road Const - Preconst Engineer.	PCNS	$9,800/mile	1 mile preconst/1 mile const
Local Road Reconst-Preconst Engineer.	PRCN	$6,300/mile	1 mile preconst/1 mile reconst
Local Road Const - Engineering	ECNS	$6,200/mile	1 mile eng/1 mile const

Activity	Spectrum Code	Cost/Unit	Production Relationship
Local Road Reconst - Engineering	ERCN	$2,400/mile	1 mile eng/1 mile reconst
Local Road Maintenance	MNTC		
Between Entries (uneven and SW)		$130/mile	0.0173 mile/1 ac harv
Between Entries in Rdls (uneven and SW)		$130/mile	0.0189 mile/1 ac harv
Pre-haul Maintenance	HMNT		
2nd Entry		$2,400/mile	0.0121 mile/1 ac harv
2nd Entry in Rdls		$2,400/mile	0.0132 mile/1 ac harv
Cable Logging - additional cost	CBLE	$124/mbf	1 mbf cable log/1 mbf harv on >40% slopes
Helicopter Logging - additional cost	HELI	$166/mbf	1 mbf helicopter log/1 mbf harv on inaccessible areas

Outputs in the Spectrum Model

Outputs that were modeled using Spectrum included timber yields, wildlife structural stage, and water production. The following table describes the output codes and their production functions. Only the timber output (CMBF) generated a revenue.

Table B-8. Summary of outputs and revenues.

Activity	Spectrum Code	Revenue/ Unit	Production Relationship
Timber Harvest in MCF	CMCF		Aggregate SWLG; Age-dependent yield tables from FVS model
Timber Harvest in MBF	CMBF	$212/mbf	Aggregate SWLG; Age-dependent yield tables from FVS model
Long-Term Sustained Yield	LTSY		Special timber relationship in yield composite
Stand Average Volume	SAV		Special timber relationship in yield composite
Inventory	INV		Special timber relationship in yield composite
Water Production	WATR		Based on acres harvest of CMCF; defined in complex sequence dependent relationships; varies by species, size and harvets method
Acres Timber Harvest	HARV		1 ac harv/1 ac cmcf timber harvest
Acres Final Harvest	FHAR		1 ac fhar/1 ac cmcf final harvest
Acres Uneven-aged Harvest	UNEV		1 ac unev/1 ac cmcf uneven-aged harvest
Existing Effective Alteration for Visuals	0EFL		
Existing Effective Alteration for Visuals	0EFL		
LP6			1 ac 0EFL/1 ac LP6 for the next 20 years
SF6			1 ac 0EFL/1 ac SF6 for the next 30 years
PP6			1 ac 0EFL/1 ac PP6 for the next 25 years
Effective Alteration for Visuals	EFLT		
LP final harvest			1 ac EFLT/1 ac harvest for the next 30 years
LP uneven-aged harvest			0.3 ac EFLT/1 ac harvest for the next 20 years
SF final harvest			1 ac EFLT/1 ac harvest for the next 45 years

Activity	Spectrum Code	Revenue/ Unit	Production Relationship
SF uneven-aged harvest			0.3 ac EFLT/1 ac harvest for the next 20 years
PP final harvest			1 ac EFLT/1 ac harvest for the next 40 years
PP uneven-aged harvest			0.3 ac EFLT/1 ac harvest for the next 20 years
Existing Disturbance to Watershed	0WTR		
Timber Size Class 6			1 ac 0WTR/1 ac size 6 in decade 1 and dimishing by 0.1 ac per decade for following 8 decades
Timber Size Class 7			0.7 ac 0WTR/1 ac size 7 in decade 1 and dimishing by 0.1 ac per decade for following 5 decades
Disturbance for Watershed	WTRT		
Clear cut			1 ac WTRT/1 ac harvest for first 20 years then dimishing by 0.1 ac per decade for 8 decades
Prep cut (Shelterwood)			0.5 ac WTRT/1 ac harvest for first 20 years then 1.0 acre in decade 3 and dimishing by 0.1 ac per decade for next 8 decades
Uneven-aged harvest			0.3 ac WTRT/1 ac harvest till end of plan horizon
No Commercial Harvest	NCHA		1 ac NCHA/1 ac allocated to min-level management
Wildlife Structural Stage	SS1 - SS4C		Time dependent and age dependent yield tables; structural stage qualifier; coefficients from FVS model

Timber and wildlife structural stage coefficients were modeled using Forest Vegetation Simulation model (FVS). This modeling process used stratified forest data to develop growth and volume estimates on the forest.

Water yield coefficients were developed by the hydrologist. Complex sequence dependent yield composites were used to calculate the water yield. Output code WATR was dependent on the acres of conifer timber harvest in the existing stand. Treatment types of clearcut or shelterwood cuts generated water yield. Selection harvest systems were assumed to have no affect on water yields, since the basal area removed was so small. The coefficients for water yield based on species, size, and harvest method derived by the hydrologist were then associated with the acres of timber harvest in the complex sequence dependent yield composites. Forestwide and area specific reports of water yield increase were then generated from the Spectrum solution.

Forestwide and area specific reports of water yield increase were then generated from the Spectrum solution. Several minor tracking errors for water yield were discovered during review of the model. These consisted primarily of missing water yield coefficients assigned to various combinations of forest type, prescription and thinning entries. These errors were corrected and the resulting water yields were reviewed and verified manually to verify accuracy.

Spectrum Constraints

Several constraints were developed for the Spectrum model in response to standards and guidelines and the management requirements in the NFMA regulations (36 CFR 219.27). Constraints were also developed in response to management goals and to improve the model's simulation of actual management of the Forest. The following Spectrum constraints were applied to all alternatives. The affect of each constraint on the model is discussed in the following section on "Sensitivity Analysis."

- **Long-term Sustained Yield and Nondeclining Yields**

  Ensures that the timber yield is sustainable and will not decline in any decade.

- **Snags**

  To allow for the retention of snags, the timber yields for regenerated stands were reduced in the yield tables. For clearcuts, shelterwood, and coppice, four trees per acre were retained for snags. For group or individual tree selection, two trees per acre greater than 10 inch DBH were retained in management area prescriptions 5.13, 5.21, 3.32, 4.22, 4.31, 5.15 and 5.4. Four trees per acre greater than 20 inch DBH were retained in management area prescription 5.11.

- **Watersheds (WTA0, WTA1, WTA2, WTA3, and WTA4)**

  Timber must be harvested only where soil, slope, and watershed conditions are not irreversibly damaged (NFMA as summarized in the Watershed Conservation Practices Handbook). The SPECTRUM watershed constraint was developed and used to address NFMA, Clean Water Act and the Forest Plan standard below. The paragraph following the standard below is from the Watershed Conservation Practices Handbook 2509.25 and provides a reference to the 25% level that is utilized in the SPECTRUM watershed constraint. The *standard* below is not quantitative and is not specific to a single land use (i.e. it applies to timber harvest, prescribed fire or any other management activity that may adversely impact stream health):

- **Manage land treatments to conserve site moisture and to protect long-term stream health from damage by increased runoff. (STANDARD)**

  “In nearly every region, cutting trees increases water yield from forested watersheds (USFS 1980). As real as these increases are, they are such a small increment of total water yield that they can rarely be measured in larger watersheds. Annual climate variations are much more important. Flow increases occur mostly during spring runoff and summer, and are not significant until about 25% of the basal area of a forested watershed is cut (USFS 1980). Large openings can suffer snow scour that can actually reduce site moisture and water yield." (Watershed Conservation Practices Handbook 2509.25)

Changes in water yield are generally not measurable until 20-25% of a watershed is harvested. Bankfull discharges have been found to mobilize and transport the majority of annual sediment loads over a period of years (Andrews, 1980). Troendle and Olsen (1998) found that the duration of bankfull discharge increased after timber harvest. Channel morphology changes as a result of forest canopy changes therefore might be expected to occur as a result of altered flow and sediment transport characteristics. The Forest Plan standard above provides a means to protect stream channels against increased flows as a result of vegetation management. The SPECTRUM watershed constraint is intended to identity watersheds where channel instability as a result of increased water yield from vegetation management may occur and limit the amount of timber harvest in those watersheds until hydrologic recovery has occurred. Channel instability is not expected to be a significant issue in most areas on the Forest due to the harvest levels in individual watersheds and the channel conditions present on most of the Forest. The SPECTRUM watershed constraint provides a Forestwide modeled indication of potential conditions for use in harvest and yield modeling and is not intended to represent the actual conditions in any single watershed. Project specific analysis and mitigation may be necessary to address channel instability as a result of increased water yield from vegetation management in the few cases where there may be concerns.

Analysis was conducted to determine current levels of disturbance in each watershed (including fire, blowdown, beetle kill, roads, and timber harvest). An Equivalent Clearcut Area (ECA) was determined for each sixth level watersheds on the Medicine Bow in order to normalize activities based on basal area removal and hydrologic recovery due to vegetative regrowth since the activity occurred. Watersheds were then grouped by the percent of land currently available for harvest before the 25% threshold would be reached. Grouping was by 0%, 10%, 16%, 22% and 25%. This grouping became part of the analysis area definition and was incorporated in Spectrum Layer 2 (see earlier discussion on Spectrum layers)

Two output codes were created to track the acres disturbed. One output code tracked the acres currently disturbed. The other output code tracked new disturbance acres. The disturbance factor (e.g., one acre timber harvest equals one acre or less of disturbance) diminishes over time.

Disturbed areas due to harvest were adjusted to reflect hydrologic recovery over time and the type of harvest. Full hydrologic recovery was estimated to occur in 80 years, based on water yield data from the Fool Creek experimental watershed near Winter Park, Colorado (Troendle and King 1985). The amount of basal area removed by harvest type was used to normalize the disturbance factors for various types of harvest from clearcut to partial cuts (Kaufmann, Troendle et al. 1987).

The output code that tracks current disturbance is 0WTR. For areas in size class 6, the disturbance factor equals 1. The disturbance factor diminishes incrementally by decade to reflect an 80 year recovery period at which time the disturbance factor is set to 0. Factors vary by harvest method, but are all based on an 80 year recovery period.

The output code that tracks new disturbance is WTRT. Disturbance factors are the same as 0WTR.

An aggregate output, AWTR, was then built to reflect the total of 0WTR and WTRT. A constraint was built for each watershed group to limit the aggregate output AWTR to no more than 25% of the total acres in the watershed group for each decade.

Map B-1. Percent of watersheds available for harvest.

- **Scenery (VLRD, VLNR, VMRD, and VMNR)**

  The scenic integrity constraints are intended to address spatial harvesting issues related to standards and guidelines for scenic integrity. While SPECTRUM is not capable of explicitly addressing spatial constraints, the overall approach used in developing the scenic integrity constraints is one that is commonly used, and has a good degree of acceptance for strategic-oriented planning models.

  Two questions had to be answered to model the scenery constraints. The first is "How long does it take for an opening to no longer affect the visual quality of an area?" The second is "How much of an area may be in an opening and still meet the scenic integrity objective (SIO)?"

  Because of similarities of ecosystems and timber growth, analysis completed for the Routt EIS for the revised plan was used in developing the Medicine Bow scenery constraint. Regeneration surveys and stand exam data were reviewed to determine the age when stands would be 25 feet tall and have 400 trees per acre. Wayne Shepard, a research scientist at the Rocky Mountain Research Station, was consulted as to the age. From this information, it was determined that it requires approximately 30 years for a regenerated lodgepole pine stand and 40 years for a regenerated spruce/fir stand on the Routt to achieve a 25 foot average height and 400 trees/acre. At this point, the opening would no longer have an affect from a visual standpoint.

  Any stands that are lodgepole pine and size class 6 (nonstocked) at the beginning of the planning horizon will be considered to be openings for another 20 years. Stands that are spruce/fir and size class 6 at the beginning of the planning horizon will be considered to be openings for another 30 years.

  Analysis was performed using viewpoints, stand data, and terrain data to determine the amount of the landscape that could be in an opening and still meet the SIO. The analysis indicated that, on the average, 25% of a landscape is unseen from viewpoints.

  To maintain a SIO of moderate, 10% of the seen landscape could be in an opening. Although unseen areas are not constrained for visuals, they are still limited in the amount that can be in an opening at one time. Watershed, wildlife cover, and dispersion requirements limit the amount of openings in unseen areas to approximately 20%. The weighted average for the whole area is 12.5% in an opening (based on 0.75 of area multiplied by 0.10 plus 0.25 of area multiplied by 0.20).

To maintain a SIO of low, analysis indicated that 20% of the seen landscape could be in an opening. Because only timber harvest resulting in an opening was included in the constraint and because there are other harvest limits (watershed, wildlife, and dispersion), the threshold of 20% for the entire area was used.

The SIO is found in level 3 of the analysis areas and varies by alternative. Two output codes were used to keep track of the openings. Existing openings were tracked with the code 0EFL. New openings were tracked with EFLT. The total of the two output codes were aggregated into output code AEFL. Complex time dependent yield composites were used to track an existing (size class 6) opening as an opening (20 years for lodgepole pine and 30 years for spruce/fir and ponderosa pine) at the beginning of the planning horizon. Sequence dependent yield composites were used to track any harvest opening as an opening (30 years for lodgepole pine and 40 years for spruce/fir and ponderosa pine). A General Relational Constraint was then used to limit the amount of conifer by SIO that could be an opening or, in other words, the amount of AEFL.

- **Pre-commercial Thinning (PCTA and PC2A)**

Because of the upfront cost with delayed returns, the model does not choose on its own to pre-commercial thin (PCT) any existing stands. Because, in reality, the Forest would PCT these stands to improve forest health and increase productivity, a constraint was included that requires at least 5,000 acres (500 acres/yr) to be PCT in the first decade only. This PCT would occur in size class 7 (saplings).

Lodgepole pine stands that are currently nonstocked or seedlings (size class 6) are required to have a PCT within 2 decades. However, because of the cost of doing PCT in the second decade, the model does not choose on its own to put any of the size class 6 stands into timber production. In reality, the Forest would be doing PCT on these stands and managing them on a rotation basis. A constraint requiring at least 5,000 acres of size class 6 lodgepole pine to be PCT in decade 2 was built. This constraint puts these lands into timber management.

- **Cable Logging (CABA)**

The Forest has not used cable logging in the past, and it is unrealistic to assume we will begin to cable log many hundreds of acres in future years. In order to support a higher level of harvest in current decades, the model may choose to do a substantial amount of cable logging in future decades. Thus, a constraint was included that limits cable logging to 2,000 acres for any one decade.

- **Helicopter Logging (HELI)**

  As with cable logging, the model may choose to do a substantial amount of helicopter logging in future decades in order to support a higher level of harvest in current decades. The Forest has not used helicopter logging in the past and it is unrealistic to assume we will begin to helicopter log many hundreds of acres in future years. To limit the helicopter logging to a reasonable number of acres in any decade, a limit of 2,000 acres for any one decade was included.

- **Species Mix (MIXP and MIXS)**

  Revenue value is not broken out by species. Therefore, the model would choose to harvest the species with the highest volume, while meeting all other constraints. In reality, the species harvested are mixed (historically about 60% lodgepole). To more accurately reflect plan implementation, the total timber harvested was constrained to be comprised of between 40 and 60% lodgepole pine.

- **Financial Efficiency (FINP and FINS)**

  A constraint was evaluated to insure that revenues must exceed costs in all decades. Sensitivity analysis determined that this constraint had no effect on PNV even when completely disabled.

- **Budget Constraint (BUDG)**

  To assess effects under current budget levels, each alternative was run with a desired condition budget constraint as identified in the S-3 tables of the FEIS. At the experienced budget level, the constrained budget varies by alternative, based on the theme. The model was run with this constraint to determine the estimated volume offer. The model was also run with the budget constraint set to experienced budget levels.

- **Mix of Silvicultural Prescriptions for 5.11 and 5.13 / 5.15 / 5.21 / 3.32 / 4.22 / 4.31 / 5.4**

  The interdisciplinary team and district timber management assistants (TMAs) developed a mix of silvicultural prescriptions to define 5.11 and 5.13 (and 5.15, 5.21, 3.32, 4.22, 4.31, and 5.4) management area prescriptions. Because 5.11 is less intensive, more uneven-aged management was emphasized, while 5.13 allowed more even-aged management. The following constraints were used to define the mix of silvicultural systems by management prescription:

  For Rx 5.11 and species lodgepole pine:

  - Group selection is minimum of 10% acres harvest. (MLLG)

  For Rx 5.11 and species ponderosa pine:

  - 2-step shelterwood is minimum of 95% acres harvest. (MLPS)

For Rx 5.13/5.15/5.21/3.32/4.22/4.31/5.4 and species ponderosa pine:

- 2-step shelterwood is minimum of 95% acres harvest. (MFPS)

For Rx 5.11 and species spruce/fir:

- 3-step shelterwood is minimum of 45% acres harvest. (MLS3)
- 2-step shelterwood is minimum of 10% acres harvest. (MLS2)
- Group selection is minimum of 35% acres harvest. (MLSG)
- Individual tree selection is minimum of 5% acres harvest. (MLST)

For Rx 5.13/5.15/5.21/3.32/4.22/4.31/5.4 and species spruce/fir:

- 2-step shelterwood is minimum of 10% acres harvest. (MFS2)
- 3-step shelterwood is minimum of 40% acres harvest. (MFS3)
- Group selection is minimum of 40% acres harvest. (MFSG)
- Individual tree selection is minimum of 5% acres harvest. (MFST)

- **Old Growth Retention**

a) Alternative A (OLDG and OLDF)

Old growth in the Alternative A is defined as structural stages 4B, 4C, and 5. An aggregate output code named OLDGROWTH was developed which is the sum of SS4B, SS4C and SS5.

Two old growth constraints were developed. For management areas 3.32 and 5.4, the minimum acres in old growth is 20% for the planning horizon. For the remaining management areas, the minimum acres in old growth is 10% for the planning horizon.

b) Alternative B, C, D, E (PPOG, SFOG, LPOG, PPRO, SFRO, LPRO)

Old growth in these alternatives is based on tree species in structural stages 4B, 4Cand 5. An aggregate output code named OLDGROWTH is used as the sum of SS4B and SS4C. Three old growth constraints were developed. Ponderosa Pine (PPOG) will have 25% retained, Spruce/Fir (SFOG) will have 20% retained and Lodgepole Pine (LPOG) will have 10% retained. To keep the model from placing all the old growth in roadless areas, three additional constraints were created to force old growth into roaded areas, roaded Ponderosa Pine (PPRO) will have 25% retained, roaded Spruce/Fir (SFRO) will have 20% retained, and roaded Lodgepole (LPRO) will have 10% retained. (NOTE: Alternatives C & D can not meet the 25% retention in roaded for Ponderosa Pine because of unavailability due to management area prescriptions, thus the constraint was lowered to 22%).

Old growth constraints for Alternative D FEIS were adjusted to accommodate the need to account for recruitment old growth. The adjustments included changing lodgepole pine from 10% to 15%, and spruce/fir from 20% to 25%. This increase is expected to adequately account for wildlife security areas as well, since the majority of these areas will also serve to meet that constraint.

c) Alternative F (PPOG, SFOG, LPOG)

Old growth in this alternative is based on tree species, tree age and canopy closure. Tree specie, tree age and canopy closure are incorporated into the structural stage, with structural stages 4B and 4C meeting the criteria. An aggregate output code named OLDGROWTH is used as the sum of SS4B and SS4C. Three old growth constraints were developed. Ponderosa Pine (PPOG) will have 50% retained, Spruce/Fir (SFOG) will have 50% retained and Lodgepole Pine (LPOG) will have 50% retained. (NOTE: The 50% retention in Ponderosa Pine could not be obtained because of unavailability due to management area prescriptions, thus the constraint was lowered to 38%)

- **Management Area 5.15 Constraint (QXRT)**

These areas are managed to maintain or restore ecological conditions through a variety of management activities, while providing a mix of ecological and human needs including commercial wood products. To reflect natural ecological disturbances, Management area 5.15 has a restraint to limit the amount of harvest in roaded areas of tree size class 9. For the DEIS the constraint is divided into withholding 25% of a harvested area from being harvested, to emulate patterns of horizontal and vertical structure typical of the forest cover type under natural ecological processes. An additional 28% is withheld from harvest to emphasize ecological objectives such as restoring and maintaining connectivity, blocks of interior forest, and legacy material. The total amount to maintain at min level is a minimum of 53% of the management area of tree size 9 in the roaded environment. For the FEIS this variable was modified to reflect only the increased levels of unharvested islands within clearcuts. This level is estimated to be approximately 20% of clearcut acres. Since 4% was already removed for snag retention through FVS modeling, the variable was set to 16% in the SPECTRUM model.

Sensitivity Analysis

A series of sensitivity analyses were conducted for key modeling constraints. The results are summarized below.

Table B-9. SPECTRUM sensitivity comparison.

Constraint	PNV	Harvest Level 1st decade
Base run Alternative D FEIS for Comparison	$65,726,128	257,920 mbf
Remove watershed constraints	$65,726,128	257,920 mbf
Remove visual constraints	$65,765,364;	257,617 mbf
Drop budget constraint in half	$46,235,592	151,523 mbf
Remove species mix constraint for harvest volumes:	$65,986,348	255,754 mbf
Remove MA5.15 min-lvl mgmt acres constraint:	$65,931,484	259,767 mbf
Remove old growth constraints by forest type:	$67,169,128	264,597 mbf
Remove financial efficiency constraint;	$65,726,128	257,920 mbf
Cable and Road Construction Costs reduced by half	$73,133,440	262,640 mbf
Increase Revenue to $300	$82,462	257,920 mbf
Decrease Revenue to $100	$27,487	257,920 mbf

These results indicate that the most restrictive constraint in the SPECTRUM model is budget. As described in other sections of the EIS, actual budget levels will vary and are not a part of the Record of Decision.

Additionally, these analyses indicate that increasing or decreasing revenue values only changes the amount of money generated and not the amount of timber the model chooses to harvest.

Benchmark Comparison of SPECTRUM Model Outputs

The outputs for this model were compared with the results of the 1985 outputs projected in 1985.

The 1985 benchmark Alternative estimated 56.6 MMBF/year. The SPECTRUM model in 2002 estimated a 50 year average ASQ of 59.5 MMBF.

These differences are attributed primarily to updated suitability coverages using GIS, more detailed stratification of commercial species, and changes in the model itself.

Total Sale Program Quantity

In Chapter 3, Timber Resources section, Anticipated Harvest and Processing subsection, the anticipated average annual Total Sale Program Quantity (TSPQ) for the first decade is presented in the following table:

Table B-10. Average annual total sale program quantity for first decade (MMBF).

Harvest	A	B	C	D DEIS	D FEIS	E	F
Experienced Budget	15.3	17.6	15.3	15.1	15.1	12.0	4.8
Desired Budget Level	37.3	35.4	33.7	31.8	30.1	27.6	6.2

What follows is a more detailed accounting of the components and assumptions that constitute this determination of TSPQ for the Medicine Bow National Forest plan revision.

Experienced budget projected for the first decade is the most constraining factor in determining anticipated sawtimber harvest levels. It is more constraining than applying the actual proportion of Allowable Sale Quantity (62%) that has been harvested over the life of the initial plan (1986-2002). The following table shows this relationship for each alternative.

Table B-11. Anticipated sawtimber harvest levels by alternative.

Alt	Annual ASQ Decade 1 (MMBF)	Estimated Annual Sawtimber Harvest Constrained by All Factors--History	Estimated Annual Sawtimber Harvest Constrained by Budget Only--Anticipated	Estimated Annual Sawtimber Harvest Most Limiting Constraint
A	28.9	18.0	10.6	10.6
B	27.2	16.9	12.5	12.5
C	25.8	16.1	10.6	10.6
D DEIS	24.2	15.1	10.4	10.4
D FEIS	22.8	14.2	10.4	10.4
E	20.7	12.9	7.8	7.8
F	3.0	1.9	3.0	1.9

Other harvests anticipated on the Medicine Bow are not counted toward the Allowable Sale Quantity. These include 1) sawtimber from fuel treatments and other non-timber resource actions, 2) firewood, and 3) products-other-than-logs (POL), such as posts and poles, from all harvests and treatments,. In this analysis, POL is estimated for traditional timber sales for timber management purposes, treatments for fuels, and treatments for other resource purposes.

The following table shows the POL addition to sawtimber harvests made for timber management purposes. In recent years, POL volume has typically added about 20 percent to the sawtimber volume of traditional timber sales.

Table B-12. POL volume anticipated as part of sawtimber harvest in first decade.

Alt	Estimated Annual Sawtimber Harvest (MMBF)	MMBF Removed		
		Total	Sawtimber	POL
A	10.6	12.7	10.6	2.1
B	12.5	15.0	12.5	2.5
C	10.6	12.7	10.6	2.1
D DEIS	10.4	12.5	10.4	2.1
D FEIS	10.4	12.5	10.4	2.1
E	7.8	9.4	7.8	1.6
F	1.9	2.2	1.9	0.4
Alt	Full ASQ Sawtimber Harvest (MMBF)	MMBF Removed		
		Total	Sawtimber	POL
A	28.9	34.7	28.9	5.8
B	27.2	32.6	27.2	5.4
C	25.8	31.0	25.8	5.2
D DEIS	24.2	29.0	24.2	4.8
D FEIS	22.8	27.4	22.8	4.6
E	20.7	24.8	20.7	4.1
F	3.0	3.6	3.0	0.6

Fuels treatments in the wildland urban interface provide another source of POL. In FY03, fuel treatments were conducted on about 700 acres of the Medicine Bow NF. For the FEIS, it was assumed that treatment acres throughout the first decade would match experienced budget levels in 2010. Of total acres treated, 70 percent would be burned and 30 percent would be treated mechanically. The forest-wide average of 10 MBF per acre was assumed for these treatment areas. Given that 30 percent of the volume would be removed when an acre is mechanically treated, the harvest volume for such acres would yield 3 MBF per acre. The following table shows the resulting timber removal (both sawtimber and POL) for anticipated fuel treatments in each year of the first decade.

Table B-13. Annual timber removal as part of fuel treatments in the first decade.

Alt	Treated Acres - Exp Budget - Decade 1	MMBF Removed		
		Total	Sawtimber	POL
A	2,500	0.23	0.06	0.17
B	3,500	0.32	0.08	0.24
C	3,500	0.32	0.08	0.24
D DEIS	4,000	0.36	0.09	0.27
D FEIS	4,000	0.36	0.09	0.27
E	4,000	0.36	0.09	0.27
F	2,200	0.20	0.05	0.15

Timber resulting from treatments for non-timber objectives has been negligible in recent years. However, it is more typical to realize some timber from such treatments. Consequently, it was estimated that total volume from treatments for non-timber resource objectives, including fuels, would be 1 MMBF of POL. POL from fuel treatments is shown above. The table below is the balance from non-fuel treatments. It is assumed that all volume from other treatments is POL.

Table B-14. POL harvest from non-fuels vegetation treatments.

	MMBF Removed		
Alt	Total	From Fuels	From Other
A	1.0	0.2	0.8
B	1.0	0.2	0.8
C	1.0	0.2	0.8
D DEIS	1.0	0.3	0.7
D FEIS	1.0	0.3	0.7
E	1.0	0.3	0.7
F	1.0	0.1	0.9

The following table shows the annual average of all timber removed from the forest during the first decade, regardless of originating purpose.

Table B-15. Total timber removed by alternative in decade 1, annual average, MMBF.

	Anticipated Harvests				Full ASQ Harvest			
Alt	Sawtimber	POL	Firewood	Total	Sawtimber	POL	Firewood	Total
A	10.7	3.1	1.5	15.3	29.0	6.8	1.5	37.2
B	12.6	3.5	1.5	17.6	27.3	6.4	1.5	35.2
C	10.7	3.1	1.5	15.3	25.9	6.2	1.5	33.5
D DEIS	10.5	3.1	1.5	15.1	24.3	5.8	1.5	31.6
D FEIS	10.5	3.1	1.5	15.1	22.9	5.6	1.5	30.0
E	7.9	2.6	1.5	12.0	20.8	5.1	1.5	27.4
F	1.9	1.4	1.5	4.8	3.0	1.6	1.5	6.1

Analysis of Rangeland Capability and Suitability for Livestock Grazing

Requirements to perform analysis of rangeland capability and suitability are found at 36 CFR 219.20. There is no corresponding manual or handbook direction. FSM 1905 contains a definition of "Lands Suitable for Grazing or Browsing" as "Lands with vegetation that can be used by grazing animals, both domestic and wild herbivores, without damage to the soil and water resource values."

Rangeland Capability

The definition of rangeland capability is found in 36 CFR 219.3 and is as follows:

Capability: The potential of an area of land to produce resources, supply goods and services, and allow resource uses under an assumed set of management practices and at a given level of management intensity. Capability depends upon current resource conditions and site conditions such as climate, slope, landform, soils, and geology, as well as the application of management practices, such as silviculture or protection from fire, insects, and disease. Rangeland capability does not vary by alternative and is therefore only determined once through the Land Management planning process.

Required Data for Determination of Rangeland Capability:

- Land Ownership (from Cartographic Feature Files (CFF), or from the Common Land Unit (CLU) of the Integrated Resource Inventory (IRI)
- Soil Map Unit - from IRI or other soil inventory
- Geology - optional -- from IRI or other inventory
- Optional - Potential plant community production - from RMRIS database or from Common Vegetation Unit or IRI
- Water polygons - from CFFs or from Common Water Unit (CWU) of IRI
- Rivers/Streams - from CFFs or CWU of IRI
- Roads - from CFFs or Infra Travel Routes
- Slopes - from Digital Elevation Models (DEM)
- Optional – Distance to water from CFFS, Common Water Unit and/or Range Structural Improvement layer.

Process for Determination of Rangeland Capability:

Use GIS to identify areas that meet the following criteria (it is not expected that all National Forest System units will have all of the following data sets available in the near future. Use the best available data in making the determination and document what data sets are not available and what steps were taken to provide similar data). If local changes are made to the values to be applied, document the rationale behind the changes:

1. Begin with all lands within the project area that are National Forest System (NFS) lands.
2. Subtract soil types that are dominated by a large percentage of rock outcrop and rubbleland, loose granitic or highly erosive soils, or very wet and boggy soils. Optional - to identify erosive areas, a geologic layer to identify active landslides, slumps, etc. may be used.
3. Subtract soil types that are not inherently capable of producing more than 200 pounds of forage/acre within their Potential Natural Community (such as badland outcrops or alkali salt flats).
4. Subtract areas that consist of lakes, reservoirs, or ponds, e.g. the area covered by water at the high water mark (from polygon water layer from CFFs).
5. Buffer major rivers (Colorado or North Platte, for example) by the actual width (averaged for individual reaches if need be) and subtract.
6. Buffer perennial streams by the actual width of the water surface at the mean high water mark, or use an average width of 3 feet on either side of center line and subtract. **

   ** *The 6-foot width for perennial streams represents an <u>average</u> width for a stream's water surface and can be used as a Unit-wide average for purposes of modeling.*
7. Buffer Forest development roads by 8 feet on either side of center line and subtract.**

   ** *The 16-foot width for roads represents an <u>average</u> width for a road's surface and can be used as a Unit-wide average for purposes of modeling. The road surface is non-capable unless the road surface has been obliterated and revegetated in which case, the road surface will remain within the capable land base.*
8. Subtract slopes meeting the following criteria:
   a. Subtract slopes greater than 60% (not capable for either sheep or cattle). Keep track of capable acres for cattle and sheep separately (may also need to track separately for other kinds and classes of livestock such as bison as the need presents).
   b. From the above (a) capability calculations, subtract slopes greater than 40% (slopes of 41-60% are capable for sheep but not normally for cattle). This figure can be modified for each specific Forest or Geographic area to fit with local situations (with documented rationale).

9. Optional: subtract areas that lack available water, or lack the potential to develop water, within approximately 3 miles of the center of the polygon for Grasslands or one mile in mountainous rangelands. This figure can be modified for each specific Forest or Geographic area to fit with local situations (with documented rationale).
10. The remaining area is **Capable Rangeland.** The capable rangeland will normally be displayed as two separate map displays/acreage tables: one map/acreage table set displays capable polygons/acreage for cattle; and, a second set displays capable polygons/acreage for sheep. Other displays may be used for other kinds of animals as needed.

Rangeland Suitability

The definition of suitability is found at 36 CFR 219.3 and is as follows:

> *Suitability:* The appropriateness of applying certain resource management practices to a particular area of land, as determined by an analysis of the economic and environmental consequences and the alternative uses forgone. A unit of land may be suitable for a variety of individual or combined management practices.

Rangeland suitability may vary by alternative being considered in the Land Management Planning process. For this reason, suitability will need to be determined by alternative or grouping of similar alternatives.

Required Data for Determination of Rangeland Suitability

- Percent tree or unpalatable shrub canopy cover - from RMRIS database or from Common Vegetation Unit or IRI
- Management Area Prescription/Allocation proposed for each alternative.
- Areas closed to grazing or not in an allotment as proposed for each alternative.
- Fenced Recreation Areas and/or Sites where livestock is to be excluded, as proposed for each alternative.
- Fenced cultural resource or other special management areas proposed to be excluded from livestock grazing by alternative.
- Administrative Sites where livestock grazing is, or is proposed to be, excluded during the life of the plan (except administrative pack and saddle pastures which would be considered to be suitable)
- Special Use Sites where livestock grazing is determined to be incompatible with the purpose of the special use (summer homes, electronic sites, etc.). This determination may vary by alternative.
- Permanent exclosures fenced so as to exclude livestock use during the life of the plan.

- Road rights of way/easements (not including the actual road bed as covered in the capability analysis) where such right of way is, or is proposed to be, fenced to exclude livestock grazing. Include actual area fenced or estimated (from CFFs).
- Railroad rights of way/easements where such right of way is, or is proposed to be, fenced to exclude livestock grazing. Include actual area fenced or estimated (from CFFs).
- Research Natural Areas where decisions have been made, or are proposed in the alternative, to exclude livestock.
- Research facilities, Municipal Watersheds, or other special purpose areas where decisions have been made, or are proposed in the alternative, to exclude livestock.
- Threatened or Endangered Species habitat permanently excluded from livestock grazing, or proposed in the alternative for exclusion through the life of the plan.
- Minerals production areas (mills, mines, settling ponds, etc.) where livestock grazing is incompatible with the minerals activity for safety or other reasons.
- Perform economic analysis by alternative to determine cost efficiency (36 CFR 219.3, definition of suitability and 36 CFR 219.20(b)). Determine if areas that are not economically efficient under circumstances expected to prevail during the life of the plan should be classified as unsuitable. NFMA does not require present net value to be positive for rangelands to be suitable. There are no criteria for determining suitability based on economic efficiency. This analysis is completed so that the decision maker is better informed and understands the economic trade-offs prior to making the decision.

Process for Determination of Rangeland Suitability.

To determine rangeland suitability (36 CFR 219.3, definition of suitability), perform the following as a separate GIS analysis for each alternative or group of similar alternatives:

1. Subtract areas that currently have an overstory of tree canopy cover and/or unpalatable shrub canopy cover greater than 70%.
    a) Transitory range will be considered as a special short-term instance where suitability occurs because of the removal of the overstory vegetation (as by fire or harvest). However, since the long term site potential is normally a moderate to dense canopy with little understory production, and since these areas are normally dedicated to timber (and other resource) production, these areas are generally considered to be suitable for grazing only for the lifespan of the time that it takes for the canopy to once again close back to 70% or greater, and only if the costs or viability of adequately mitigating effects

relative to livestock grazing on forest vegetation regeneration are acceptable.

Use harvest maps and records to determine if specific areas currently meet the suitable criteria and if they are expected to remain within that criteria for the life of the plan. If so, they are determined to be suitable. If the transitory site will become non-suitable during the life of the plan, either portray it as non- suitable, or show it as being suitable only for the estimated time that it will continue to meet suitability definitions.

Optional: Certain vegetative types (such as some Aspen communities) may be suitable for a given type of livestock in certain geographic areas and not in other areas. If appropriate, these vegetative communities may be subtracted out of the suitable acres as needed. Document the rationale for the decision.

2. Subtract areas that have a proposed management area prescription allocation that does not allow for livestock grazing (e.g., certain Research Natural Areas, experimental forest, municipal watersheds). Subtract only management area prescriptions that have proposed standards & guidelines that do not allow for livestock grazing management, or where decisions have previously been reached that livestock grazing is incompatible with the planned land management prescription and the proposed alternative would continue that incompatibility finding.

3. Subtract fenced recreation areas, developed recreation sites, administrative sites (except administrative pack and saddle stock pastures), minerals production sites, fenced cultural resource sites, permanent exclosures, and appropriate special use sites, where livestock use has been determined to be incompatible with the primary land use and/or where the alternative proposes to exclude livestock use.

4. Buffer primary roads (from CFFs or Infra Travel Routes; Primary roads are defined by the actual fenced area, or where a fence is known or proposed to exist but the exact location is unknown, buffer by 100 feet on either side of the center line and subtract. **

5. Buffer secondary/county roads by the actual fenced area, or where a fence is known or proposed to exist but the exact location is unknown by 33 feet on either side of the center line and subtract to account for the area that is fenced along secondary/county roads. Only use when the road (or road segment) is fully excluded from livestock grazing on NFS lands. **

   ** The road surface itself is non-capable. The fenced area alongside the road is capable of growing harvestable forage, but is unsuitable for livestock grazing if decisions have or will be made that livestock grazing is incompatible with other objectives associated with the ROW/easement.

Road surfaces are taken out at the capability analysis level and fenced areas along roads are taken out at the suitability analysis level.

6. Buffer railroads by 100 feet on either side of centerline or by the actual fenced area, or where a fence is known or proposed to exist but the exact location is unknown, and subtract.
7. Subtract areas that are not currently within any range allotment or are closed to grazing. The reason for past or proposed closure or current lack of livestock grazing activity needs to be explained (e.g., lack of access, conflicts with wildlife, conflicts with recreation, etc.).
8. Subtract areas where decisions have been made that specific TES habitats need to be excluded from livestock grazing.
9. Have IDT specialists on the planning team identify any additional areas where conflicts occur between livestock grazing and other resources to the extent that the conflicts cannot be resolved or satisfactorily mitigated, and where the other resource values are proposed in the alternative to take precedence over livestock use. If the planning recommendation is that livestock use in these areas is incompatible, or the conflicts are incapable of being resolved in a satisfactory manner, these lands will be designated as non-suitable for the specific alternative for this planning cycle. Document the reason for the non-suitable determination.
10. The remaining area is **Suitable Rangeland. --** The suitable rangeland will normally be displayed as multiple map displays and acreage tables with one map/acreage table display for each alternative.

Capability & Suitability Determination

The overlay of the capable acres with the suitable acres yields the Capable and Suitable Acres. This analysis is done separately for cattle and for sheep (and possibly for other kinds of animals as needed) and for each alternative (or grouping of similar alternatives) being considered.

The capability and suitability analysis and determination is not a decision to graze livestock on any specific area of land, nor is it a decision about or estimate of livestock grazing capacity. The capability/suitability analysis and determination may or may not provide supporting information for a decision to graze livestock on a specific area.

Any grazing allotment will contain areas that are capable and/or suitable as well as areas that are modeled as being not capable and/or suitable. Since the evaluation is based on a modeling process and is dealing with a variety of complex landscapes, it is inevitable that this intermingling will occur on a land base of any significant size. Therefore, these capability/suitability determinations are not intended to imply that livestock will be precluded from occasionally being found on lands that may be modeled as non-capable or non-suitable.

Together, the capability and suitability analyses can provide information for Forest Plan level analysis as well as project level analysis and subsequent NEPA decisions.

At the Forest Plan level, capability and suitability analysis provides basic information regarding the potential of the land to produce resources and supply goods and services in a sustainable manner, as well as the appropriateness of using that land in a given manner. This information assists the interdisciplinary team and the line officer in evaluating alternatives and arriving as Forest landscape level decisions. It also helps in an analysis of alternative uses foregone.

At the project level, rangeland capability and suitability may be reviewed, updated, or made more site-specific, if it is an issue for that project or provides information useful to the decisions being made. For instance, rangelands identified as capable and suitable for domestic livestock grazing in the land and resource management plan may include areas that are not appropriate for domestic livestock grazing when analyzed at the site-specific level (i.e., some wetlands or some campgrounds). A more site-specific analysis at the allotment (or multi-allotment) scale may provide information useful in planning management of the given allotment(s).

Display of Rangeland Capability/Suitability in the EIS

Table B-16. Acres of land determined as capable for livestock use.

Classification/Description	Acres Deducted	Running Totals
Net National Forest System Acres		1,084,390
Deductions for Non-Capable Acres		
Rock outcrop, rubbleland; loose granitic, highly erosive, or very wet soils.	9,024	1,075,366
Soils/plant communities that at site potential inherently produce <200 lbs/acre.	0	1,075,366
Lakes, reservoirs, and ponds	4,662	1,070,704
Major Rivers	0	1,070,704
Perennial Streams	1,262	1,069,442
Road beds (not restored/revegetated)	4,829	1,064,613
Slopes greater than 60%	9,751	1,054,862
Slopes between 41-60% (not capable cattle)	74,017	980,845
Optional: areas w/out drinking water capability	0	980,845
Total capable for sheep grazing		1,054,862
Total capable for cattle grazing		980,845

Table B-17. Acres of land determined as suitable for livestock use.

Classification/Description	Acres Deducted	Running Total for Cattle	Running Total for Sheep
Net National Forest System Acres Capable for Grazing		980,845	1,054,862
Deductions for Non-Suitable Acres			
Existing canopy cover >70%	53,137	927,708	1,001,725
M.A. prescription (S&Gs) does not provide for grazing (ex: some Research Natural Areas, Research Facilities, Municipal Watersheds, etc.).	613	927,095	1,001,112
Developed Recreation, Administrative, Minerals, Cultural, or Special Use Sites - excluded	3,760	923,335	997,352
Road ROW - excluded	386	922,949	996,966
Railroad ROW - excluded	0	922,949	996,966
Areas not within allotments or areas currently closed to grazing by decision	38,716	884,233	958,250
TES habitat permanently excluded from grazing	0	884,233	958,250
Other areas identified by IDT to be excluded from grazing	0	884,233	958,250
Total suitable acres for grazing		884,233	958,250

Table B-18. Acres determined to be both capable and suitable for livestock use.

Classification/Description	Acres Capable and Suitable
Total Capable and Suitable Acres for Cattle grazing for this alternative	884,233
Total Capable and Suitable Acres for Sheep grazing for this alternative	958,250

Note: The determination of acres both capable and suitable is not strictly a mathematical exercise of subtracting both the non-capable and the non-suitable acres from the total NFS acres. This is because some acres are both non-capable and non-suitable. Therefore, this table is a summary of a GIS exercise in applying both criteria and determining what remains (what remains after eliminating all acres classified as non-capable, non-suitable, or both, is acres both capable and suitable).

The number of acres capable, and suitable, for livestock grazing does not vary by alternative; estimated AUM outputs are similar for Alternative A-E. While Alternative F plans for an estimated reduction of AUMs by 25%, the number of capable and suitable acres does not vary - the allowable forage utilization by livestock is reduced accordingly.

Economic Analysis:

Forest-wide standards and guidelines for grazing identify desired resource conditions across all alternatives. To achieve those desired resource conditions, specific grazing systems, stocking rates, needed structural and non-structural improvements, and coordination with other resource uses and values are developed at the allotment management planning level based on the site-specific conditions. Presently, there are numerous grazing systems being used on the Forest including, but not limited to, multi-pasture rotation, deferred rotation, alternate year, once over lightly, high intensity and short duration, and, to a limited degree, continuous.

Table B-19. Summary of economic analysis for livestock grazing.

Measure	Average Profile for Lands Managed under Alts A-E	Average Profile for Lands Managed under Alternative F
Annual Average over 10 Years		
Head Months - Sheep	42,000	31,500
Head Months - Cows	56,000	42,000
Head Months - Total	98,000	73,500
Acres Capable & Suitable - Sheep	958,250	958,250
Acres per Head Month – sheep allotments only	2.1	3.0
Revenue/Head Month - Sheep	0.27	0.27
Acres Capable & Suitable - Cattle	884,233	884,233
Acres per Head Month – Cattle allotments only	14	21
Revenue/Head Month - Cows	1.35	1.35

Alternative Range Management Prescriptions

To assess the environmental and economic consequences of livestock grazing management on National Forest System rangelands, two different management prescriptions were developed and analyzed. Under each of the two prescriptions, management would focus on meeting the goals and objectives of the alternatives by using the approved standards, guidelines, and practices. Allotment management plans (AMPs) would continue to be developed and refined to meet the intent of the Rescissions Act (PL 109-14) schedule for completion of allotment NEPA.

Table B-20. Financial and economic comparison of grazing prescriptions.

Grazing Prescriptions	Average Profile for Lands Managed under Alts A-E	Average Profile for Lands Managed under Alternative F
Estimated Grazing (Annual Average, 2003-2012)		
Sheep:		
Head Months per Acre	0.43	0.32
Animal Unit Months per Acre	0.13	0.10
Cattle:		
Head Months per Acre	0.06	0.05
Animal Unit Months per Acre	0.08	0.06
Financial Analysis (taxpayer/agency perspective)		
Revenues per Acre per Year		
Sheep	$0.13	$0.09
Cattle	$0.09	$0.07
Costs per Acre per Year		
Sheep	$1.07	$1.09
Cattle	$0.70	$0.71
Net Revenue per Acre per Year		
Sheep	-$0.94	-$1.00
Cattle	-$0.61	-$0.64
Present Net Value Per Acre in Decade 1		
Sheep	-$8.25	-$8.76
Cattle	-$5.35	-$5.61
Economic Analysis (society perspective)		
Benefits per Acre per Year		
Sheep	$1.47	$1.11
Cattle	$0.96	$0.72
Costs per Acre per Year		
Sheep	$3.40	$2.84
Cattle	$1.52	$1.33
Net Benefit per Acre per Year		
Sheep	-$1.93	-$1.73
Cattle	-$0.56	-$0.61
Present Net Value per Acre in Decade 1		
Sheep	-$16.19	-$14.68
Cattle	-$4.42	-$4.95

The first grazing management prescription is the continuation of current livestock grazing management. This prescription forms the baseline, or "no action" prescription. Existing livestock grazing management goals and objectives would be continued under the current management prescription (Alternative A), as well as under Alternatives B-E. Standards and guidelines are designed to improve any existing unsatisfactory rangeland condition; areas in unsatisfactory condition become satisfactory through mitigation identified during site-specific analysis. Grazing systems are developed within this direction at the site-specific level. Rangeland improvements are maintained at grazing permittee expense. Existing improvements that have reached the end of their physical life span would be reconstructed as needed or removed. New improvements and vegetative treatments are approved on a case-by-case basis. Vegetation treatment with prescribed fire would be conducted primarily for wildlife habitat improvement, fuels reduction, and to meet desired conditions. In general, Forest-wide stocking is expected to remain fairly constant at or near 2.1 acres per sheep-month and 14 acres per cattle-month. Actual stocking levels by allotment will vary over time depending on site specific conditions and in response to needs to maintain, protect, or enhance other resources uses and values.

The second grazing management prescription provides for a reduced level of livestock grazing. Although the same acreages continue to be available for livestock use and management, reduced forage utilization levels across much of the landscape would result in approximately a 25% reduction in livestock use levels. The same requirements and considerations for grazing systems, improvements, and vegetative treatments would be employed as in the first prescription. In general, Forest-wide stocking would be at or near 3.0 acres per sheep-month and 21 acres per cattle-month. Actual stocking levels by allotment would vary over time depending on site specific conditions and in response to needs to maintain, protect, or enhance other resource uses and values.

The economic analysis was completed from two perspectives: financial efficiency and cost effectiveness. Financial considerations include only those revenues received by and costs incurred by the Forest Service. Economics considerations include the benefits and costs of grazing to all of society. Economically, actively grazed lands benefit society by providing food and fiber, and employment. These calculations do not include benefits or costs for which monetary values are unavailable.

Environmental Consequences

The environmental consequences discussed in this section apply only to the capability/suitability analysis and are not related to the effects of specific alternatives discussed in detail in the Environmental Consequences section of the FEIS.

There are no direct, indirect, or cumulative effects associated with the determination of capability and suitability. This determination is not a decision to permit grazing. Any potential decisions to either continue to permit livestock grazing or to permit any new grazing will be made only under a site-specific analysis and decision. This site-specific analysis is where the effects and environmental consequences would be analyzed and displayed.

Determination that a parcel of land is capable and suitable is a finding that the land is capable of sustaining grazing over time and that there are no current or planned activities for that parcel of land that would render grazing incompatible. The Forest Plan, utilizing this analysis and determination, may make the decision that certain parcels should remain as active grazing allotments, should be vacated, or should be managed as forage reserves. The decision could also be made that additional capable and suitable parcels of land could become allotments or be added to allotments. Where these decisions are made in the Forest Plan, the specifics associated with those decisions are to be disclosed in the Environmental Consequences chapter.

The Forest Plan will also develop goals, objectives, and standards and guidelines associated with management of permitted livestock and/or other grazing animals on lands determined to be capable and suitable. These goals, objectives, and standards and guidelines will also consider the management of inclusions of non-capable and/or non-suitable lands within a broader landscape of capable/suitable lands where it is determined that livestock grazing may be permitted. The effects of these standards and guidelines will be disclosed in the Environmental Consequences chapter of the NEPA document.

Alternative Uses Foregone

An analysis of alternative uses foregone is required in the planning document based on how each specific alternative deals with the findings of capability and suitability. This analysis is expressed in terms of the effects of: continuing to permit livestock grazing of existing lands or to permit livestock grazing of any lands not currently authorized under permit and the potential effects that permitting grazing would have on the elimination or restriction of other activities or resource values. For example, a decision to potentially allow livestock use of a given area means that Forest visitors desiring to experience a wildland free of human influences would not be able to do so on that given area of land. Conversely, decisions to eliminate livestock grazing from any lands where it is currently authorized, or potentially could be authorized, may have effects on values such as local community stability, rural lifestyle, open space protection, etc. The analysis of uses foregone must detail the effects of the alternative actions with regard to the tradeoffs associated with decisions regarding permitted grazing or no grazing to the extent that those decisions preclude or restrict other resource uses and values.

Some lands are incompatible with grazing or browsing. Management area prescriptions identify Forest management activities that are authorized and appropriate for the area. Livestock grazing has been identified as an appropriate activity in all the management areas. Livestock grazing may not be appropriate in a few specific management areas in order to prevent unacceptable impacts to alternative uses (ex. scientific research in ungrazed areas in Research Natural Areas) or unacceptable impacts to critical resource values.

There are other areas of land within the Forest that are not planned by a specific alternative to have permitted livestock grazing for various reasons. Areas such as developed campgrounds and administrative sites (except for administrative pack and saddle stock pastures) are not generally considered to be suitable for livestock grazing. There are also areas on the Forest where no livestock grazing allotments exist due to various administrative reasons such as areas with concentrated historic recreation use. These unsuitable areas are generally common to all action alternatives.

Graphics and Documentation:

As shown and discussed above, livestock grazing was not considered a significant revision topic, and the areas determined to be capable and suitable did not vary by alternative. The following map displays acres not capable or suitable for livestock use, acres suitable for cattle use, and acres suitable for use only by sheep.

Map B-2. Alternatives A-F, Lands suitable for livestock grazing

Economic Impact Analysis

Introduction

In order to estimate the economic effects to local communities, the MBNF was divided into southern and northern sections. The southern part of the MBNF included the Pole Mountain, Snowy Range, and Sierra Madre portions of the Forest. The study area for this part of the analysis was a three county region including Albany and Carbon Counties in Wyoming and Jackson County in Colorado. Although Jackson County is not part of the MBNF, it was included in the analysis because it was part of the functional economy of the region. The northern part of the MBNF represented the Laramie Peak portion of the Forest. The study area for this part of the analysis was Converse County. A substantial portion of Laramie Peak area is in fact located outside of Converse County. However, due to the isolated location of the Laramie Peak area, it was assumed that the regional economic activity associated with this part of the Forest primarily affected the Converse County economy.

Procedures

The economic impacts of the MBNF were analyzed using two input-output models. For the southern MBNF a modified IMPLAN database for the three-county area supplemented with primary data was used to develop a model to estimate economic impacts. For the northern MBNF a standard IMPLAN model for Converse County was used to estimate economic impacts. IMPLAN is a software package for personal computers that uses the latest national input-output tables from the Bureau of Economic Analysis, secondary economic data at the county level from a variety of sources, and proprietary procedures to develop an input-output model for a study area. The software was originally developed by the Forest Service and is now maintained by the Minnesota IMPLAN Group, Inc. (MIG).

The analysis considered four economic activities associated with the MBNF including: 1) Recreation, 2) Timber Production, 3) Livestock Grazing, and 4) MBNF Operating Budget. Timber was not considered in the northern MBNF analysis because Forest Service records indicated that there were no purchases of timber sales on the Forest by firms located in Converse County in recent years. The base year for current analysis was 2001. The economic impact of the various alternatives was estimated for the midpoint of the planning period at 2010.

Data and Assumptions

Recreation

Recreation data for the Medicine Bow National Forest from the National Visitor Use Monitoring Results (NVUM) was used in the analysis (Kocis et al, July 2003). The NVUM data indicated a total of 929,230 recreation trips to the Forest annually. Based on 1997 Recreation Information Management (RIM) data it was estimated that over 96 percent of these trips were to the southern part of the Forest and less than 4 percent to the northern part of the Forest. The estimated growth in recreation on the Forest between 2001 and 2010 was based on projections for outdoor recreation in the Rocky Mountain region from Bowker et al, 2003, except for snowmobiling. The potential growth in snowmobiling was based on the growth in registered resident snowmobiles in Wyoming between 1995 and 2000.

In order to estimate the economic impact of recreation it was necessary to first separate local resident (Albany and Carbon County in the south and Converse in the north) recreation use from other Wyoming resident and nonresident (out-of-state) recreation use. Jackson County resident recreation use of the MBNF was assumed to be minimal. For purposes of the analysis, Wyoming residents from outside Albany, Carbon, and Converse Counties and out-of-state residents were considered as nonresidents to the study areas. This estimation was necessary since economic impacts are based on new dollars flowing into the regional economy. Resident recreation expenditures, however, represent a part of the current distribution of existing dollars already in the regional economy. Zip code data for Forest visitors from the NVUM was used to allocate trips between local and non-local residents, except for hunting, fishing and snowmobiling. Hunting, fishing, and snowmobiling trips were allocated between local and non-local residents based on secondary data from the Wyoming Game and Fish Department and the Wyoming Department of State Parks.

The NVUM data listed 26 categories of recreation activities, however due to a lack of corresponding expenditure data the number of categories analyzed was limited to the ten categories listed in Table 1. Table 1 summarizes the daily per person and trip per person non-local recreation visitor expenditures used in the analysis. These visitor expenditure estimates came from three sources. Hunting and fishing expenditures were based on the U.S. Fish and Wildlife Service's *2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, Wyoming*. Snowmobiling expenditures were obtained from the Wyoming Department of State Park's *2000-2001 Wyoming Snowmobile Survey*. Non-local overnight trip and non-local day trip expenditures were developed from Morey & Associates, Inc. *Report on the Economic Impact of the Travel Industry in Wyoming, 1998*, prepared for the Wyoming Business Council. These lodging based expenditure numbers were adjusted for inflation to 2002 dollars.

Timber Production

The estimates for the economic impact of timber production from the southern MBNF were initially based on a 1995 survey of local sawmills and other timber purchasers. This survey was updated in 1997 by again contacting all the sawmills in the region to review any changes since 1995. The timber information was again updated in 2003 based on a report by Keegan et al (2003). Current timber production on the Forest for 2001 was 2.4 MMBF of sawtimber and 1.0 MMBF of POL. These numbers represent a multi-year average of harvest on the Forest. It was assumed that there was no economic impact associated with firewood. Due to the uncertainty associated with timber production a total of six different scenarios were considered in terms of timber production and process capacity in the region. MBNF timber volumes considered in the analysis include none, anticipated (historical average percent of ASQ), and full ASQ. Processing capacity in the region included low, high, and very high based on the number of mills potentially operating in the region.

Due to the fluctuations in timber prices in recent years, the economic impact of timber production was based on quantity rather than price. Using Keegan's estimates of employment and the sawmill employment multiplier from the input/output model for the Southern MBNF, it was estimated that one million board feet of sawtimber would directly or indirectly generate 11.6 jobs in the local economy. Using a similar procedure, it was estimated that one million board feet of POL would directly or indirectly generate 9.6 jobs in the local economy. Combining Keegan's estimates of direct employment with information from the Wyoming Department of Employment on average earnings per job in the sawmill and logging sectors and using the income multipliers from the input/output model for the Southern MBNF, it was estimated that one million board feet of sawtimber directly or indirectly generated about $231,000 of labor earnings in the local economy. Using a similar procedure for POL it was estimated that one million board feet of POL would directly or indirectly generate about $211,000 of labor earnings in the local economy. As previously note no timber production was analyzed for the northern part of the MBNF.

<u>Livestock Grazing</u>

USFS data indicates that there were 86,600 AUMs of livestock grazing on the Forest in 2001, including 74,000 AUMs of cattle grazing and 12,600 AUMs of sheep grazing. Eighty-six percent of these AUMs were on the southern part of the Forest with the other 14 percent on the northern part of the Forest. USFS records indicate that over 73,000 of the total AUMs on the Forest were used by operation located in Albany, Carbon, Converse, or Jackson Counties. The analysis was based on these 73,000 AUMs of grazing. Due to the substantial variability in livestock prices, the ten-year average of production (1992-2001) was used to value MBNF livestock production (Table 2). For cattle, the 10-year average value of production, adjusted for inflation, was $35.96 per AUM. For sheep, the 10-year average value of production, adjusted for inflation, was $22.57 per AUM. The cattle ranching sectors of IMPLAN model for Converse County were modified to more accurately reflect region operations using livestock budgets from the University of Idaho (Rimby et al, 2000).

<u>MBNF Operating Budget</u>

This section considers the economic impact of the regional expenditures by the USFS to operate and manage the MBNF. USFS data indicates that the MBNF operating budget was nearly $7.4 million in 2001. Approximately 80 percent of this budget was associated with the managing the southern part of the Forest with the other 20 percent use in the northern part of the Forest. In 2001 the Forest employed 243 people and had a payroll of $5.4 million. In the analysis the distribution of these expenditures was based on the budget object codes from FY 2000 from the National Finance Center. In addition to the experience budget level ($7.4 million), the analysis also considered the economic impact of the desired budget level of $12.5 million.

Comparisons of Alternatives and Cumulative Effects

The comparison of alternative and cumulative effects analysis were based on the above assumptions and the Forest Service estimates of the quantities of outputs from the various alternatives. As previously noted, 2001 was the base year for the current economic effects analysis. All alternative were estimated based on projected quantities of output as of 2010. Impacts to the local economies were measured in two ways: employment and labor income. Employment was expressed as jobs. A job can be seasonal or year-round and full-time or part-time. In this analysis jobs represent the annual average of 12 monthly estimates. The income measure used was labor income. Labor income includes both employee compensation (pay plus benefits) and proprietor income (e.g. self-employed).

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U.S. Fish and Wildlife Service, 2003, 2001 *National Survey of Fishing, Hunting, and Wildlife-Associated Recreation - Wyoming*, FHW/01-WY Rev.

Table B-21. Daily per person recreation visitor expenditures.

	Per Person	Days Per	Per Person
	Per Day	Trip	Per Trip
Resident Fishing (1)	$35.18	1.31	$46.08
Nonresident Fishing (1)	$75.92	2.09	$158.68
Resident Hunting (1)	$59.89	1.35	$80.85
Nonresident Hunting (1)	$116.31	4.37	$508.29
Resident Snowmobiling (2)	$63.42	2.10	$133.18
Nonresident Snowmobiling (2)	$91.39	4.50	$411.26
Outfitted Snowmobiling (2)	$156.00	3.50	$546.00
Non-local Overnight on Forest (3))	$28.27	5.00	$141.36
Non-local Day Trip (3)	$33.27	1.00	$33.27
Non-local Overnight off Forest (3)	$60.10	4.30	$258.41

Sources:

(1) U.S. Fish and Wildlife Service, *2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, Wyoming*.
(2) University of Wyoming, Department of Agricultural and Applied Economics, *Results from 2000-2001 Wyoming Snowmobile Survey*, Prepared for the Wyoming Department of State Parks and Historic Sites, Wyoming State Trails Program.
(3) Morey & Associates, Inc., *Report on the Economic Impact of the Travel Industry in Wyoming, 1998*, Prepared for the Wyoming Business Council (Adjusted to 2002 dollars).

Table B-22. Value of production for Wyoming cattle and sheep, 1989-98.

		Per AUM	**Per AUM**
		Cattle	**Sheep**
Year		**(1999 $)**	**(1999 $)**
1992		$44.05	$21.09
1993		$45.36	$18.97
1994		$36.92	$21.72
1995		$32.00	$26.93
1996		$28.74	$25.90
1997		$32.55	$27.86
1998		$29.00	$21.16
1999		$34.29	$20.22
2000		$37.31	$21.68
2001		$39.38	$20.18
Average		**$35.96**	**$22.57**

Source: Adapted from Wyoming Agricultural Statistics, Various Years

Recreation Analysis

Introduction

The recreation topic question is "what variety and mix of opportunities will be provided, taking into account resource protection measures?" The complexity of the issue involves the full range of recreation opportunities that are currently available on the Forest:

- Recreation Opportunities – Zoned areas of the Forest that help determine desired conditions, summer and winter. There was no winter ROS developed for the current plan.
- Developed recreation - specifically campgrounds in need of rehabilitation and modernization to meet visitor needs, and trailheads to facilitate backcountry motorized and nonmotorized recreation.
- Trail dependent recreation - spatial differences between systems and crowding. Trail types and uses vary across the Forest, but use on Medicine Bow Peak is the highest.
- Dispersed recreation - the all-encompassing term that includes all activities for which the forest Service provides on roads and trails, and in the open backcountry.
- Winter recreation – the 'other' season of use for which the Forest hasn't planned, but facilitates from concentrated parking and trailheads. This season is in need of active management.
- Wilderness recreation and substitute areas are discussed in order to implement the National Wilderness Agenda.
- Ski Area expansion – planned for, and partially implemented in the last Plan. Some parts of this expansion area need to be approved.
- Recreation Special Uses – part of the overall program, permitted activities are an important component of the budget, and in need of full funding.
- Visitor preferences for opportunities – have evolved with society's technological advances. Americans have also become more involved in analysis, decision making, and in implementation.
- Visitor use estimates are difficult to validate - the National Visitor Use Monitoring project (NVUM) will help provide accurate visitor use information (not necessarily by activity) that will be used to help identify preferences for the final EIS and Plan.

Analysis Process

There are several analysis processes used to analyze this issue. Following is a summary of the steps taken in the analysis:

1) Recreation Opportunity Spectrum (ROS)

ROS Inventory Process and History

The ROS inventory tells what we have and what's potential. The ROS also tells us how what we have is distributed. The assumption is that the Forest Service provides the setting in which the public can fulfill their recreation/leisure goals and objectives. We use the ROS to determine where we might choose to zone specifically for recreation use or where other management activities are prevalent (relative availability), but not in conflict with recreation. Relative availability is a consideration affecting decisions that determine needed opportunity. Adequate supply is a function of spatial distribution (where on the landscape are opportunities located relative to one another?).

Settings are classified along the spectrum using the following components.

a.) Physical Setting:

Absence or presence of human sights and sounds; Size of the area; Amount of resource modification.

b.) Social Setting:

Amount and type of contact (opportunities for solitude, small group, or large group interactions).

c.) Managerial Setting:

Amount and kind of restrictions on visitors. Level of management evident in the area.

In 1993, the recreation staff began updating the ROS inventory. The information was completed on as detailed a basis as possible, given that the scale was the visitor's map. Recreation data was compiled to match specific polygons which also reflected the ROS class. This information was eventually digitized on the GIS. The 1995 and later maps include a new ROS Classification - Roaded Modified (RM) - which is used specifically to reflect timber harvest areas. This illustrates the differences in methodology and philosophy as discussed below.

In 1999, the 1981 ROS inventory was digitized, and the 1998 preliminary inventory was re-visited. Some adjustments were made, based on the roadless inventory. It was determined that some of the inventoried roadless areas did not qualify as semi-primitive non-motorized areas due to current uses, and the physical presence of well-worn roads in these areas. Roads are one of the reasons areas are difficult to move toward a semi-primitive ROS class (see the ROS desired condition map).

Management Area Allocations

ROS classifications are limited by past management, other management objectives, and established recreational uses. Some areas might be allocated for a dominant type of recreation as the major management prescription; in some areas there will be no dominant uses so recreation will be one of the multiple uses to manage for, and in other areas uses other than recreation will be the dominant use(s) but there will still be opportunities for recreation. The process is simultaneous.

Reproducibility and reversibility are fundamental considerations. They address the question of the extent to which an opportunity can be technologically reproduced, and the ability of management to reverse the outcome of decisions. Modern opportunities can generally be reproduced, whereas reversing decisions which transform an area from a primitive condition to something more developed needs to be carefully considered.

When or if an inconsistency occurs, there may have been a management decision to consciously add access to an otherwise primitive setting (timber sale). Another instance may be the provision of universal access when there are limited opportunities elsewhere.

Alternatives were mapped using the following GIS process:

SUMMER ROS	WINTER ROS
MA 1.13 ROS = SPNM	MA = 1.13 through 3.58 = SPNM
IF MA = 1.31 through 1.5, and existing = SPNM, ROS = SPNM	MA = 1.33 = SPM
IF MA = 1.31 through 1.5 and existing = SPM, ROS = SPNM	Ski trails = SPNM – buffer to 1/16 mile
IF MA = 1.31 through 1.5 and existing = RN, ROS = SPNM	Sheep Mountain = Non-use
IF MA = 1.31 through 1.5 and existing = RM, ROS = SPNM	MA 2.1 < 2500 acres = SPM
IF MA = 1.31 through 1.5 and existing = RL, ROS = SPM	MA 2.1 > 2500 acres = SPNM for Alternatives A, B, C, D, E, H
MA = 1.41 and existing = SPM, ROS = SPM	MA 3.21 = SPNM outside snowmobile trails
IF MA = 3.21 through 3.58 and existing = SPNM, ROS = SPNM	MA 3.24 = SPNM outside snowmobile trails
IF MA = 3.21 through 3.58 and existing = SPM, ROS = SPM	MA 3.5 = SPNM outside snowmobile trails
IF MA = 3.21 through 3.58 and existing = RN, ROS = SPM	MA 3.31 = SPM
IF MA = 3.21 through 3.58 and existing = RM, ROS = SPM	MA 3.32 = SPM
IF MA = 3.21 through 3.58 and existing = RL, ROS = SPM	MA 3.56 = SPM
MA 3.55 = RN	MA3.57 = SPM
MA 3.31 = SPM	
IF MA = 4.2 through 4.31 and existing = SPNM, ROS = SPNM	MA 4.2 through 5.4 = SPM, except Hwy 130

SUMMER ROS	WINTER ROS
IF MA = 4.2 through 4.31 and existing = SPM, ROS = SPM	MA 5.41 and 5.42 = SPNM outside snowmobile trails
IF MA = 4.2 through 4.31 and existing = RN, ROS = RN	MA 8.22 = SPNM outside snowmobile trails
IF MA = 4.2 through 4.31 and existing = RM, ROS = **SPM**	MA 7.1, 8.21, and 8.6 = SPM
IF MA = 4.22 through 4.31 and existing = RL, ROS = RN	Use Snowmobile Trail maps – buffer trails to 1/8 mile either side
IF MA = 5.11 through 5.12 and existing = SPNM, ROS = SPNM	IF MA = 1.2 and existing = SPNM, ROS = SPNM
IF MA = 5.11 through 5.12 and Existing = SPM, ROS = SPM	IF MA = 1.2 and existing = SPM, ROS = SPM
IF MA = 5.11 through 5.12 and Existing = RN, ROS = RN	
IF MA = 5.11 through 5.12 and Existing = RM, ROS = **RN**	
IF MA = 5.11 through 5.12 and Existing = RL, ROS = RL	
IF MA = 5.13 through 5.15 and Existing = SPNM, ROS = RM	
IF MA = 5.13 through 5.15 and Existing = SPM, ROS = RM	
IF MA = 5.13 through 5.15 and Existing = RN, ROS = RN	
IF MA = 5.13 through 5.15 and Existing = RM, ROS = RM	
IF MA = 5.13 through 5.15 and Existing = RL, ROS = RL	
IF MA = 5.21 through 5.42 and Existing = SPNM, ROS = SPNM	
IF MA = 5.21 through 5.42 and Existing = SPM, ROS = SPM	
IF MA = 5.21 through 5.42 and Existing = RN, ROS = RN	
IF MA = 5.21 through 5.42 and Existing = RM, ROS = **RM**	
IF MA = 5.21 through 5.42 and Existing = RL, ROS = RL	
IF MA = 7.1 through 8.6, ROS = RN	
IF MA = 4.2, ROS = RL Skinny buffer on Alt F and G	
IF MA = 2.1and existing = SPNM, ROS = SPNM	
IF MA = 2.1 and existing = SPM, ROS = SPM	
IF MA = 2.1 and existing = RN, ROS = RN	
IF MA = 2.1 and existing = RM, ROS = RN	
IF MA = 2.1 and existing = RL, ROS = RL	
IF MA = 2.2, ROS = SPNM	
IF MA = 1.2 and existing = SPNM, ROS = SPNM	
IF MA = 1.2 and existing = SPM, ROS = SPNM	

Limitations to the Baseline (Inventory) Data

Scale has already been mentioned as a limiting factor in accurate ROS class delineation. There are subtle differences between the 1995 and 2000 maps, simply because the acreages are more precise given the electronic tools used. The process outlines criteria, but beyond space, noise, use levels, and management levels, classification is subjective. In addition, there are differences in background, training, and philosophies among district managers.

2) Supply and Demand Analysis

Demand

The National Visitor Use Monitoring (NVUM) project was implemented as a response to the need to better understand the use and importance of and satisfaction with national forest system recreation opportunities. This level of understanding is required by national forest plans, Executive Order 12862 (Setting Customer Service Standards), and implementation of the National Recreation Agenda.

To improve public service, the agency's Strategic and Annual Performance Plans require measuring trends in user satisfaction and use levels. It will assist Congress, Forest Service leaders, and program managers in making sound decisions that best serve the public and protect valuable natural resources by providing science based, reliable information about the type, quantity, quality and location of recreation use on public lands. The information collected is also important to external customers including state agencies and private industry. NVUM methodology and analysis is explained in detail in the research paper entitled: *Forest Service National Visitor Use Monitoring Process: Research Method Documentation*; English, Kocis, Zarnoch, and Arnold; Southern Research Station; May 2002.

In conjunction with guidelines and recommendations from the Outdoor Recreation Review Commission, the USDA-Forest Service has estimated recreation use and maintained records since the 1950s. Many publications on preferred techniques for estimating recreation use at developed and dispersed recreation sites were sponsored by Forest Service Research Stations and Universities. Implementation of these recommended methodologies takes specific skills, a dedicated work force, and strict adherence to an appropriate sampling plan. The earliest estimates were designed to estimate use at developed fee recreation facilities such as campgrounds. These estimates have always been fairly reliable because they are based upon readily observable, objective counts of items such as a fee envelope.

Prior to the mid-1990s, the Forest Service used its Recreation Information Management (RIM) system to store and analyze recreation use information. Forest managers often found they lacked the resources to simultaneously manage the recreation facilities and monitor visitor use following the established protocols. In 1996, the RIM monitoring protocols were no longer required to be used.

The Medicine Bow National Forest participated in the National Visitor Use Monitoring (NVUM) project from October 2001 through September 2002. The forest coordinator was Mary Sanderson. Thirteen forest employees conducted the interviews, with 3 employees conducting the bulk of them.

Between June 8 and the end of July two major wildfires rated within the Douglas Ranger District on the Medicine Bow National Forest. Although none of the campgrounds were closed, use plummeted during this time. It appears use was down by almost 50% based upon fee receipts collected in 2001 compared to fee receipts collected in 2002 during the same time period in these campgrounds**.** A fire ban from July through Sept may also have discouraged people from visiting since most campers like to have an evening campfire.

Recreation use on the forest for fiscal year 2002 at the 80 percent confidence level was 929,230 national forest visits +/- 14.9 percent. There were 1.1 million site visits, an average of 1.2 site visits per national forest visit. Included in the site visit estimate are 10,974 Wilderness visits.

Table B-23. 2002 Visitor participation (visits).

Activity	Percent participation	Percent who said it was their primary activity
Camping in developed sites (family or group)	13.2	3.8
Primitive camping	14.7	3.4
Backpacking, camping in unroaded areas	4.7	1.5
Resorts, cabins and other accommodations on Forest Service managed lands (private or Forest Service run)	1.0	0.2
Picnicking and family day gatherings in developed sites (family or group)	6.9	1.8
**Viewing wildlife, birds, fish, etc on national forest system lands	44.0	5.8
**Viewing natural features such as scenery, flowers, etc on national forest system lands	45.8	6.3
Visiting historic and prehistoric sites/area	3.6	0.1
Visiting a nature center, nature trail or visitor information services	4.1	0.1
Nature Study	5.5	0.9
General/other- relaxing, hanging out, escaping noise and heat, etc,	33.1	11.5
Fishing- all types	17.8	8.3
Hunting- all types	13.5	13.4

Activity	Percent participation	Percent who said it was their primary activity
Off-road vehicle travel (4-wheelers, dirt bikes, etc)	7.8	3.0
Driving for pleasure on roads	13.7	4.5
Snowmobile travel	9.1	9.4
Motorized water travel (boats, ski sleds, etc)	0.3	0.0
Other motorized land/air activities (plane, other)	1.9	.2
Hiking or walking	39.3	16.4
Horseback riding	1.0	0.2
Bicycling, including mountain bikes	3.3	1.7
Non-motorized water travel (canoe, raft, etc.)	0.8	0.3
Downhill skiing or snowboarding	6.5	6.4
Cross-country skiing, snow shoeing	5.9	5.9
Other non-motorized activities (swimming, games and sports)	1.6	1.1
Gathering mushrooms, berries, firewood, or other natural products	1.3	0.2

Futuring is difficult due to the changes that are occurring in the industry. We use the assumption that "people generally maintain recreation and leisure preferences based on learned activities while growing up," and so use is expected to increase relative to current use levels, and by at least as much as the population. Coefficients developed by the Southern Research Station of the Forest Service were used to provide an estimate of future use. Some activities had no coefficients, so the total visits add up to less than the 929,230. Current use levels will continue to follow some trend based on historic use levels, and changes in the population.

Table B-24. Visits by primary activity 2002 and 2010.

Activity	Visits by Primary Activity 2002	2002-2010 Percent Change	Visits by Primary Activity 2010
Developed Camping	32,277	7.7%	34,762
Primitive Camping	28,879	1.5%	29,313
Backpacking	12,741	3.1%	13,136
Resort Use	1,699	N.A.	1,699
Picnicking	15,289	-1.6%	15,044
NC Wildlife Viewing	49,265	2.2%	50,349
Viewing Natural Features	53,512	4.2%	55,759

Activity	Visits by Primary Activity 2002	2002-2010 Percent Change	Visits by Primary Activity 2010
Visiting Historical Sites	849	11.1%	944
Visiting Nature Centers	849	4.2%	885
Nature Study	7,645	4.2%	7,966
General Relaxing	97,680	3.1%	100,708
Fishing	70,500	4.4%	73,602
Hunting	124,517	-2.2%	121,777
ORV Use	25,482	3.1%	26,272
Driving for Pleasure	38,223	11.2%	42,504
Snowmobiling (1)	87,348	9.8%	95,908
Motorized Water Activity	0	9.6%	0
Other Motorized Activity	1,699	4.2%	1,770
Hiking/Walking	139,301	6.1%	147,798
Horseback Riding	1,699	3.2%	1,753
Bicycling	14,440	3.8%	14,988
Non-Motorized Water Activity	0	3.7%	0
Downhill Skiing	59,471	3.1%	61,314
Cross-Country Skiing	54,825	26.4%	69,298
Other Non-Motorized Activity	9,343	4.2%	9,736
Gathering Forest Products	1,699	4.2%	1,770
Total	929,230	5.4%	979,056

Changes in Winter Use by Alternative

There were a number of comments relative to snowmobile use on the Forest, and how different management actions would change participation rates.

The Effects on Winter Motorized Recreation from Restrictions in the Forest Plan:

Discussions in the Steering Committee (October 3, 2003) led to the conclusion that use would not necessarily be affected (to levels below current) in any alternatives except Alternative F, which restricts snowmobile riding to roads and designated trails. In order to determine how much that use level would go down, and to calculate the associated effects to tourism, the following assumptions had to be made:

- In a Colorado ATV Survey sponsored by Colorado Off-Highway Vehicle Coalition (COHVCO 2002), 60% of snowmobile riders said they ride trails
- Percent Resident/Non-Resident (from the 2001 Wyoming Snowmobile Survey). The percent of trips by residents is 62.1 percent of the total

assuming outfitter clients are nonresidents. Since residents take shorter trips than nonresidents, the days of use are about 50:50.

- 54% of residents' snowmobile riding occurs on the Med Bow (University of Wyoming, 1998)
- Non-residents would have little incentive for choosing the Med Bow over Rabbit Ears (open, off-trail riding) - estimate non-resident use at 20% of current

The results follow:

2010 use projected	95,908
Total use* 60%	57,545
Resident use (50%)	47,954
Resident * 54%	25,895.1
Non-Resident use * 20 %	9,591
Total 2010 Use, Alt F = 37.00% of 2010	35,486
	37.00%

Supply

The Forest Plan provides some baseline conditions that would cause negative effects to visitors. For purposes of this analysis, capacity is a function of how many facilities (campsites, picnic sites, and trails) there are, the season of use, and average number of users per site (campsite, picnic site, or parking site). This calculates persons at one time, season-long (PAOT Days).

- An average of five (5) people per camp and picnic site was used, and
- Three (3) people per parking site in trailhead parking lots was used to estimate capacity.
- Parking lot site numbers were taken from District inventories and the Forest database.
- One hundred fifty (150) days were the estimated summer and winter season lengths. Hunting season is not dependent on facilities.
- Road miles were taken from the Roads Analysis for the Medicine Bow National Forest. Trail mileages were reported by District personnel, and winter snowmobile trail mileages came from State snowmobile trails maps.

3) Needs Analysis

Developed needs were estimated based on use levels estimated from fee envelopes, and on public comment.

4) Budget

The final step in the process is to determine how much can be accomplished, given the realistic budget projections. There are two budget levels in this planning process; realistic three year averages and full implementation (approximately 150% of current), which reflects those activities we would do with few additions to current full time staff.

For this analysis, activities re planned, and budgeted for in the constrained budget. Projects include developed site construction and reconstruction, trail construction and reconstruction, days spent monitoring resource conditions, and special use permit administration. Per unit costs were estimated, based on Meaningful Measures (Forest Service costing Database) costs and on-the-ground estimates see following table.

Table B-25. Recreation budget estimates – per unit costs.

Recreation Budget Estimates - Per Unit Costs							
Activity *	Sites	Capacity	Cost Per… **	To Standard Unit	***To Standard Maintenance Cost (MM)	To Standard Operation Cost (MM)	Total Cost
General Rec Const	NA						*$289,332.15
*General Recreation Construction is paid for out of a mix of appropriated funds, and the Capital Investment Program funds from the Regional construction budget. The dollar amount shown is an estimate, based on appropriations that could be used for capital improvement and deferred maintenance.							
Campgrounds	**703**	412,350	$0.40	PAOT Day	$0.47	$0.34	$164,940.00
Campgrounds costs – *Taken from the 2000 Meaningful Measures cost estimates: **Maintenance costs assume sites are clean of debris, and meet safety standards. ***Maintenance and Operations costs to Standard assume sites meet all Meaningful Measures Standards. Only ~ 60% of all Forest Campsites meet all Standards. Deferred Maintenance costs are those costs it would take to meet these standards, forestwide.							
Picnicgrounds	**312**	263,520	$0.20	PAOT Day			$52,704.00
Trailhead costs include some road grading, facility maintenance, and general litter control. The costs to develop trailheads are based on a Persons At One Time per year estimate (Annual Capacity). These numbers are not meant for trailhead construction cost estimating and planning; every project has special considerations.							
Trailheads (summer)	438	234,795	0.17	PAOT Day			$39,915.15

Trailheads (winter)	356	186,900	0.17	PAOT Day			$31,773.00
Trailhead Construction			$12.00	PAOT Day			
Dispersed Uses	**Days to Standard**		$700.00				$140,000.00
Dispersed Use Maintenance costs are based on Meaningful Measures estimates of concentrated use areas. Costs assume a maintenance crew is assigned to monitor and clean these use areas, throughout the summer, and fall seasons.							
Wilderness	**78,850**	0.04	$0.88	Acres	$2.00	$1.00	$69,388.00
Wilderness management costs include trail maintenance and patrols. They're based on current budgets, and do not include area planning. Costs To Standard are an estimate by Wilderness managers of optimum funds per acre that would include thorough planning.							
Summer N-Motorized Trails	**235 miles outside Wilder-ness**		$250.00	Mile	$300.00	$174.00	$58,750.00
Summer Motorized Trails	**70**		$200.00	Mile	$200.00	$150.00	$14,000.00
Winter Motorized Trails	**435.8**		$35.00	Mile	$10.00	$30.00	$15,253.00
Winter N-Motorized Trails	**84.5**		$40.00	Mile	$40.00	$10.00	$3,380.00
Summer trail maintenance costs are higher for the forest than winter trail maintenance due to the state trails program work on winter snowmobile trails, and the volunteer work of individuals, and the Medicine Bow Nordic Association on winter non-motorized trails. Much of the maintenance occurs during the summer on the non-motorized trails; most motorized trails are on roads, except for a few that are summer non-motorized trails. These trails receive summer maintenance.							
Downhill Skiing			$10,000.00	Permit			$10,000.00
Rec Special Uses		195	$682.00	Permits			$132,990.00

5) **Dispersed Campsite Condition Form**

Management Areas reference Cole's Condition Class for dispersed campsites.
Equipment Checklist for Campsite Inventory

- Compass
- Forms and parameter rating descriptions
- Clipboard
- 100' tape measure
- Camera and film (or extra batteries)
- Photo identification board and chalk
- Enlarged field maps
- Collapse-able shovel for dismantling and naturalizing fire-rings
- Topographic Maps
- Permanent medium or fine tip black marker
- GPS unit (if using) with the following form as the data dictionary.

Following is the form to use for evaluation (see Figure .

Dispersed Campsite Condition Evaluation Process

Objective: Evaluate dispersed campsite conditions according to Management Areas Standards and Guidelines. This will provide baseline data that can be accurately re-measured and used to judge impacts and monitor management decisions.

Indicator: Condition and number of campsites along roads, trails, and streams/lakes.

Methodology: Cole's Modified Classification System

Using either a GPS, USGS Quad sheet, or both, record the location of the campsite and assign it an exclusive number. *NOTE: Even if the campsite will be obliterated because it is illegal (too close to the water) always record the existence of the site.*

On the campsite inventory form (enclosed), fill in the information as follows:

Prescription: Management area prescription for the area as specified in the Forest Plan

Geographic Area: GA as specified in the Forest Plan

ROS Class: Desired Condition ROS Class of the area as specified in the Forest Plan

Campsite Number: Legal and illegal campsites will be numbered separately (illegal campsites should have an "I" in front of the number, legal campsites should begin with an "L").

Individual Parameter Indicators

Vegetation Loss – For this parameter to be meaningful, there must be a comparison between vegetation cover on the site, and the amount of cover in an area, which is off-site. The observations are expressed in a percentage of cover on the ground. *NOTE: All veg cover data is relative to what the site may have looked like before.*

Vegetation cover is estimated in one of the following classes:

0-5% = 1; 6-25% = 2; 26-50% = 3; 51-75% = 4; 76-100% = 5

Compare the two coverage classes to achieve the rating for vegetation loss. Ratings are derived in the following manner:

"1" if on-site and off-site are equal and there is no vegetation loss.

"2" if there is one class difference (i.e.; on-site = 0-5% and off-site = 6-25%).

"3" if there are two or more coverage class differences.

Mineral Soil Exposure - The same rating system is used for this parameter as for Vegetation Loss above. Bare mineral soil is more difficult to estimate than vegetation because there is usually a continuous gradation from twigs, leaves, and needles through partially decomposed and decomposed litter to mineral soil. Where litter layers are thin and have obviously been displaced by recreational use, estimates of bare soil should be high.

Tree Damage –

N = No trees on site

0 = Trees on site by no damage

1 = Some broken lower branches

2 = One to seven trees with mutilation (ax marks, carvings, nails, and cut stumps)

3 = More than seven mutilations (make notes about what the damage consists of.

Root Exposure -

N = No trees on site

0 = Trees on site by no damage to the trees

1 = Root exposure in one tree

2 = Root exposure in two trees

3 = Root exposure in three or more trees (make note of actual number over three).

Development – Developments include fire rings, log or stone seats and tables, windbreaks, leveled or ditched tent pads and other human constructions. The following ratings will be used:

0 = No development

1 = Nothing more than a fire ring

2 = Nothing more than one fire ring and crude log or stone seats

3 = Either more than one existing fire ring or well developed seats, tables, windbreaks, leveled tent pads or other developments. Make notes about the developments.

Cleanliness – The following ratings are recommended:

0 = Site clean

1 = Scattered charcoal from one fire site

2 = Scattered remnants of more than one fire site, some litter, or blackened logs.

3 = Large piles of horse manure (as opposed to scattered droppings), any human waste, dog droppings, toilet paper, widespread litter or blackened logs.

Camp Area – Estimates of camp areas will be made based on some initial measuring of sites. The edge of a site will be determined by the area that could possibly be occupied. If an area could be occupied by two different parties at one time, then it would be broken down into 2 sites. The following ratings will be used:

1 = 0-500 sq. ft. or 20’ x 25’

2 = 500-1000 sq. ft. or 50’x 20’; 32’ x 32’

3 = More than 1000 sq. ft.

Bare Soil – Usually the area around the fire ring. Vegetation has been removed, and the soils are generally compacted. Use the following ratings:

1 = 0-50 sq. ft., or 5’ x 10’

2 = 50-500 sq. ft. or 22’ x 22’

3 = More than 500 sq. ft.

Access Trails – These can be either access or social trails; trails radiating from the campsite to the main trail, the water source, streambank, or other. Use the following rating:

1 = No Trails

2 = One discernible trail

3 = More than one discernible, or one well-established trail.

4 = More than one well established trail.

Location Information

Vegetation Type – This is used for management prescription S&Gs related to maximum number of occupied sites. Alpine, open areas above timberline, and sub-alpine grass types are considered open. Forested areas are any sites that the majority is surrounded by tall shrubs or trees.

Distance from Water – Estimate this distance

Spacing of Sites – Number of sites within the following distances: 0-300' and 300-500'.

Use Category – The use category helps determine where specific impacts are coming from. Parameter ratings can be compared with the types of use to provide a measure of the effects of a use. Hunter camps may be distinguished by the presence of meat poles, etc. Horse use indicators would be manure, tethering, etc.

Field Notes – Campsite Condition

Describe ALL other human impacts in the sub-area: (i.e.; livestock grazing, mining activity, structures, human waste facilities/non-facilities).

Site Rehabilitation: Note specifics of activities carried out to rehabilitate impacts in the sub-area (i.e.; removing developments, improving cleanliness).

Trash Collection: Show location of trash cache, if any, on the area map. Provide brief directions here on how to find the cache. *NOTE: Approximate volume, and weight of trash collected; indicate type, if other than bagged garbage.*

Summary Rating: The summary rating is the sum of the product of each parameter.

Cumulative Effects

Objectives regarding the management of National Forest System lands are often not transferable to other public or private lands. The forest met with specialists and experts from the State and Regional Office to jointly identify all the known projects and concerns, based on meetings.

Figure B-1. Campsite Inventory Form.

OBSERVER	DATE	CAMPSITE NUMBER (I = Illegal; L = Legal)
MANAGEMENT PRESCRIPTION	GEOGRAPHIC AREA NAME	
ROS CLASS	MAP NUMBER	
Vegetation Loss Off-site Class ____ On-site Class ____ Difference rating ____	Mineral Soil Exposure Off-site Class ____ On-site Class ____ Difference rating ____	

Parameter	Rating	Vegetation Loss plus Difference	Mineral Soil Exposure Difference	Total Rating
Vegetation Loss				
Mineral Soil Exposure				
Tree Damage				
Root Exposure				
Development				
Cleanliness				
Camp Area				
Bare Area				
Access Trails				

Notes:
____
____
____
____

Roadless Inventory

Background

The Forest Service is required to inventory, evaluate and consider all roadless areas for possible inclusion in the National Wilderness Preservation System. 36 CFR 219.17 states:

"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…"

Historical Summary

In 1970, the Forest Service studied all administratively designated primitive areas, and inventoried and reviewed all roadless areas in the National Forest and Grasslands greater than 5,000 acres. This study was known as the Roadless Area Review and Evaluation (RARE). RARE was halted in 1972 due to legal challenge.

In 1977, the Forest Service began another nationwide Roadless Area Review and Evaluation (RARE II) to identify roadless and undeveloped areas within the National Forest System that were suitable for inclusion in the National Forest Wilderness Preservation System. As a result of RARE II, 27 roadless areas on the Medicine Bow National Forest were evaluated and five areas were recommended to Congress for addition to the National Wilderness Preservation System. Two of these areas (Laramie Peak and Snowy Range) were found not suitable for wilderness. RARE II was also challenged in court and it was determined that it did not fully comply with National Environmental Policy Act (NEPA) requirements.

Congress passed the Wyoming Wilderness Act of 1984 (PL 98-550) which designated three new wilderness areas on the Medicine Bow National Forest. The three areas include the Platte River Wilderness 22,363 acres; the Encampment River Wilderness 10,400 acres; and the Huston Park Wilderness 31,300 acres. With the Savage Run Wilderness, 15,260 acres, there are a total of 79,323 acres of designated wilderness on the Forest. The Wyoming Wilderness Act also released all remaining roadless areas to multiple use management (Title IV of the Wyoming Wilderness Act of 1984).

Laws, Policy and Direction

Initial authority for roadless inventories and evaluations is based on the Wilderness Act of 1964 (P.L. 88-577). Current direction for roadless area inventories and evaluations is found in 36 CFR 219.17. The primary intent of the evaluation is to consider areas for potential wilderness designation. Further requirements for evaluation of wilderness are found in FSH 1909.12,7, FSM 1923, and FSM 2320. FSH 1909.12,7 discusses the inventory criteria for roadless areas and their evaluation for wilderness. FSM 1923 is manual direction on wilderness evaluations as part of the forest plan revision process. FSM 2320 is manual direction on wilderness management. Based on the above direction, the region developed a guidance paper entitled *A Roadless and Unroaded Area Inventory, Purpose, Process and Products* (R2 paper) prepared by the Region 2 Planning Analysis Team and Approved by the Regional Directors on 6/4/97. This paper outlines guidance for using the GIS system in the roadless inventory process.

Inventory Process

The first step in the evaluation of potential wilderness is to identify and inventory all roadless, undeveloped areas that satisfy the definition of wilderness found in section 2(c) of the 1964 Wilderness Act.

Section 2 (c) reads: "A wilderness, in contrast with those areas where man and his own works dominate the landscape, is herby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value."

Using the process outlined in the R2 paper as a guide the IDT evaluated the forest areas using GIS. ARC/Info GIS was used as a tool to assist in identifying areas that might meet the following criteria (via FSH, FSM, and regional direction):

- They contain 5,000 acres or more
- They contain less than 5,000 acres but are contiguous to an existing wilderness
- They do not contain classified roads[1]

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[1] Roads were buffered by 300 feet. A classified road is a road constructed or maintained for long-term highway vehicle use. All trails, both motorized and non-motorized, were left in the inventory, all obliterated roads and post 1968 user created roads were also left in. Please note that on page 14 of our Addendum to Purpose and Need/Planning Criteria (published 3/99), step 2 we discussed the inclusion of Class 4 & 5 roads inside the inventoried roadless areas. However, *Miscellaneous Report FS-643 Roads Analysis: Informing Decisions about Managing the National Forest Transportation System*, uses the terms classified and unclassified roads. A classified road is a road constructed or maintained for long-term highway vehicle use. An unclassified road is a road that is not constructed, maintained, or intended for long-term highway vehicle use, such as roads built for temporary access and other remnants of short-term-use roads associated with fire suppression; timber harvest; and oil, gas, or mineral activities; as well as travel-ways resulting from off-road vehicle use. In addition unroaded areas are defined as areas that do not contain classified roads. In order to provide consistency with these definitions and avoid confusion, these definitions were adopted into our Planning Criteria and inventory process.

Other criteria that was used to develop the initial maps included the elimination from the inventory of:

- Recreation and administrative sites
- Ski areas (buffered by 100 feet)
- Wilderness areas
- Utility corridors (buffered by 100 feet)
- Major harvest units, pre-commercial and commercial thinning units (FSH 1909.12,7 7.11a#9)
- All of the lands that are not forest service ownership within the forest boundary

Then, using the raw computer generated maps as a starting point, the IDT considered the following:

- The definition of wilderness from section 2(c) of the 1964 Wilderness Act which states that areas should have outstanding opportunities for solitude and the imprint of man should be substantially unnoticeable
- The standards from the Recreation Opportunity Spectrum (ROS) for a semi-primitive non-motorized (SPNM) area that states a person should be ½ mile from a road to experience semi-primitive non-motorized opportunities
- The issue of ecological integrity, an area has to be large enough to provide for natural disturbance processes without being influenced by the hand of man
- The idea of practicability in a management sense to the areas

These issues were then used by the IDT to further refine the areas. Following this refinement, maps were printed and taken to the districts for their review. During this review the districts corrected errors in the data and used their on-the-ground knowledge to look for other possible errors.

Fire Regime and Condition Class Analysis

A fire regime is a generalized description of the role fire plays in an ecosystem. Systems for describing fire regimes may be based on the characteristics of the disturbance, the dominant or potential vegetation of the ecosystem in which ecological effects are being summarized, or fire severity based on the effects of the fire on dominant vegetation (Agee 1993).

In its simplest form, a fire regime can be described by frequency and intensity or severity. Fire frequency is determined by ignition sources and burning conditions (primarily fuel moisture and wind). Although related, intensity is more an indicator of resistance to control and severity is a measure of ecological impact (i.e. to organisms, tree mortality, etc.). However, the term "intensity" is commonly used synonymously with severity in describing a fire regime. For example, a ponderosa pine stand which "historically" may have burned at relatively frequent intervals (i.e. less than 35 years) with relatively low surface fire intensity would be characterized as having a high frequency – low severity fire regime.

Many methods are available for quantifying and describing fire regimes. The method used here is the same as used in the National Fire Plan (USFS 2000). Five combinations of fire frequency, expressed as fire return interval and fire severity are defined in the table below. Groups I and II include fire return intervals in the 0-35 year range. Group I would include (on the Medicine Bow NF) ponderosa pine and dry-site Douglas fir. Group II includes the dryer grassland types and shrubland communities. Groups III and IV include fire return intervals in the 35-100 plus year range. Specifically, on the Medicine Bow, fire regime group III would include species such as aspen, limber pine and younger and more open-grown stands of lodgepole pine. Fire regime group IV would include older dense stands of lodgepole pine. Group V is the long-interval (infrequent), stand replacement fire regime which is composed of Engelmann spruce and subalpine fir on the Medicine Bow National Forest.

Table B-26. Fire regime groups, frequencies and severity.

Fire Regime Group	Frequency (Fire Return Interval)	Severity
I	0-35 years	low severity
II	0-35 years	stand replacement severity
III	35-100+ years	mixed severity
IV	35-100+ years	stand replacement severity
V	>200 years	stand replacement severity

Within the fire regime groups listed in the table above, dominant cover species respond to fire occurrence and intensity in different ways. It is important to note that although related, intensity is more an indicator of resistance to control, measured in BTU's/foot/second, and severity is a measure of ecological impact (i.e. to organisms, ecosystems, etc.). The effect of fire related to dominant cover species found on the Medicine Bow National Forest is briefly addressed below (adapted from the Fire Effects Information System 2002):

Engelmann spruce (Picea engelmannii) – Engelmann spruce is easily killed by both surface and crown fire. It is susceptible to fire because it has: (1) thin bark that provides little insulation for the cambium, (2) a moderate amount of resin in the bark which ignites readily, (3) shallow roots which are susceptible to soil heating, (4) low-growing branches, (5) a tendency to grow in dense stands, (6) moderately flammable foliage, and (7) heavy lichen growth. Most any crown or canopy fire will kill Engelmann spruce trees. This species is also susceptible to surface fire as the fine fuels that often concentrate under mature trees burn slowly and girdle the thin-barked bole or char the shallow roots. Some of the larger Engelmann spruce may survive light surface fire, but these often die later due to infection by wood-rotting fungi that enter through fire scars.

Subalpine fir (Abies lasiocarpa) - Subalpine fir is one of the least fire-resistant western conifers and is easily killed by both surface and crown fire. It is susceptible to fire because it has: (1) thin bark that provides little insulation for the cambium, (2) bark which ignites readily, (3) shallow roots which are susceptible to soil heating, (4) low-growing branches, (5) a tendency to grow in dense stands, (6) highly flammable foliage, and (7) moderate to heavy lichen growth. Subalpine fir forests are normally subject to highly destructive canopy fires that occur at 100-year or longer intervals. Such fires typically kill all subalpine fir trees. Subalpine fir is also susceptible to surface fires because fine fuels that often concentrate under mature trees burn slowly and girdle the thin-barked bole.

Lodgepole pine (Pinus contorta var. latifolia) - Lodgepole pine is more damaged by surface fire than thicker barked species such as ponderosa pine or Douglas-fir. Because its thin bark has poor insulating properties, many trees are killed from surface fires as a result of cambial heating. However, some trees may survive, a low-intensity surface fire which will have the affect of actually thinning the stand. In northwestern Wyoming, numerous individuals in open lodgepole pine stands have been observed with two or three fire scars. Seeds are well protected from heat inside closed cones (serotinous).

The percentage of lodgepole pine trees with serotinous and/or semi-serotinous cones varies considerably throughout the Rocky Mountains. This allows lodgepole to regenerate following both high and low-intensity fires.

Ponderosa pine (Pinus ponderosa var. scopulorum) - The effect of fire on ponderosa pine is related to tree size, fire intensity, and stand density. Low-severity surface fire usually kills trees less than 3 to 5 years of age or less than 6 inches (15 cm) DBH, and mortality in the 6- to 30-inch (15-76 cm) DBH class is not unusual. Mortality in the larger sized trees is usually a function of scorch height, or crown fire. Trees in dense stands and trees infected with dwarf-mistletoe are most susceptible to mortality, particularly in the smaller size classes. Pole-sized and larger trees are resistant to low-severity surface fires. Thick bark affords protection against cambial damage, and foliage and buds are usually elevated away from the flame zone. Heavy accumulations of litter at the base of trees increase the duration and intensity of fire, making trees more susceptible to scarring

Limber pine (Pinus flexilis) - Limber pine is often killed by fire due to its relatively thin bark. The degree of stem scorch usually determines the extent of fire injury to trees. Young trees are usually killed by any fire that scorches their stems. Mature trees with thicker bark may survive. The vulnerability of this species to fire is reduced where it is found in open grown stands with light surface fuels and sparse undergrowth.

Rocky Mountain Douglas-fir (pseudotsuga menziesii var. glauca) - The effects of fire on Rocky Mountain Douglas-fir vary with fire intensity and tree size. Saplings are often killed by surface fire because their low branching allows fire to transition from the surface into the crown. Photosynthetically active bark, resin blisters, closely spaced flammable needles, and thin twigs and bud scales are additional characteristics that combine to make saplings vulnerable to surface fires. Rocky Mountain Douglas-fir saplings are more susceptible to mortality from surface fires than ponderosa pine saplings are. Chance of survival generally increases with tree size. Because they have thicker bark and larger crowns, large trees can withstand proportionally greater bole and crown damage than small trees.

Quaking aspen (Populus tremuloides) - Small-diameter quaking aspen are usually top-killed by low-severity surface fire. Research indicates that as DBH increases beyond 6 inches (15 cm), quaking aspen becomes increasingly resistant to fire mortality. Large quaking aspen may survive low-severity surface fire, but usually shows fire damage. Moderate-severity surface fire will top-kills most quaking aspen, although large-stemmed trees may survive. Some charred stems that survived low- or moderate-severity fire initially have been observed to die within 3 or 4 post fire years. High intensity surface fire top-kills quaking aspen of all size classes. Low to moderate intensity surface fire does not damage quaking aspen roots as they are insulated by soil. A high intensity fire, especially where fuel loading adds to fire residence time, may kill roots near the soil surface or damage meristematic tissue on shallow roots so that they cannot sprout. Deeper roots are not damaged by intense fire and retain the ability to sucker (sprout). Even when quaking aspen are not killed outright by fire, the bole may be sufficiently damaged to permit the entrance of wood-rotting fungi. Basal scars which lead to destructive heart rot can be made on aspen by low intensity surface fire. Basal fire scars may also permit entry of borers and other insects which can further weaken the tree.

Gambel oak (Quercus gambellii) – Gambel oak is extremely fire tolerant and generally sprouts vigorously from stem bases or from underground lignotubers and rhizomes following fire. Recovery time varies with fire intensity, climatic factors and site characteristics.

Gambel oak habitat and community structure affect susceptibility to fire. Tree forms are less likely to be top-killed in a low-severity fire compared to shrubs with branches closer to the burning surface fuels.

Wyoming big sagebrush (Artemisia tridentata ssp. wyomingensis) – Wyoming big sagebrush ignites readily and produces a very hot fire. Regeneration is slow to re-establish on a burned area, especially when compared to other big sagebrush subspecies, mainly because of the relatively drier sites it occupies.

In southwestern Montana, Wyoming big sagebrush seedlings were still absent from a prescribed burn site 6 years after fire. In the Missouri River Breaks of central Montana, wildfire removed the Wyoming big sagebrush from a Wyoming big sagebrush/bluebunch wheatgrass community, and it was not found during vegetation sampling performed at post fire year 14. Total coverage at that time was 50% grasses, with the remainder consisting of forbs and bare ground. Shrub cover was "minimal". Locally, experience indicates that re-establishment of sagebrush following a burn is dependent on the percentage of the stand killed, and location of the seed source. If the burn results in a mosaic pattern that is somewhat patchy, where sagebrush seed sources are present throughout the burn area, re-establishment is fairly rapid and successful. However, where all the plants are removed over a large area, reestablishment is slow.

Antelope bitterbrush (Purshia tridentata) -- Reports conflict on antelope bitterbrush's ability to sprout in response to fire. Geographic and ecotypic variation is considerable. Sprouting is common in eastern Idaho, occasional in Utah, and rare in Oregon, California, and Nevada. Some research indicates that antelope bitterbrush above 7,500 feet (2,250 m) elevation is resistant to fire due to low fuel loads. Locally, on the Medicine Bow, post fire plant response (sprouting) has been excellent with bitterbrush following spring burns. This is attributed to the higher soil moistures present at that time of year.

In addition to the five fire regimes outlined in the National Fire Plan, three condition classes have been developed to categorize the current condition with respect to each of the five historic Fire Regime Groups. Current condition is defined in terms of departure from the historic fire regime, as determined by the number of missed fire return intervals – with respect to the historic fire return interval – and the current structure and composition of the system resulting from alterations to the disturbance regime. The relative risk of fire-caused losses of key components that define the system increases for each respectively higher numbered condition class, with little or low risk at the Class 1 level.

Table B-27. Condition class[1] descriptions.

Condition Class	Fire Regimes
1	Fire regimes are within the historical range and the risk of losing key ecosystem components is low. Vegetation attributes (species composition and structure) are intact and functioning within their historical range.
2	Fire regimes have been moderately altered from their historical range. The risk of losing key ecosystem components is moderate. Fire frequencies have departed from historical frequencies by one or more return intervals (either increased or decreased). This results in moderate changes to one or more of the following: fire size, intensity and severity, and landscape patterns. Vegetation attributes have been moderately altered from their historical range.
3	Fire regimes have been significantly altered from their historical range. The risk of losing key ecosystem components is high. Fire frequencies have departed from historical frequencies by multiple return intervals. This results in dramatic changes to one or more of the following: fire size, intensity, severity, and landscape patterns. Vegetation attributes have been significantly altered from their historical range.
[1]Current conditions are a function of the degree of departure from historical fire regimes resulting in alterations of key ecosystem components such as species composition, structural stage, stand age, and canopy closure. One or more of the following activities may have caused this departure: fire suppression, timber harvesting, grazing, introduction and establishment of exotic plant species, insects or disease (introduced or native), or other past management activities.	

The following table summarizes condition class by fire regime as currently identified on the Medicine Bow National Forest. The figures were derived through the use of GIS (Arc Info using AML), using species and structural stage as the determining variables.

Table B-28. Fire regime and condition class.

Fire Regime	Condition Class	Acres	Vegetation Type
Non-NFS	N/A	304,307	N/A
N/A	N/A	34,898	Riparian/Lakes/Rock
1	2	15,344	Ponderosa Pine (managed), Douglas-fir, Gambel oak, Juniper
1	3	91,148	Ponderosa Pine (unmanaged)
2	1	67,900	All Grass Communities
2	2	115,296	Shrublands (i.e. sagebrush and bitterbrush)

Fire Regime	Condition Class	Acres	Vegetation Type
3	1	93,963	Limber pine and open-grown Lodgepole pine (< 40% canopy closure)
3	2	83,630	Aspen
4	1	390,146	Lodgepole pine with in B & C Structural Stage (>40% canopy closure)
5	1	191,688	Spruce/Fir
Total:		1,388,320	

Fire Hazard and Risk Analysis

Fire Hazard Analysis

The potential for wildland fire is measured in terms of fire hazard and resistance to control. Wildland fire hazard can be directly related to age, stand structure, and live and dead fuel loads and their resulting effects on fire behavior. In an effort to model fire behavior, fire managers have developed fire behavior modeling systems. Two of the most commonly used are the NFDRS (National Fire Danger Rating System) and the FBPS (Fire Behavior Predication System) models.

NFDRS is used as an indicator of potential fire behavior across analysis areas which may include many thousand of acres. FBPS is useful for more site-specific applications. The FBPS model illustrates the differences in fuels and how they react to such factors as wind, humidity, and topography after natural or management ignited fire.

Output from the FBPS can be rated based on relative resistance to fire suppression activities. The classifications used are usually low, moderate, high, and extreme and are routinely a function of flame length, rate of spread, or intensity. Low resistance to control typifies fires that are relatively easy to suppress in the shortest time frames. Fires in the low hazard category may correspond to the shortest flame length and intensity levels; however, they may exhibit rapid rate of spread or erratic behavior when subjected to extreme ranges of low humidity and/or high wind speeds. High-resistance fuels typically consist of the older age conifer fuel types with significant fuel load or shrub lands with extreme fuel load (e.g., older stands of oak brush). These fuels can often produce extreme flame lengths and fire intensities where the capability of direct fire suppression actions is exceeded.

In an effort to model fire hazard on the Medicine Bow NF, a forest-wide analysis was completed using GIS (Geographic Information System), FlamMap (Finney 2000) and RMRIS (Rocky Mountain Resource Information System). FlamMap is a computer program that produces fire behavior values (e.g., rates of spread, flame lengths) based on weather and physical characteristics of the ground and allows the user to produce fire behavior maps.

The objective of this hazard analysis is to quantify flame length, using 90th percentile weather[2], across the landscape. The resulting flame lengths are then grouped into four categories: (1) low – flame lengths four feet or less, (2) moderate – flame lengths greater than four feet and less than or equal to eight feet, (3) high – flame lengths greater than eight feet and less than or equal to ten feet, and (4) extreme – flame lengths eleven feet and greater. These groupings are commonly used fire behavior thresholds and are further described in the table labeled "Hazard and flame length summary."

Methods for Determining Fire Hazard

GIS was used to create a fuel model layer (collection of fuel properties; e.g., fuel loading, fuel bed depth) based on the standard Fire Behavior Prediction System (FBPS). Fuel models are simply tools to help the user realistically estimate fire behavior (Anderson 1982). The following table lists the FBPS (Fire Behavior Prediction System) fuel models identified on the forest, along with the corresponding acres.

Table B-29. FBPS fuel models.

Fuel Model	Description	Acres
N/A	Rock, Water & Riparian, non-FS lands	306,759
1	Short grass	143,994
2	Timber with grass understory	128,704
4	Shrubs (6 feet)	1,458
5	Brush (2 feet)	28,455
6	Dormant brush	327
8	Closed timber litter	652,232
9	Hardwood litter	61,108
10	Timber (litter and understory)	58,674
11	Logging slash	6,609
Total		**1,388,320**

Prior to running FlamMap, crown base height (CBH), crown bulk density (CBD), and stand height had to be determined for each fuel model identified on the forest.

[2] 90th percentile weather represents days when the fire danger is very high to extreme—a combination of low humidity, high temperature, and high winds.

This requirement enables the model to calculate surface to crown fire transition, as well as crown fire behavior. Due to the number of RIS location/sites across the forest and the time required to calculate CBD, CBH and stand height, data for sites were averaged for each fuel model and cover type. CBD, CBH and stand height was then calculated for each representative stand, using the average RIS page 1-5 reports and the Crown Mass module of the Fuels Management Analyst Suite of fire and fuels programs (Fire Program Solutions, 2001).

FlamMap also requires live and dead fuel moistures for each fuel model as well as wind speed and direction. A historic weather analysis was completed to determine these variables. Historical weather data was collected from the Sawmill Park (482105) Remote Automated Weather Station (RAWS) which contained records from 1988 through 2001 (13 years), and the Esterbrook (482102) RAWS which contained records from 1965 through 2001 (26 years). Weather data was downloaded from the Weather Information Management System (WIMS) data base and processed with Fire Family Plus (USDA Forest Service, 2000) using an annual filter of May 1 through October 31. Data was processed from the Sawmill RAWS, which is in the Snowy Range and represents the Laramie (except Pole Mountain) and Brush Creek/Hayden Ranger Districts, and the Esterbrook RAWS, located in the Laramie Range, which represents the Douglas Ranger District and Pole Mountain of the Laramie Ranger District. FireFamily Plus was then run for 90th percentile day weather observations. It should be noted this percentile can be approximated to seasonal fire behavior nomenclature, where 90th percentile equates to drought conditions. Energy Release Component (ERC) was the variable selected for the analysis. ERC is similar to Heat Per Unit Area (HPA) in FBPS. The ERC traces the seasonal trend of fire danger better than the other NFDRS indices, as it is least responsive to short term fluctuations in fire danger. Average windspeed is calculated by FireFamily Plus. Note that surface wind speed is often the most critical weather element affecting fire behavior and fire danger. It is also the most variable and, consequently, the hardest to evaluate. Air moving across the surface of the land constantly changes in both speed and direction. Over a period of time, one observes a series of gusts and lulls in the wind speed. Winds that persist for 1 minute can affect gross fire behavior, including rate of spread and fireline intensity. Momentary gusts, on the other hand, have little effect on the overall rate of spread or intensity. However, they can produce large, temporary fluctuations in flame height and can easily trigger crowning or throw showers of embers across the fireline. Both probable maximum one-minute gust and the probable momentary gust are displayed below. For the analysis, both the probable maximum one-minute speed and probable momentary gust was used as both play important roles in fire behavior. Probable Maximum 1-minute windspeed was used because winds that persist for one minute can affect gross fire behavior, including rate of spread and fireline intensity, thereby affecting surface to crown fire initiation and transition.

The next two tables summarize the fuel moisture and wind data determined from the weather analysis.

Table B-30. Esterbrook RAWS (Douglas RD and Pole Mountain).

FBPS Fuel Model	NFDRS Fuel Model	1 hour fuel moisture	10 hour fuel moistur e	100 hour fuel moisture	Herbaceous fuel moisture	Woody fuel moisture	20 foot Wind Speed	Prob. Max 1-min. Speed	Probable Momentary Gust (average)
1	A	6	9	11	60	93	11	15	23
2	C	4	6	9	48	82	12	17	25
4	B	4	5	8	64	92	11	15	23
5	T	4	6	9	45	76	12	17	25
6	F	4	5	8	66	92	12	17	25
8	H	4	6	8	56	81	12	17	25
9	U	4	6	8	57	88	12	17	25
10	G	6	6	7	55	77	11	15	23
11	K	4	6	8	62	86	11	15	23

Table B-31 Sawmill Park RAWS (Snowy Range and Sierra Madre)

FBPS Fuel Model	NFDRS Fuel Model	1 hour fuel moisture	10 hour fuel moisture	100 hour fuel moisture	Herbaceous fuel moisture	Woody fuel moisture	20 foot Wind Speed	Prob. Max 1-min. Speed	Probable Momentary Gust (average)
1	A	5	9	12	70	100	11	15	23
2	C	5	7	12	35	81	12	17	25
4	B	3	5	11	83	104	12	17	25
5	T	5	8	13	12	64	12	17	25
6	F	3	5	10	81	106	12	17	25
8	H	4	6	10	76	99	12	17	25
9	U	4	6	11	66	95	12	17	25
10	G	5	7	10	74	96	13	18	26
11	K	4	6	10	77	99	11	15	23

Once all the input data had been determined, FlamMap was run and a map generated, indicating flame lengths across the landscape. This map was then exported out to arc-info in the ASCII/raster format and processed in arc-grid, where flame length per number of acres was determined. The table below provides a summary of acres, flame lengths and fire suppression interpretation.

Table B-32. Hazard and flame length summary.

Hazard Rating	Flame Length (feet)	17 mph Maximum 1-Minute Wind speed (acres)	25 mph Probable Momentary Gust (acres)	Fire Suppression Interpretation
Low	Less Then 4	778,606	770,858	Fires can generally be attacked at the head or flanks by persons using hand tools. Handline should hold the fire.
Moderate	4.1 to 8.0	251,511	151,821	Fires are too intense for direct attack on the head by hand crews. Handline cannot be relied on to hold fire. Equipment such as dozers, engines, and aircraft retardant can be effective. Fires are potentially dangerous to personnel and equipment.
High	8.1 to 10.9	51,067	82,708	Fires may present serious control problems, i.e., torching, crowning, and spotting. Control efforts at the head will probably be ineffective.
Extreme	Greater >= 11	1,480	77,283	Crowning, spotting, and major fire runs are probable. Control efforts at the head of the fire are ineffective.

Limitations of the hazard analysis:

(1) Since CBD, CBH and tree height were only calculated on the "average" site for each cover type and subsequent fuel model, the analysis underestimates fire behavior at the upper end for each fuel model, especially is it relates to surface to crown fire initiation, transition and canopy fire behavior. As a result the table labeled Hazard and Flame Length Summary underestimates the number of acres in the extreme, high and moderate hazard classes, with the acreages in the latter two categories being the most effected by surface to crown transition and canopy fire behavior.

(2) The above analysis will not account for any future changes in vegetation due to insect epidemics or disease outbreaks.

(3) This is a broad scale assessment of fire hazard. Site-specific analysis, using more detailed site-specific information, will potentially yield more accurate fire behavior results.

(4) The analysis does not model conditional surface fire. Conditional surface fire is a potential type of fire in which conditions for sustained active crown fire spread are met but conditions for crown fire initiation are not. If the fire begins as a surface fire then it is expected to remain so. It begins as an active crown fire in an adjacent stand, then it may continue to spread as and active crown fire (Scott & Reinhardt 2001).

Fire Risk Analysis

To further evaluate fire's relationship to overall forest management and protection, fire hazard must be related to risk. Risk relates to the source and number of ignitions which could have resulted from either human-caused or natural caused (i.e. lightning) ignitions. Fire risk is simple to calculate, however, it is often difficult to predict, especially where fire starts are related to human-caused ignitions.

Fire risk is the simple measure of fire starts on a per 1,000-acre basis over a ten year period (per decade). The fire risk value corresponds to a likelihood of fire starts per 1,000 acres per decade. The following are risk ratings and range of values used to categorize risk.

Low Risk: 0 to 0.49 – This projects a fire every 20 or more years per thousand acres.

Moderate Risk: 0.5 to 0.99 – This projects one fire every 11 to 20 years per thousand acres.

High Risk: ≥ 1.0 – This level projects at least one fire every 0 to 10 years per thousand acres.

This analysis used all data available in the historical fire occurrence database. This database contains fires from 1970 to 1999 that have had suppression action taken on them and had an Individual Fire Report (FS-5100-29) completed and submitted.

In an effort to quantify risk for this analysis, fire occurrence records were obtained and processed in GIS. The fire locations were plotted and overlaid on a Forest map. Five geographic areas were identified, where fire occurrence appeared to be somewhat similar and homogeneous throughout the area. The geographic areas, as well as the associated fire risk, are listed in the following table.

Table B-33. Past fire occurrence (1970 – 1999).

Fire Risk Analysis Area	Acres	Number of Ignitions	Percent lightning Ignitions	Percent Human Caused	Fire Risk
Pole Mountain	55,582	96	39%	61%	0.6 – Moderate
Snowy Range	532,443	339	34%	66%	0.2 – Low
Sierra Madre Range	362,210	92	50%	50%	0.1 – Low
Laramie Peak (western portion)	153,160	20	90%	10%	0.1 – Low
Laramie Peak (eastern portion)	284,612	385	90%	10%	0.5 - Moderate

The structure and condition of the vegetative ecosystems on the Medicine Bow National Forest are dynamic. Climate, insect and disease activity, natural processes and human activity all play a role in vegetative condition, structure, and live and dead fuel loading, and subsequent fire behavior.

Fire Use and Appropriate Management Response

As illustrated by the previous text, fire has, and will continue to play a role in the structure, occurrence and condition of vegetative communities on the forest. Under the current Medicine Bow Land and Resource Management Plan (1985), the only management response to an unplanned wildfire ignition is a suppression strategy. One of the objectives of this revision is to establish a range of acceptable appropriate management response (AMR) actions. Assigned to each Management Area prescription in the revision, is a menu of AMR actions. The three strategies allowed under each AMR are defined below:

Direct Control:

Direct Control is associated with urban development and high value areas and is defined as the immediate and complete extinguishments of a wildfire. Quick decisive suppression action needs to be taken throughout the fire season. Usually this control is restricted to new fire starts, to steady-state fires that have not reached large sizes, and to selected portions of large fires. Direct control also includes exposure protection in which critical resources, such as houses, are shielded from the fire.

Fuels treatment for hazard reduction and pre-suppression planning is a high priority where this strategy is utilized.

Perimeter Control:

Perimeter Control is a strategy that seeks to confine the active zone responsible for fire spread. The appropriate management response to fires in the perimeter control strategy take into account site-specific values at risk. Firelines, whether natural or constructed, are used to confine the active zone of spreading fire. Direct or indirect fireline locations are selected to minimize the combined cost of suppression and the values that could be lost in the fire. The benefits of the fire's effects will be evaluated when determining fireline location. The time of season and forecasted weather may also strongly affect fire line location.

Many opportunities for fuel management exist in perimeter control areas. Strategies for ecosystem restoration and maintenance may meld ideally with strategies for hazardous fuel reduction. Close to the intermix that exists also in perimeter control areas, fuels projects are likely to be directed at defensible fuel profiles and protection of private property, while in the more remote areas of this FMU, ecological values will be emphasized more.

Prescriptive Control:

Wildland fire for resource benefit is emphasized in the prescription control strategy. This strategy allows for the use of unplanned ignitions within specific geographic areas, allowing fire to play its ecological role. Under prescription control, fire is considered to be controlled as long as it burns within specified geographic boundaries and predetermined burning indices. Parameters for this strategy are contained within a written prescription documented in the Fire Management Plan. Fires that are within prescription and advancing management goals in the prescription are allowed to burn. Where a fire jeopardizes investments or other critical resource values, a suppression response is expected. Prescribed fire also is appropriate in prescription control areas.

On the Forest, every area with burnable vegetation will have an AMR assigned to it. The parameters under which each AMR is managed are outlined in the FMP (Fire Management Plan). When the FMP has been completed and approved, all ignitions will receive the full extent of management options available, depending upon resource management objectives presented in the FMP. These options range from monitoring with minimal on-the-ground actions to intense suppression actions on all or portions of the fire perimeter. The appropriate management response is developed from analysis of the local situation, values to be protected, management objectives, external concerns, and land use. The Forest Plan is a decision document, where the Fire Management Plan is a implementation document. The current menu of AMR options allowed for each Management Area is displayed in the first table. The AMR for each alternative, expressed in acres and percent, is displayed in the second table.

Table B-34. Appropriate management response by management area.

Prescription or Perimeter	Perimeter or Direct	Prescription, Perimeter, or Direct	Direct
1.13	4.22	2.1	7.1
1.2	4.3	3.24	8.21
1.31	5.11	3.5	8.22
1.33	5.12	3.51	8.3
1.41	5.13	3.54	8.6
1.5	5.21	3.56	
2.2	5.4	3.57	
3.21	5.41	3.58	
3.31	5.42	4.2	
3.32		4.31	
3.33		5.15	
3.34			

Table B-35. Appropriate management response – acres/percent by alternative.

Alt.	Prescription or Perimeter		Perimeter or Direct		Prescription, Perimeter or Direct		Direct	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
A	132,473	12	777,609	72	167,267	15	7,265	1
B	191,812	18	628,453	58	256,711	24	7,638	1
C	286,412	26	447,443	41	343,121	32	7,638	1
D DEIS	316,263	29	255,013	24	505,700	47	7,638	1
D FEIS	312,668	29	292,934	27	471,596	43	7,192	1
E	225,334	21	302,950	28	549,065	51	7,265	1
F	444,246	41	275,306	25	357,797	33	7,265	1

Note that current direction allows for a change in tactics from a wildland fire use strategy to a confinement strategy. For example, if in the Forest Plan, an AMR for prescription control may have been assigned to a particular wilderness area. During subsequent development of the FMP, however, it may be determined that because of the small size of the wilderness area and/or the presence of values at risk, that a direct control would be a more suitable AMR. However, one may not deviate from a containment strategy, such as direct control, to a fire use strategy, such as prescription control.

Acres of Fuels Treatment (mechanical and prescribed burning) by Alternative

Based on the historic funding level experienced by the Forest, the current objectives of the Medicine Bow Land and Resource Management Plan (also Alternative A), and the management objectives for each alternative, an estimate was made for the number of acres of fuels treatment needed annually under each alternative, primarily based on values at risk. The acreage figure assumes a mix of 70 percent prescribed burning and 30 percent mechanical treatments, and includes acres under planning. The mechanical treatments will be centered around high-value areas and/or communities at risk. Any fuel breaks constructed along urban interface, or other high-value areas, will require maintenance. The type and interval of the maintenance will be determined during project level planning. The at-risk communities identified by the either by the State of Wyoming or by the Forest Service, that are located within the Forest boundary or adjacent to the Forest boundary are listed in the following table.

Table B-36. Communities at risk.

Ranger District	Community at Risk
Laramie	Albany
Brush Creek/Hayden	Battle Lake Subdivision
Douglas	Camp Grace
Laramie	Corner Mountain Estates
Douglas	Cottonwood Park
Douglas	Esterbrook
Douglas	Fletcher Park
Laramie	Foxborough
Laramie	Foxpark
Douglas	Friend Park
Laramie	Keystone
Laramie	Lake Creek Resort
Laramie	Mountain Home
Laramie	North Fork
Brush Creek/Hayden	Oberg Pass
Brush Creek/Hayden	Overlook
Laramie	Rambler
Laramie	Rambler Mine Estates
Brush Creek/Hayden	Ryan Park
Laramie	Somber Hill
Brush Creek/Hayden	Stemp Springs
Laramie	Town of Morgan
Laramie	Vedauwoo Springs
Brush Creek/Hayden	Water Valley Ranch
Brush Creek/Hayden	White Rock Estates

The next table displays the percentage of acres of condition class 2 and 3 and acres of hazard classes high and extreme (see Existing Condition section) being treated over a ten-year planning period, for each alternative. It is important to note that, while prescribed burning results in benefits to the fuels profile and/or condition class, many times the main goal of the burn will be to improve wildlife habitat or range condition.

Table B-37. Acres of fuel treatment annually by alternative.

	Alternative						
	A	**B**	**C**	**D DEIS**	**D FEIS**	**E**	**F**
Acres of Fuels Treatment	2,500	3,500	3,500	4,000	4,000	4,000	2,200
Percent of Fire Regimes 1 & 2, and Condition Class 2 & 3 Treated per Decade	0.9%	1.2%	1.2%	1.4%	1.4%	1.4%	0.8%
Percent of High and Extreme Hazard Ratings Treated per Decade	5%	7%	7%	8%	8%	8%	4%

Acres identified for treatment under Alternative A display an average level of treatment under the existing Medicine Bow Land and Resource Management Plan (1985). Alternative B and C show a 1,000 acre increase over the historic average. This is primarily due to the increased emphasis placed on fuel treatments by the National Fire Plan, both in urban interface zones and across the landscape. Alternative D and E are increased 500 acres above alternatives B and C. This was primarily due to the proposed increase in Special Interest Areas (SIA) proposed under those alternatives, the added level of protection from wildfire they would require, and a need to respond to a higher emphasis on returning fire back to fire dependent ecosystems. Acres proposed for fuels treatment under Alternative F are reduced significantly from the other alternatives. This is primarily due to the increase in special designations (i.e. proposed wilderness) and the reduced ASQ, which reduces commodity values at risk.

The actual level of fuels treatment, in any given year, is dependent on funding levels.

Acres Burned by Wildfire

Calculating an exact number of acres burned by wildfire in the future is difficult to predict. This is primarily due to annual variation in ignition sources and the flammability of fuels, which in part is a function of climate.

In an effort to predict the number of acres that will be burned in the future, over a decade, the fire probability analysis program PROBACRE (Wiitala 1999) was utilized. This program will assess the risk of catastrophic consequences from a single or series of wildfire events. PROBACRE calculates the probability of a major single event, or multiple fire events, and the long term probability that a combination of fire events, both large and small, would result in a total burned area in excess of a particular (user specified) number. All probabilities are calculated from information on annual frequency of fires by size class.

Fire frequency input is from PCHA, Historic Fire Table. Fire occurrence is expressed as annual fires/year. For this analysis, the period for the historical fire records is 1970 to 1996, as this data range of records has been edited to a higher standard than what is found in the historic fire database.

The PROBACRE analysis period was 10 years. The probability analysis was completed for each FMZ (Fire Management Zone) and for the Forest as a total. Output from PROBACRE is summarized in following four tables:

Table B-38. Probability analysis for Laramie Peak and Pole Mountain.

Probability of exceeding the	10	acre threshold in	10	years is	1.00000
Probability of exceeding the	100	acre threshold in	10	years is	1.00000
Probability of exceeding the	500	acre threshold in	10	years is	1.00000
Probability of exceeding the	1,000	acre threshold in	10	years is	0.99669
Probability of exceeding the	2,500	acre threshold in	10	years is	0.81832
Probability of exceeding the	5,000	acre threshold in	10	years is	0.67563
Probability of exceeding the	10,000	acre threshold in	10	years is	0.67004
Probability of exceeding the	15,000	acre threshold in	10	years is	0.30998
Probability of exceeding the	25,000	acre threshold in	10	years is	0.10394
Probability of exceeding the	50,000	acre threshold in	10	years is	0.00442

Table B-39. Probability analysis for the southern part of the Forest, non-wilderness.

Probability of exceeding the	10	acre threshold in	10	years is	1.00000
Probability of exceeding the	100	acre threshold in	10	years is	1.00000
Probability of exceeding the	500	acre threshold in	10	years is	0.99941
Probability of exceeding the	1,000	acre threshold in	10	years is	0.94170
Probability of exceeding the	2,500	acre threshold in	10	years is	0.43176
Probability of exceeding the	5,000	acre threshold in	10	years is	0.30937
Probability of exceeding the	10,000	acre threshold in	10	years is	0.30851
Probability of exceeding the	15,000	acre threshold in	10	years is	0.05297
Probability of exceeding the	25,000	acre threshold in	10	years is	0.00538
Probability of exceeding the	50,000	acre threshold in	10	years is	0.00000

Table B-40. Probability analysis for the southern part of the Forest, wilderness.

Probability of exceeding the	10	acre threshold in	10	years is	0.99271
Probability of exceeding the	100	acre threshold in	10	years is	0.62368
Probability of exceeding the	500	acre threshold in	10	years is	0.00328
Probability of exceeding the	1,000	acre threshold in	10	years is	0.00000
Probability of exceeding the	2,500	acre threshold in	10	years is	0.00000
Probability of exceeding the	5,000	acre threshold in	10	years is	0.00000
Probability of exceeding the	10,000	acre threshold in	10	years is	0.00000
Probability of exceeding the	15,000	acre threshold in	10	years is	0.00000
Probability of exceeding the	25,000	acre threshold in	10	years is	0.00000
Probability of exceeding the	50,000	acre threshold in	10	years is	0.00000

Table B-41 Probability Analysis – All FMZ's Forest Total

Probability of exceeding the	10	acre threshold in	10	years is	1.00000
Probability of exceeding the	100	acre threshold in	10	years is	1.00000
Probability of exceeding the	500	acre threshold in	10	years is	1.00000
Probability of exceeding the	1,000	acre threshold in	10	years is	1.00000
Probability of exceeding the	2,500	acre threshold in	10	years is	0.99511
Probability of exceeding the	5,000	acre threshold in	10	years is	0.84287
Probability of exceeding the	10,000	acre threshold in	10	years is	0.77244
Probability of exceeding the	15,000	acre threshold in	10	years is	0.53973
Probability of exceeding the	25,000	acre threshold in	10	years is	0.26327
Probability of exceeding the	50,000	acre threshold in	10	years is	0.01772

The next table shows the communities at risk identified by the State of Wyoming and published in the federal register.

Table B-42. National Fire Plan in Wyoming, communities at risk.

43435	Federal Register / Vol. 66, No. 160 / Friday, August 17, 2001 / Notices	
Aladdin, WY	Bill-Dry Creek, WY	Canyon Creek Country, WY
Albany, WY	Billy Creek Homes/Cab, WY	Canyon Junction, WY
Alpine, WY	Bitter Creek Area, WY	Carlisle, WY
Alta, WY	Black Buttes, WY	Casper, WY
Alva, WY	Bondurant, WY	Casper Mountain, WY Cedar Hills,
Ames Monument Ranches, WY	Boulder, WY	WY
Antelope Butte Ski Lodge, WY	Boulder Lake, WY	Cedar Mountain, WY
Antelope Run, WY	Boulder Ridge Estates, WY	Centennial, WY
Aspen Country, WY	Boxelder, WY	Cindde Bar Flats, WY
Aspen Highlands Estates, WY	Breakneck, WY	Cloudstreet Ranches, WY
Atlantic City, WY	Briar Patch, The, WY	Cokeville, WY
Backcountry, WY	Brunson Subdivision, WY	Cold Springs, WY
Baker Canyon, WY	Bryan Flats, WY	Colter Bay, WY
Battle Lake Subdivision, WY	Buckhorn, WY	Corner Mountain Estates, WY
Bear River Divide, WY	Buffalo Valley, WY	Cottonwood Acres, WY
Beaver Creek, WY	Burgess Jct. Lodge, WY	Cottonwood Canyon, WY
Beaver Creek Area, WY	Burgess Work Center, WY	Cottonwood Creek, WY
Big Block Cabins, WY	Buttes, The, WY	Cottonwood Park, WY
Big Goose Creek, WY	Camp Comfort, WY	North Fork, WY
Big Goose Creek Wc, WY	Camp Grace, WY	Nugget, WY
Big Sandy, WY	Canyon Club, WY	Oberg Pass, WY
Bighorn Sum. Homes, WY	Canyon Creek Cabins #1, Hazelton	Odd Fellows Campground, WY
Crooked Creek, WY	Area (East), WY	Oil Creek, WY
Crystal Lake, WY	Heck Of A Hill, WY	Old Faithful, WY
Curt Gowdy, WY	Hess Mtn/Top Of Rockies, WY	Osage, WY
Daniel, WY	Hoback, WY	Overlook Retreats, WY
Deer Haven, WY	Hoback Ranches, WY	Owl Creek, WY
Devils Tower, WY	Hobble Creek, WY	Pacific Creek, WY
Devils Tower Visitor Center, WY	Hog Island, WY	Painter Estates, WY
Dome Lake, WY	Homestead Park Subdivision, WY	Paradise Guest Ranch, WY
Downy Park, WY	Hulett, WY	Park County, WY
Dry Fork, WY	Hunter Summer Homes, WY	Piedmont, WY
Dull Knife Reservoir, WY	Hwy 6/Hi Country Estate, WY	Pine Bluff, WY
E. Gros Ventre Butte, WY	Hyatt Ranch Area, WY	Pine Creek Area On S Pass, WY
E. Upton, WY	Indian Paintbrush, WY	Pine Creek Ski, WY
Elk Ridge Estates, WY	Jackson, WY	Pine Grove Estates, WY
Esterbrook, WY	Jackson Lake Lodge, WY	Pine Horizon, WY
Evanston North, WY	Jelm Mountain Ranchetts, WY	Pine Island, WY
Ferguson Canyon, WY	Jim Bridger, WY	Pinedale, WY
Fish Creek, WY	Jy Ranch, WY	Pines/Middle Fork, WY
Flagg Ranch, WY	Keyhole, WY	Pocket Creek, WY

Fletcher Park, WY	Keystone, WY	Poison Creek, WY
Flying X Ranch, WY	Kortes Dam Camp, WY	Pomeroy Subdivision, WY
Fontenelle, WY	Lake Creek Resort, WY	Porcupine R.S. & Cabins, WY
Forty Rod, WY	Cow Creek, WY	Porcupine Shell Wc's, WY
Fox Park, WY	Crandall, WY	Porcupine Subdivision, WY
Foxborough, WY	Meeks Cabin, WY	Rabbit Creek, WY
Fren Park, WY	Middle Fork Powder River, WY	Rainbow Forest Estates, WY
French Creek, WY	Middle Mountain Estates, WY	Rambler, WY
Friend Park, WY	Moose Haven Subdivision, WY	Rattlesnake, WY
Gilbert Creek, WY	Mosiure Gulch, WY	Red Top Meadows, WY
Glendo State Park, WY ,2	Mountain Home, WY	Remount, WY
Granite Creek, WY	Mountain Meadow, WY	Resorts, WY
Granite Springs, WY	N Fork Shoshone River, WY	
Grave Springs, WY	New Fork, WY	
Green Creek Subdivision, WY	New Haven, WY	
Greybull River, WY	Newcastle, WY	
Guernsey State Park, WY	North Blacktail, WY	
WY	Sunlight, WY	
Canyon Creek Cabins #2,	Sweetwater, WY	
Harriman, WY	Sylvan Bay, WY	
Harris Park, WY	Te-Ke-Ki Subdivision #1, WY	
Hazelton, WY	Ten Sleep Preserve, WY	
Revised Lankford/Rinker, WY	Tensleep-Spec. Use Area, WY	
Rice Subdivision, WY	Teton Valley Ranch, WY	
Rinker-Lankford Exchange, WY	Teton Village, WY	
Robertson, WY	The Bend, WY	
Rockaway Ranch, WY	Tongue River/Dayton, WY	
Rocky Top Subdivision, WY	Town Of Morgan, WY	
Round Hill Ranch, WY	Twin Creek, WY	
Ryan Park, WY	Tyrell Wc & Cabins, WY	
S Fork Shoshone River, WY	Union Pass Area, WY	
Sage Jct, WY	Upper Green, WY	
Sage Valley, WY	Upper Wood River, WY	
Sage Valley Subdivision, WY	Upton, WY	
Sand Creek, WY	Urban Thermopolis, WY	
Saw Pine Cow Camp, WY	Vedauwoo Springs, WY	
Seminoe Reservoir, WY	W. Gros Ventre Butte, WY	
Shadow Mountain, WY	Wapiti Subdivision, WY	
Shell R.S. & Cabins, WY	Warm Springs, WY	
Shoshone River, WY	Warm Springs Mountain, WY	
Sierra Madre Ranch, WY	Water Valley Ranch, WY	
Signal Mountain, WY	Waywest Subdivision, WY	
Silver Hills, WY	West Slope Sierra Madre, WY	

Sinks Canyon, WY Skyline Church Camp, WY Snake, WY Soda Butte, WY Solitude, WY Somber Hill, WY Sourdough, WY South Fork Inn, WY South Pass City, WY Spring Creek, WY Star Valley, WY Story, WY Stumpy Ridge/Tepee, WY Sundance, WY	West Thumb, WY White Rock Estates, WY Wigwam, WY Wild River, WY Wildwood Camp, WY Willow Creek, WY Wind River, WY Windsong Ranch, WY Wold Subdivision, WY Wood River, WY Woodedge, WY Woods Landing Leases, WY	

Water Yield Analysis

Introduction: This section describes the analysis of changes in water yield as a result of vegetation management proposed in the Medicine Bow National Forest, Forest Plan revision. This analysis was completed to address the issue of whether and how much water yield could be produced from forest management activities that alter forest canopy density. The protocols utilized to estimate water yield changes for the Arapaho and Roosevelt, Routt, and Medicine Bow Forest Plan revisions are all similar.

Background: Water from the Forest is used not only for municipal and agricultural uses but also for instream uses. Streamflow from forested watersheds is primarily a function of total precipitation and losses due to evapotranspiration and groundwater storage. Trees in the watershed affect streamflow by transpiring water, intercepting snow or rain which may be evaporated or sublimated back into the atmosphere, and by modifying the understory's evapotranspiration (Kaufmann et al. 1987). Reductions in forest canopy density results in water being available for streamflow by reducing evapotranspiration and increasing snowpack accumulation into the openings (Alexander et al. 1985). Many experiments have measured changes in streamflow from reductions in vegetative cover on small watersheds, less than a couple square miles (e.g. Bosch and Hewlett,1982). Research on the 6.5 square mile Coon Creek watershed in the Sierra Madre range showed a significant increase in streamflow after timber harvest on 24 percent of the watershed (Troendle et al. 1998).

Precipitation is a primary factor influencing water yield from a basin and the change in water yield caused by vegetation management is also largely determined by the amount of precipitation which occurs on a site. Thus, treatment in spruce-fir yields the greatest change per unit area, because spruce-fir typically occupy the wetter sites. Changes are smaller for treatment of lodgepole pine and smallest for ponderosa pine. Changes in streamflow from vegetation management are not permanent. As an area is restocked and the trees grow, water that was available for streamflow is slowly redirected back to evapotranspiration. Research at the Fraser Experimental Forest indicates that changes in water yield from timber harvest persist at declining levels for approximately 80 years (Troendle and King, 1985).

Management activities such as land use authorizations for water development facilities and changes in vegetative cover influence the quantity and timing of streamflows. Land use authorizations for water development facilities have a significant and relatively large impact on the amount and timing of streamflows (see Effects from Land Use Authorizations section of FEIS and Water Resources – Affected Environment), but are not expected to vary by alternative. Wildfire, insects and disease are natural processes that affect the timing and quantity of streamflow, and may be expected to vary by alternative due to management prescriptions for the Forest. Timber harvest and fuels treatment levels vary by alternative and also affect the amount and timing of streamflows. The methods and modeling used to estimate changes in water yield for each alternative are described below.

Methods: Changes in water yield as a result of alternative vegetation management scenarios were estimated for the Forest Plan Revision. Timber harvest, fuels treatment (prescribed fire and mechanical treatment), wildfire and insect and disease are the activities analyzed, by alternative, for changes in water yield. Alternatives G and H were analyzed and dismissed from detailed analysis in the DEIS. Water yield estimates for those alternatives are presented in the DEIS and not duplicated in the FEIS. Alternative D DEIS presented below provides an indication of the alternative as it was presented in the DEIS, with only corrections made to errors and assumptions. Alternative D FEIS presented below provides an indication of the modified alternative D developed for the FEIS.

A computer model (Swanson, 1989) commonly referred to as WRENSS, based on *An Approach to Water Resources Evaluation of Non-Point Silvicultural Sources* (EPA, 1980) was used for this analysis. The following is a discussion of the information and assumptions used for each field to run the model. The protocols for estimating water yield increases for Forest Plan revisions in Region 2 were established on the Arapaho and Roosevelt National Forest (Chambers, No date), followed for the Routt Forest Plan revision and now followed for the Medicine Bow Forest Plan revision. The information presented below describes minor modifications to the procedure described by Chambers (No date), but does not duplicate the information presented in that report. Model runs and computation spreadsheets have also been utilized for this analysis and are on file in the Forest Plan administrative record.

Area: Followed procedure described by Chambers (No date).

Aspect: Followed procedure described by Chambers (No date). See the following spreadsheet for data and computations:

k:\lmp\projects\medbow_amend\resources\water_rip_wet\water_yield\h2oyield_coefficients_med_bow.xls

Precipitation: Followed procedure described by Chambers (No date), except as noted here. Utilized PRISM precipitation data from Oregon Climate Center, Oregon State University. Troendle and Nankervis (2000, Table 1 p. 26) estimated the percent of annual precipitation occurring in each month by elevation zone, for Forests in the North Platte basin. Average elevation for vegetation types were determined with GIS and utilized to estimate the monthly precipitation distribution for each vegetation type. The area weighted mean annual precipitation for each vegetation type was proportioned accordingly for each month. The following table provides average elevation zone and average annual precipitation by vegetation type.

Table B-43. Average elevation zone and average annual precipitation by vegetation type.

Vegetation Type	Average Elevation (ft)	Average Annual Precipitation (inches)
Lodgepole	8000	29
Spruce fir	9000	39
Aspen	8000	29
Ponderosa	7000	20

Lapse: Followed procedure described by Chambers (No date).

Elevation: Followed procedure described by Chambers (No date).

Tree Height: Tree height was set to zero, since this field is irrelevant if the adjustments to precipitation described by Chambers (No date) are followed.

Type: Followed procedure described by Chambers (No date). Douglas fir and Limber pine were lumped with Ponderosa Pine, since the model does not have routines for these vegetation types and they were expect to have similar water yield responses.

Wind Speed: Followed procedure described by Chambers (No date).

Days of no snow: Followed procedure described by Chambers (No date).

Gauge: Followed procedure described by Chambers (No date).

Exposure: Followed procedure described by Chambers (No date).

Snow Scour: Set parameter to "No", assuming no snow scour as described by Chambers (No date).

Unimpacted vs. Impacted: Followed procedure described by Chambers (No date).

Max BA: Followed procedure described by Chambers (No date).

BA: Followed procedure described by Chambers (No date).

Area Cut: Followed procedure described by Chambers (No date).

BA in Cut: Followed procedure described by Chambers (No date).

Roughness Height: Followed procedure described by Chambers (No date).

Windward Width: Followed procedure described by Chambers (No date).

Block Area: Followed procedure described by Chambers (No date).

The WRENSS model was run for the various vegetation types, aspects, and tree size. Data and results for each file were saved. Filenames use the following naming convention (e.g. TLPLSA – Lodgepole pine, large, south aspect, adjusted precipitation): Covertype (TLP(lodgepole), TSF(Spruce-fir), TPP(Ponderosa Pine), TAA(Aspen); Size Class (L(large), M(medium); Aspect (N-north, S-south, E-east/west); Precipitation(U-unadjusted, A-adjusted). These files are currently filed:

K:\rr\2500_watershed_mgt\programs\wrens.

The change in water yield (inches) for each vegetation regime was determined by subtracting the unadjusted precipitation *unimpacted* water yield from the adjusted *unimpacted* water yield. Weighted average water yield increases we calculated following methods described by Chambers (No date).

Timber Harvest: The following table was provided as input to the SPECTRUM growth and yield model. The SPECTRUM model applied these coefficients to the harvest scenarios for each alternative for the first five decades and produced a value for water yield increase for each decade (acre-inches/decade), which was converted to an average annual value in acre-feet ((acre-inches/10)/12). Additional documentation is available with the SPECTRUM model.

Table B-44. Water yield due to timber harvest.

Water Yield due to timber harvest (inches)	Decade 0	Decade 1	Decade 2	Decade 3	Decade 4	Decade 5
LP 9 (Sawtimber)						
Clearcut (existing)	7.724	6.759	5.793	4.828	3.862	2.897
Prep (E2)	4.248	3.717	3.186	2.655	2.124	1.593
Over (E2)	3.476	3.041	2.607	2.172	1.738	1.303
LP 8 (Poletimber)						
Clearcut (existing)	7.692	6.731	5.769	4.808	3.846	2.885
Prep (E2)	4.231	3.702	3.173	2.644	2.115	1.586
Over (E2)	3.461	3.029	2.596	2.163	1.731	1.298
SF 9 (Sawtimber)						
Over (E3) 3STSW	3.300	2.888	2.475	2.063	1.650	1.238
Over (E2) 2STSW	4.950	4.332	3.713	3.094	2.475	1.856
Prep (E2)	6.051	5.294	4.538	3.782	3.025	2.269
Prep (E3)	3.300	2.888	2.475	2.063	1.650	1.238
Seed (E3)	4.400	3.850	3.300	2.750	2.200	1.650
SF 8 (Poletimber)						
Over (E2) 2STSW	4.982	4.360	3.737	3.114	2.491	1.868
Over (E3) 3STSW	3.322	2.906	2.491	2.076	1.661	1.246
Prep (E2)	6.090	5.328	4.567	3.806	3.045	2.284
Prep (E3)	3.322	2.906	2.491	2.076	1.661	1.246
Seed (E3)	4.429	3.875	3.322	2.768	2.214	1.661

See the following spreadsheet for data and computations: K:\lmp\projects\medbow_amend\resources\water_rip_wet\water_yield\h2oyield_coefficients_med_bow.xls

Fuel treatments: Fuel treatments (mechanical treatments and prescribed fire) may have an effect on water yield. Since most prescribed fire occurs in grass, shrub and aspen on the Forest, and water yield changes from these cover types are minimal, only mechanical treatments were assumed to change water yield. Mick Hood, fire fuels specialist for the Forest Plan assumed 30% mechanical treatment/70% prescribed fire with mechanical treatment most likely to occur in Lodgepole or Ponderosa pine with similar basal area removal to first step of shelterwood. The acres of fuel treatment shown below were multiplied by 0.3 to reflect the proportion of fuels treatments which were mechanical treatment. Mechanically treated acres were then multiplied by 4.248 inches, the estimated water yield produced during the first step of shelterwood of large lodgepole pine.

Table B-45. Relative impacts between alternatives for fuels treatment.

Alternative	A	B	C	D DEIS	D FEIS	E	F
Fuel Treatment (acres/year)	2,500	3,500	3,500	4,000	4,000	4,000	2,200

See the following spreadsheet for data and computations: K:\lmp\projects\medbow_amend\resources\water_rip_wet\water_yield\h2oyield_coefficients_med_bow.xls

Wildfire: Wildfire may have an effect on water yield. Kathy Roche (10/21/03), Forest Ecologist, estimated acres of wildfire for each Forest Plan Alternative as shown in the Table below.

Table B-46. Acres of wildfire by alternative.

WILDFIRE Acres	Alternatives						
Stand Replacement	**A**	**B**	**C**	**D DEIS**	**D FEIS**	**E**	**F**
Cumulative for Decade 5	13,065	18,135	23,855	31,070	29,250	31,005	48,035
One year Avg	261	363	477	621	585	620	961
Non Stand Replacement	**A**	**B**	**C**	**D DEIS**	**D FEIS**	**E**	**F**
Cumulative for Decade 5	65,325	90,675	119,275	155,350	146,250	155,025	240,175
One year Avg	1,307	1,814	2,386	3,107	2,925	3,101	4,804

For the water yield analysis, it was assumed that stand replacement wildfires had similar water yield coefficients to large size class Lodgepole pine. Non stand replacement wildfire was assumed to remove 55% of the basal area, similar to a 1st step shelterwood entry in a Lodgepole pine stand. Wildfire acres were then multiplied by the appropriate water yield coefficient to obtain estimated increases in water yield. See the following spreadsheet for data and computations: K:\lmp\projects\medbow_amend\resources\water_rip_wet\water_yield\h2oyield_coefficients_med_bow.xls

Insect and Disease: Insects and disease may have an effect on water yield. Kathy Roche (10/21/03), Forest Ecologist, estimated acres of insect and disease for each Forest Plan Alternative as shown in the Table below.

Table B-47. Acres of insect and disease by alternative.

INSECT AND DISEASE Acres	Alternatives						
Stand Replacement	**A**	**B**	**C**	**D DEIS**	**D FEIS**	**E**	**F**
Cumulative for Decade 5	8,291	11,509	15,139	19,718	18,563	19,676	30,484
One year Avg	166	230	303	394	371	394	610
Non Stand Replacement	**A**	**B**	**C**	**D DEIS**	**D FEIS**	**E**	**F**
Cumulative for Decade 5	2,764	3,836	5,046	6,573	6,188	6,559	10,161
One year Avg	55	77	101	131	124	131	203

For the water yield analysis, it was assumed that stand replacement insect and disease had similar water yield coefficients to large size class Lodgepole pine. Non stand replacement insect and disease was assumed to remove 55% of the basal area, similar to a 1st step shelterwood entry in a Lodgepole pine stand. Insect and disease acres were then multiplied by the appropriate water yield coefficient to obtain estimated increases in water yield. See the following spreadsheet for data and computations: K:\lmp\projects\medbow_amend\resources\water_rip_wet\water_yield\h2oyield_coefficients_med_bow.xls

Results: Water yield due to changes in forested vegetation are presented in the table below. The estimated average annual water yield due to timber harvest in the first decade of Plan implementation ranged from 0 acre-feet/year for Alternatives F to 1165 acre-feet/year for Alternative A. Alternatives B and C would generate the next greatest annual water yield increases, 1142 and 1118 acre-feet, respectively. Fuels treatment would generate the greatest change in water yield in Alternatives D DEIS, D FEIS and E (425 acre-feet/year), followed by Alternatives B and C (372 acre-feet/year). Water yield projected for wildfire range from 631 (Alternative A) to 2319 acre-feet/year (Alternative F). Insect and disease would generate from 126 (Alternative A) to 464 (Alternative F) acre-feet/year. Total modeled average water yield increases for all vegetation management activities in the first decade of Plan implementation range from 2188 (Alternative A) to 3287 (Alternative D DEIS) acre-feet per year.

Table B-48. Estimated water yield due to changes in vegetation (average AF/yr[1]).

Alternatives	A	B	C	D DEIS	D FEIS	E	F
Timber Harvest (AF-yr)	1,165	1,142	1,118	1,062	1,000	916	0
Fuel Treatments (AF-yr)	266	372	372	425	425	425	234
Wildfire (AF-yr)	631	875	1,152	1,500	1,412	1,497	2,319
Insect and Disease (AF-yr)	126	175	231	300	283	300	464
Total (AF-yr)[2]	2,188	2,564	2,873	3,287	3,120	3,138	3,017

1 Average annual water yield for the first 10 year cycle of the planning period.

2 Provides and indication of the relative difference between alternatives by including timber harvest, wildfire, fuels treatment and insect and disease, which vary by alternative.

Water yield potential under a maximum, unconstrained harvest level scenario ("Benchmark T"), was also estimated. An estimated average annual 1923 acre-feet of water, almost double the other alternatives considered, was modeled for the first decade of implementation due to timber harvest. This scenario provides a basis for comparison to the alternatives in the Forest Plan, but does not meet the legal and environmental constraints necessary to be considered as a viable alternative.

Alternative D DEIS provides the highest estimated water yield due to vegetation changes (3287 acre-feet/year), followed by Alternative D FEIS (3120 acre-feet/year). The sources of predicted water yield in these alternatives approximately 60 percent natural disturbances (wildfire and insect and disease) and 40% active vegetation management (timber harvest and fuels treatment). Alternatives A and B are estimated to provide the smallest amount of water yield due to vegetation management with 2188 and 2564 acre-feet per year respectively. The proportion of water yield from active management increases in these alternatives.

Water yield persists for about 80 years, as discussed above. Water yield produced by canopy changes in the first decade add to water yield from the second decade, and so on. Detailed projections of timber harvest levels are available for a 50 year period, but similar information is not available for other vegetation management activities. Timber harvest generated water for decade 5 of Plan implementation were estimated to provide an indication of the cumulative effects of vegetation management over time. Cumulative average annual water yields for decade 5 are estimated at 4968 (A), 5284(B), 5170(C), 4627(D DEIS), 4173(D FEIS), 3919(E), and acre-feet per year 100(F).

Scientific, technical, and operational constraints in modeling water yields from forested landscapes: Many research studies based on relationships between precipitation, evapotranspiration, and groundwater storage in forested landscapes, at the small watershed scale, clearly demonstrate that water yields can be increased through vegetation manipulation. These increases in water yield can be modeled using various techniques. At the same time, however, experience has shown that operational programs that attempt to increase water yields at a larger scale have not been successful (Ziemer, 1987).

Outlined below are scientific, technical and operational limitations on the potential for water yield augmentation from vegetation manipulation on National Forest System land. Although water yield analyses (i.e. modeling) for vegetation manipulation may result in specific numbers, extreme caution must be used in interpreting the significance of these modeled results.

I. Issues of Scale: Spatial and temporal issues of scale that play an important role in potential water yield increases are often not adequately addressed in analyses that extrapolate research data from small watersheds to larger landscapes.

Spatial Scale: Research from small watersheds shows that approximately 20 – 25 % of the forest cover must be removed to show a measurable on-site increase in water yield. These increased yields are not dependent on a particular silvicultural prescription. Although most water yield studies have been done on small watersheds (e.g. 714 acre Fool Creek on the Fraser Experimental Forest), the Coon Creek experiment on the Medicine Bow National Forest demonstrated that water yields were also shown to increase on this 4,133 acre drainage when it was impacted to the same degree (24 % of the watershed was impacted by road construction or timber harvest) (Troendle at al, 1998). It is reasonable to conclude that these results can be extrapolated to larger watersheds, as long as the entire forested landscape in the watershed is impacted to the same degree.

Therefore, to realize measurable increases in water yield from vegetative manipulation on the Medicine Bow National Forest, approximately 25 % of the forested landscape in the Platte River Basin or Colorado River Basin would have to be removed at a given time. The Platte River Basin on the Forest contains 700,900 acres of forested landscape – 25 % of these acres equals 175,225 acres. The highest recorded amount of timber harvest and natural disturbances on the Forest for an entire decade (1980's) is less than 40,000 acres, averaging less than one percent of the forested landscape per year. These acreages are significantly less than those needed to have a measurable effect on water yield at the river basin scale. Large-scale natural events, such as fire, insects, disease or blowdown, may have the potential to reduce forest cover on enough acreage at one time to result in measurable changes in water yield at the Forest or river basin scale. Based on recent history, events of this size are rare on the Forest.

Temporal Scale: Most discussions of potential water yield increases are presented as averages. These average numbers do not represent the actual variability on a monthly or annual basis. Research shows that water yield increases for subalpine landscapes in the Rocky Mountains are limited to the months of spring runoff (typically May or June) and are not present in any other month of the year (Troendle and Nankervis, 2000). Additionally, increases are proportional to the natural precipitation in the basin – i.e. a percentage increase in a flow in a wet year will be a greater absolute increase than a percentage increase in a dry year. A drought will still be a drought, and a flood will be a bigger flood. Rare, large flow events may distort "average" numbers by making them appear higher, but in reality these events are seldom captured or put to beneficial use. The most reliable indicator for water yield from large basins is precipitation, which is fairly constant in the long term. Researchers have not been successful in finding other significant correlations at this scale (Kircher et. al. (1985) discussed in Troendle and Nankervis, 2000).

Forest Health: Changes in forested landscapes and riparian corridors do not alter basic ecological processes under which these landscapes evolved. Dillon and Knight (2000) found insufficient evidence to suggest that many stand and landscape scale vegetation characteristics, such as canopy density and ratio of forest to non-forest, were outside of the range of historic variability. Since they are still within the historic range of variability, there is limited evidence to suggest that current water yields are below the range of historic variability as a result of upland vegetation conditions.

II. Limitations of technology and modeling: Modeled water yield increases are generally difficult to measure off-site because they are an extremely small fraction of total streamflow. Where water yield increases have been measured on-site, they are undetected in the next larger watershed. The inability to measure these increases off-site, or to measure transmission losses to the point of use, makes it virtually impossible to document the magnitude or persistence of modeled increases in water yields as they are transmitted downstream. Therefore, although we can use models such as WRENNS to estimate theoretical on-site increases in water yield from timber harvest across larger forested landscapes, we cannot track or measure these theoretical increases at the larger scales.

III. Operational Constraints: Extrapolating the results from small watershed studies to larger basins can easily result in overstated goals and benefits. The realities of fixed and variable constraints such as land ownership, inoperable lands that are too steep, unstable or unproductive, multiple use coordination, water quality or habitat concerns are often left out of analyses that make broad conclusions about possible water yield increases across large landscapes. These practical limitations and resource coordination requirements limit our ability to remove the forest cover from a large portion of the landscape. At Coon Creek, which was set up as a water yield research study, the intent was to harvest one third of the watershed, but other considerations resulted in only 24 percent of the watershed actually being harvested (Troendle and Nankervis, 2000).

As discussed above water yields that are realized are proportional to precipitation. The largest increases would be predicted to occur in wet years when reservoir storage is least available to capture increased flows.

Maintenance of the increased water yield over time presents an additional operational constraint. Water yield persists over time following vegetation manipulation at a decreasing rate as vegetation grows back to pre-treatment conditions. To continue to realize the increase in water yield, vegetation within the watershed would have to remain in the altered condition. Short of vegetation type conversion, this would require near perpetual manipulation of vegetation over large areas, a near impossible task given the operational constraints noted above.

Discussion: Because the Forest is bisected by the Continental Divide, water from the western portion of the Forest drains into the Colorado River drainage and water from the eastern portion drains into the Platte River drainage. The proportion of water yield increases from timber harvest for each drainage varies for each alternative. Values for different alternatives range from 83-98 percent of the increase occurring in the Platte River drainage with the remainder occurring in the Colorado River basin. The location of the fuels reduction, wildfire and insect and disease could not be accurately projected by river basin, so no proportional estimate of the water yield is available for those activities.

For the alternatives considered in detail, modeled average water yield from changes in vegetation in the first decade of Plan implementation range from 1077 (Alternative F) to 2055 (Alternative D DEIS) acre-feet per year. With the exception of Alternative F, total water yield due to changes in vegetation varies by less than 400 acre-feet per year by alternative. The mechanism by which the density of forest cover changes varies by alternative as management prescriptions tend to emphasize one type of vegetation management over others. The changes in the type of vegetation management tend to compensate for each other in terms of water yield. In other words, an alternative with a greater amount of timber harvest tends to have less wildfire, and an alternative with more wildfire tends to have less timber harvest, but to some degree the overall water yields due to vegetation changes are similar.

The differences in water yield between alternatives as a result of vegetation management are greatly masked by the comparison to other water quantity values on and downstream of the Forest (See Table below). Existing water yield from the

Encampment River above Hog Park Reservoir, a watershed of similar size to many of the streams as they leave the Forest, averages 82,118 acre feet per year. Existing water yield for the entire Forest was estimated at approximately 1,017,000 acre feet in 1981 (USDA Forest Service, 1985) and provides a reasonable estimate of the magnitude of average annual streamflow coming off the Forest. Natural streamflows for the North Platte River at the Wyoming/Nebraska state line were estimated to average 1,687,600 acre feet. The modeled water yield increases that might be generated by any of the alternatives as a result of vegetation management are quite small when compared to the natural average annual water yield at the local watershed (<2%), Forest (<0.2%) and basin-wide scale (<0.1). While real, these projected increased yields are a very small component of the water produced on the Forest, and the difference in water yield between alternatives is even less significant.

Table B-49. Water yield indicators (average AF/yr).

Location	Water Yield (AF-yr)
Existing Water Yield - Encampment River above Hog Park (AF-yr)[1]	82,118
1981 water yield from Forest (ac-ft)[2]	1,017,000
North Platte River – state line outflow: natural conditions (AF-yr)[3]	1,687,600

[1] Existing Water Yield - Encampment River above Hog Park Reservoir (73 square mile watershed). USGS gage 06623800. 1965-2000 average annual streamflow.

[2] Water yield for the Forest in 1981 was estimated at approximately 1.017 million acre feet (USDA Forest Service, 1985).

[3] Estimated natural streamflow at Wyoming/Nebraska stateline 1969-1988 (Marston, 1990)

For comparative purposes, several indicators of water uses are provided in the table below. Forest Service administrative and authorized water uses, in conjunction with other water uses in a basin, can influence the quantity and timing of local and regional streamflows. These types of water use activities are different from vegetation management activities in that they deplete water from streams, rather than potentially increasing streamflow. Nonetheless just considering the two water use values presented below, which are a only a portion of administrative and authorized water uses on the Forest, Forest management activities which deplete water appear to have a more significant effect on streamflow than all vegetation management activities proposed in the Forest Plan.

Table B-50. Water uses indicators (average AF/yr).

Location	Water Yield (AF-yr)
Evaporative loss at Rob Roy and Hog Park Reservoirs[1]	1160
Consumptive use of all "minor" authorized and administrative water uses on Forest[2]	263

[1] Estimated from evaporation rates provided by Cheyenne Board of Public Utilities (D. Gloss personal communication with H. Noe 9/1/02).

[2] Minor (<25 acre-feet/year) consumptive water uses on Forest, such as campground wells and stock water facilities. From data in the "Supplement to - Programmatic Biological Assessment for Minor Water Depletions Associated with Routine Forest Decisions in the Platte River Basin (USDA Forest Service, 1996) and Colorado River basin.

Most beneficial uses of water, such as fish-bearing streams or diversions for agriculture, occur at locations where water yield changes due to vegetation management on the Forest are unlikely to be measureable. While real, in the majority of watersheds on the Forest, these increased yields do not contribute significantly to beneficial uses at the local level. If adequate storage capacity is available in the following reservoirs, water yield due to vegetation management has a higher likelihood of being used beneficially: Hog Park, Rob Roy, Lake Owen, High Savery, Sand Lake, and Turpin Reservoirs. Storage capacity in other reservoirs on or near the Forest is likely too small or too far downstream to realize the benefits of water yield due to vegetation management.

Wildlife species and habitat in downstream locations in the Platte or Colorado River systems are unlikely to be measureably affected by water yield from vegetation management on the Forest. While real, water yield from vegetation management is unlikely to be measureable at the Forest boundary, let alone several hundred miles downstream (e.g. Troendle and Nankervis, 2000). Water yield from 1997-2001 harvest levels on all Forests in the North Platte basin, when projected into the future, are expected to only partially offset decreases in streamflow as a result of increased stand density in the next couple decades (Troendle, et al, 2003). Vegetation manipulation under most alternatives in the Forest Plan may increase the offset in water yield, but is unlikely to offset the projected decreases in streamflow in the next 30-50 year period. Additionally, no legal means to protect this water are available, and any incidental water yield increases would likely be used through application of water rights for municipal and agricultural purposes long before water reached the Platte or Colorado River mainstem ecosystem. Thus, there would be no significant, measurable regional change in water yield from any of the Forest Plan alternatives.

Biological Diversity Analysis

<u>Introduction:</u> This section describes the analyses that were conducted in association with the evaluation of biological diversity.

1. Forest Successional Stage Residence Times and Successional Stage Progression Sensitivity Analysis.
2. Landscape Pattern Analysis (FRAGSTATS)
3. Natural Processes Analysis (Acres of Wildfire, Insects and Diseases)
4. Use of Yellowstone National Park (YNP) as a reference landscape.
5. Potential Natural Vegetation
6. Amount of the MBNF within a specified distance of Roads, Trails and Developed Sites

Forest Vegetation Simulator

The primary tool used for estimating growth of forest stands was the Forest Vegetation Simulator (FVS) (Wycoff 1986), (Wycoff, Dixon et al. 1990), (Teck 1996). 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 (Stage 1973). Staff at the USFS Forest Management Service Center in Fort Collins have now calibrated a variant of this model for the Central Rockies geographic area (Dixon 2001). FVS extensions were also used to allow modeling of canopy cover (Crookston and Stage 1999), (Crookston 1985), (Crookston 1990).

The results of FVS modeling were incorporated into:

- Growth and yield information for inclusion in the SPECTRUM modeling of timber harvest (see SPECTRUM section for details);
- Developing standards, guidelines, goals and objectives for old growth retention, ecological restoration (MA 5.15);
- Determining residence times for structural stages for successional stage modeling (see sucessional stage modeling section for details)
- Determining old growth descriptions for species and cover types not covered by Mehl (Mehl 1992).
- Determining Potential Natural Vegetation (PNV) Structural Stages.

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.

The FVS model structure contains modules for growing trees; predicting mortality; establishing regeneration; simulating growth reductions, damage, and mortality due to insects and disease; performing management activities; calculating tree volumes; and producing reports. One of the strengths of the FVS system is its ability to incorporate local growth rate data directly into the simulation results.

FVS information for SPECTRUM used actual forest stand data selected from the Forest's RMRIS data base to project growth and yields for future outputs. FVS information for other applications modeling regeneration from bare ground using average forest parameters (elevation, aspect, stocking, species representation) by cover type.

Forest Successional Stage Residence Times

Residence time in each structural stage and basic successional pathways were constructed from FVS modeling for each cover type based upon procedures developed by Stage *et al.* (Stage, Hatch et al. 1996) and Stage (Stage 1997). Residence times were used to calculate Continuous, even supply of habitat structure stages (CES-HSS) which is potentially a measure of central tendency (median) for the fluctuations represented in HRV.

Late successional stages (habitat structure stages 4 and 5) are developed by forest growth and succession in the absence of stand replacement disturbance. The amount of late successional HSSs is most often the focus of concern for maintaining selected biological structures and compositions within the historical range of variability (HRV).

A continuous, even supply of habitat structure stages would be defined by a continuous and even replacement of an amount of HSS 5 by HSS 1 each year equal to the ratio of one to the maximum age for the cover type. Each species is identified as having a maximum age that can be applied to the cover type that is dominated by that species. Although individual trees may be found occasionally that exceed the maximum age, stands that still meet the density and cover for mature and old growth and exceed the maximum age are extremely rare.

A forest composed of a mixture of habitat structure stages that provide a continuous and even supply of habitat structure stages over time would have each habitat structure stage occupying a percentage of the landscape that is equal to percentage of the total life cycle represented by that habitat structure stage. This relationship can be represented by the following equation (Davis 1966, Davis and Johnson 1987):

% of Area in HSS = (years in HSS/oldest stand age) x 100

Although a particular landscape would rarely provide a continuous and even supply of habitat structure stages, the computation of values for a theoretical continuous and even supply of habitat structure stages provides a measure of central tendency (median) and allows for a comparison of an existing or proposed condition to be compared to the continuous even supply condition. Landscapes that supply habitat structure stages below or above the identified continuous, even supply levels may provide widely fluctuating amounts of habitat structure stages over time or may supply later habitat structure stages at lower levels than the potential if earlier habitat structure stages cycle back into HSS1 without completing development of all habitat structure stages.

To identify the percentage of the total life cycle represented by each habitat structure stage requires information about how stands grow and change in density and structure over time. A growth model, such as the Forest Vegetation Simulator (FVS) can be used to model stand growth from bare ground for even-aged stands that are represented by habitat structure stages (Stage 1997 and Stage *et al.* 1996). The results of the stand growth simulation can be used to identify the starting and ending points for each habitat structure stage as the stand grows through time based on the structural characteristics required by the HSS definitions (Hoover and Wills 1987, Mehl 1992).

An approach to quantifying the HRV of HSSs for the MBNF was developed that focused on Potential Natural Vegetation Structure (PNVS) within each cover type. The FVS stand growth model (Wycoff 1986, Wycoff *et al.* 1990 and Wycoff *et al.* 1982, Crookston 1985, Crookston 1990, Crookston and Stage 1999), Central Rockies Variant (Dixon 2001) were used to predict the growth of forest stands from bare ground and to quantify the stand characteristics of the different habitat structure stages. Based upon this modeling, residence times for each habitat structure stage were developed following the procedures developed by Stage (1997) and Stage *et al.* (1996).

Mehl's (1992) descriptions of maximum age of stands for each cover type were used as end points for forest stand development except where Mehl didn't describe a particular cover type. For these cover types (limber pine and gamble oak) information on maximum ages was taken from other sources (Wier 1998, Thorin 1999).

Successional Stage Progression Sensitivity Analysis.

Vegetation patterns across landscapes are the result of complex interactions between biotic and abiotic disturbances, processes and constraints. Vegetation can change due to a variety of factors such as human activity, fires, insects, pathogens, animals, weather, growth, and competition. It can be difficult to project the combined effects of these complex interactions over long periods of time. Averaging patterns in plant succession over a landscape allows for prediction of changes (Brown, Kaufmann et al. 1999), (Bormann and Likens 1979), (Urban 1994). The Vegetation Dynamics Development Tool (VDDT) was developed to model and track such averaged patterns in plant succession over time (Beukema and Kurz 1998), (Kurz 1999), (Hann, Keane et al. No date) (Keane, Long et al. 1996).

Using values for harvest, prescribed fire, wildfire and insect and diseases predicted in the DEIS for each alternative a sensitivity analysis was conducted to determine if changes in vegetation structure over time would create unsustainable conditions. Succession models covering ten to twenty decades were formulated for each cover type and each habitat structure stage each alternative. Successional pathways were modeled after Stahelin (Stahelin 1943) and Moir (Moir 1992). For each cover type, vegetation development followed a pathway based upon basic successional processes. Sucessional probabilities to move from one structural stage to the next were calculated from the residence times. The probability of natural and human disturbance events were calculated for each cover type and structure stage based upon their frequency on the landscape. Natural disturbances included wildland fire, insect and disease events. Management activities such as prescribed fire, and timber harvest changed the direction of vegetation development to reflect the outcome from such treatment. Based upon the probabilities determined, vegetation would develop along the basic successional pathway or it would be diverted along a disturbance pathway. The results of this sensitivity analysis are reported in Chapter 3 – Biological Diversity.

Landscape Pattern Analysis (FRAGSTATS)

Patches of late successional or old growth habitat, well distributed over the Forest to link to other late successional/old growth ecosystems (patches) within and adjacent to the forest, are necessary to ensure species dispersal and recruitment. Whether these patches occur in a size and shape such that the core area will provide habitat and ecological functions of interior forest (minimal edge effects) is part of the analysis for biological diversity.

The core area of each patch is determined by the occurrence of similar or dissimilar habitat structures at the edges. More dissimilar habitat structures create greater edge effect. The analysis of the core area of patches requires quantification of the edge effects of each structural element at the edge of each patch.

The FRAGSTATS model was developed to quantify spatial patterns across the landscape (McGarigal and Marks 1995). Existing spatial patterns including patch size and core size for 42 structural elements (habitat functional types --combination of cover type and habitat structure stage) were determined using FRAGSTATS. Edge effects were modeled following the procedures in Baker (Baker 1994) and Baker and Knight (Baker and Knight. 2000).

For each cover type, similar habitat structure stages (HSS) were grouped into habitat functional types (HFT). These grouping were made such that the any HSS within the group would not modify the ecological functions of any of the other HSS within the group and can be conceived of as a habitat functional type (HFT).

The following HFTs based upon groupings of cover types and HSSs have been defined as ecologically meaningful for the MBNF:

Grasses, forbs, rushes and sedges were grouped into HFT grass;

Non-vegetated lands excluding rock were grouped into HFT non-vegetation;

Rock stands as HFT rock;

All shrub cover types were grouped into HFT shrubs;

Limber pine and juniper were grouped into HFT for conifer woodlands;

Cottonwood and gambel oak were grouped into HFT of other hardwoods.

For each major forest cover type (lodgepole pine, ponderosa pine, spruce/fir and aspen): a series of habitat functional types would be

HSS 1 and 2 would be grouped into HFT early seral

HSS 3a would stand as HFT mid-seral low density.

HSS 3b and 3c would be grouped into HFT midseral med-high density

HSS 4a would stand as HFT late seral low density.

HSS 4b, 4c and 5 would be grouped into HFT late seral med-high density.

This grouping is similar that followed by other R2 forests in approaching this same question and following process documentation in Hessburg *et al.* (Hessburg, Smith et al. 2000).

For the MBNF there were a total of 42 HFTs including one for roads. Each edge created between HFT was given an edge effect value of 0, 30, 60 or 90 meters based upon the similarity of the two HFTs with those of greater dis-similarity receiving greater values.

Existing RIS polygons that form the GIS record and the database were designated based upon many features including administrative considerations that do not reflect the ecological function of the landscape. These polygon boundaries that do not reflect ecological functions were removed (dissolved) prior to quantifying landscape structure. In addition, the designation of RIS polygons does not reflect the ecological functions of roads across the landscape. Roads can create edges and edge effects similar to those created by dissimilar HFTs located adjacent to each other depending upon the width and use of the road.

To reflect the ecological function of the landscape two separate quantifications of the landscape will be completed:

1. Based upon the definition of HFTs, the RIS polygon boundaries was dissolved between polygons of HSSs as defined for each HFT (FRAGSTATS coverage without roads).
2. A road polygon coverage was created by buffering the road lines with a 30 m buffer (FRAGSTATS coverage with roads).

Each landscape representation was gridded (rasterized). Prior to quantification with FRAGSTATS, the road grid was combined a copy of the HFT grid. This replaced HFT values with road (non-vegetation values) where roads exists.

Quantification of each landscape representation was completed using FRAGSTATS. The results are displayed in Appendix D.

Using the FRAGSTATS GIS coverage, a frequency analysis of polygon size for the whole forest, with and without roads was conducted. Also, using the same GIS coverage, a frequency analysis for the four major cover types by mountain range was conducted.

Natural Processes Analysis (Acres of Wildfire, Insects and Diseases)

The following management areas have a desired future condition where human disturbances play a minimal role in changing composition and in which natural processes such as growth, fire, insects and diseases are the primary agents of compositional change.

The following table displays the management areas in which natural processes will be the primary agent of vegetation change to varying degrees:

Table B-51. Management areas with natural processes as the primary agent of change.

Management Area Emphasis	MA #
Wilderness Semi-primitive	1.13
Areas Recommended for Wilderness	1.2
Backcountry Recreation Non-motorized	1.31
Backcountry Recreation Non-motorized with Winter Limited Motorized	1.33
Core Areas	1.41
National River System -Wild Rivers Designated and Eligible	1.5
Special Interest Areas	2.1
Research Natural Area	2.2
Limited Use	3.21
Wildlife Corridors	3.24
Backcountry Recreation Year-round Motorized	3.31
Backcountry Recreation Nonmotorized with Winter Motorized	3.32
Backcountry Recreation Summer Motorized with Winter Nonmotorized	3.33
National River System - Scenic Rivers, Designated and Eligible	3.4
Forested Flora or Fauna Habitats Limited Management	3.5

Management Area Emphasis	MA #
Bighorn Sheep	3.51
Special Wildlife Areas, Limited Management	3.54
Aspen Maintenance and Enhancement	3.56
Late Successional Forests, Limited Management	3.57
Deer and Elk Winter Rangelands -- Limited Management	3.58

The alternatives allocate different amounts of the MBNF to the management areas where natural processes will be the primary agent of vegetation change. This allocation provides a context for the consideration of the change in composition of the MBNF as the alternatives are implemented.

These predictions are based on critical assumptions regarding the interactions of natural disturbance and management. Assumptions are outlined below.

Critical Assumptions:

1. Natural disturbance processes are most likely to occur in a similar amount and pattern to the recent historical period.
2. Natural disturbance patterns are reflective of existing conditions and levels of insect and disease activity and risk of increases based on forest conditions.
3. Climate patterns that would influence the occurrence of natural disturbance patterns are not likely to change suddenly or drastically in the implementation period for this plan (10-15 years). These climate patterns are not expected to produce conditions that exceed those described as part of the historic range of variability (Griggs 1938.), (Griggs 1946),(Kipfmueller and W. L. Baker 2000). Other climatic events that can create extreme conditions (such as the Hale magnetic cycles, El nino -southern oscillation or volcanic eruptions (Fye and M.K. Cleaveland 2001)) are unpredictable. Natural disturbances are unpredictable in the short term (10-15 years) because of the fluctuations from year to year. Therefore this analysis focuses on a longer period of 50 years. A wider variety of climate change is possible over longer periods. Other possible outcomes that deviate significantly from those presented this are also noted or described.
4. Active management is not expected to entirely prevent native disturbance processes. However, salvage activities permitted and/or encouraged in management areas with renewable resource management emphasis are likely to utilize most of the timber mortality from wildfires, insects and diseases. Although not required, this material has in the past substituted for live green volume with regards to the allowable sale quantity. It is likely that this pattern of substitution will prevail in the future. Since cumulative effects have been based upon the patterns of human uses and natural disturbance patterns, where natural disturbance processes occur in area where salvage harvesting would be expected, this has been shown as part of the predicted harvesting.

Process for Estimation of Acres Burned by Wildfire:

Based upon the HRV for wildfire (Dillon and Knight 2000), the allocation to Management Areas where natural processes will be the major agent of change and the relationship between stand-replacement and non-stand replacement wildfire for subalpine landscapes of YNP, the amount of land that will be affected by wildfire was estimated for the different alternatives.

Information about acres that might be burned by wildfire is needed to predict effects of those alternatives with a large amount of the forest in allocations that provide for wildfire, insects and diseases as the primary agents of vegetation change and to predict cumulative effects of management actions and natural processes on viability of plant and animal populations. The following process was developed by Kathy Roche, Forest Planning Ecologist, Dave Harris, Forest Planner and Lynn Jackson, Director of Planning.

Context Development:

The following information on the context of wildfire was provided by Dillon et al. (Dillon, Knight et al. 2003):

- Fire is thought to be the most significant natural disturbance agent.
- In certain cases, in high elevation forests, low intensity surface fires may occur.
- During each major fire period, a large percentage (7-26%) of the entire area burned, initiating extensive, relatively even-aged patches of forest.

Applied to the MBNF:

- Total acres in forest cover types: 866,531
- 7% of 866,531 = 60,657 acres
- 26% of 866,531 = 225,298 acres

MBNF fire history from von Ahlefelt and Speas(Von Ahlefeldt and Speas 1996) for 48 years indicates that 3% of MBNF forest cover acres (866,531) burned in those 48 years. This was mostly during a period of extensive fire suppression and low frequency of ignitions.

The following information on the context of wildfire was provided by Rothermel *et al.* (Rothermel, Hartford et al. 1994):

> For the 1988 fires in YNP and environs, the average % Canopy Burn (Stand Replacement) was 27% of the area within the fire perimeter. While non-stand replacement burn was 30% of the area within the fire perimeter.

This information from Rothermel et. al. (Rothermel, Hartford et al. 1994) is consistent with information from Dillon et al. (Dillon, Knight et al. 2003) and von Ahlefelt and Speas (Von Ahlefeldt and Speas 1996) for the MBNF.

Process Development:

The following is context on fire return intervals was provided by Dillon *et al.* (Dillon, Knight et al. 2003):

- In unmanaged forests (such as YNP), stand replacing fires may occur in the same stand, on average, every 200-400 years; and they may burn over a large portion (perhaps 5-25%) of the landscape approximately once each century.

Applied to the MBNF:

- 5% of 866,531 = 43,327 per 100 years (21,664 per 50 years)
- 25% of 866,531 = 216,632 per 100 years (108,316 per 50 years)

Midpoint of above

- 15% of 866,531 = 129,979 per 100 years (64,990 per 50 years)
- Rounded to 65,000 base acres to predict future wildfire extent from past occurrence.

The following is context on non-stand replacement fire is taken from Dillon *et al.* (Dillon, Knight et al. 2003):

- In certain cases, in high elevation forests, low intensity surface fires may occur.

Using data from Rothermel *et al.* (Rothermel, Hartford et al. 1994) approximately 16% of YNP burned in non-stand replacement fire in 1988.

There is more non-stand replacement fire in years with "ordinary" burning conditions. Of the 866, 394 acres forested acres for the MBNF, there are 118,573 acres (13%) that are not part of the subalpine landscape described here and more subject to non-stand replacement fire than the subalpine landscape.

So, then to adjust the number of Rothermel et al. (Rothermel, Hartford et al. 1994) to fit conditions expected to occur during the life of the plan (10-50 years), it was estimated that 325,000 (30% of the MBNF) was an appropriate base for acres for non-stand replacement fire.

For both stand replacement and non-stand replacement wildfire apply base acres to each alternative as a percentage of the forest where natural processes are the major agent of change.

Fires will occur in both areas where natural disturbance processes are the major agent of change and in areas where human disturbances are the major agent of change. In areas that are managed for renewable resources and have human disturbance processes as the major agent of change there will be more fire suppression and fires are generally expected to be suppressed at lower acreage.

Wildfire can follow insect and or disease attacks but can also damage trees and create conditions that lead to insect or disease mortality. Also, under certain conditions, there will be few acres in common where wildfire, insects and/or disease are the agents of change. Historic reports are vague about whether there were dual causes to the vegetation change. So, we made no attempt to quantify the acres in common.

Process for Estimation of Acres Affected by Insects and Diseases:

Information about acres that might be affected by insects and disease is needed to predict effects of those alternatives with a large amount of the forest in allocations that provide for wildfire, insects and diseases as the primary agents of vegetation change and to predict cumulative effects of management actions and natural processes on viability of plant and animal populations. The following process was developed by Kathy Roche, Forest Planning Ecologist, Dave Harris, Forest Planner and Lynn Jackson, Director of Planning.

Context Development:

The following information on the context of insects and diseases was provided by Dillon and Knight (Dillon and Knight 2000):

- Mortality caused by insects has probably been the second most important form of disturbance in high elevation forests as the spruce beetle and mountain pine beetle are capable of reaching epidemic population sizes in some spruce-fir and lodgepole pine forests.
- A MPB epidemic did affect a large number of ponderosa pine at low-elevations in the Laramie Peak area from 1988 to 1994.
- Measurements of epidemics are imprecise, making comparison of past, present and future epidemics difficult.

Process Development:

Total acres of high risk for the MBNF = 153,073 – rounded to 153,000 acres (use as base acres for insect and disease attacks). These numbers are from the insect risk rating procedures are applied to all acres by cover type. (The methodology for this analysis is displayed in Appendix B – Insect Risk Analysis.)

The following information on the context of insects was provided by Dillon et al. (Dillon, Knight et al. 2003):

- Lodgepole pine forests up to 9,500 feet are susceptible to only 25-50% mortality, while those above 9,500 feet are susceptible to less than 25% mortality.

So that a portion of the mortality is likely to be stand replacement (groups of mortality greater than 5 acres) and a smaller portion is likely to be non-stand replacement.

Based upon the above observations:

- Use 60% of base acres for stand-replacement insect and disease attacks.
- Use 40% of base acres for non stand-replacement insect and disease attacks.

Apply base acres to each alternative as a percentage of the forest in management areas where natural processes are the major agent of vegetation change.

Wildfire can follow insect and or disease attacks but can also damage trees and create conditions that lead to insect or disease mortality. Also, under certain conditions, there will be few acres in common where wildfire, insects and/or disease are the agents of change. Historic reports are vague about whether there were dual causes to the vegetation change. So, we made no attempt to quantify the acres in common.

Process for Comparison to Yellowstone

To evaluate current ecological conditions, the ecosystems of the MBNF can be compared to the ecosystem of Yellowstone National Park (YNP) where a substantial body of fire-related research findings is available. Fire and disturbance history information for the MBNF is limited. The information that is available on historical conditions on the MBNF is summarized in Dillon *et al.* (Dillon, Knight et al. 2003), Von Ahlefelt and Speas (Von Ahlefeldt and Speas 1996) Crane (Crane 1982), Brown *et al.* (Brown, Kaufmann et al. 1999) Brown *et al*. (Brown, Ryan et al. 2000), Brown and Shepperd (Brown, Reinhardt et al. 2001) Goldblum and Veblen (Goldblum and Veblen 1992), Honaker (Honaker 1995), Kipfmueller (Kipfmueller 1997), (Kipfmueller and W. L. Baker 2000), Kipfmueller and Baker (Kipfmueller and W.L. Baker 1998a) and (Kipfmueller and W.L. Baker 1998b), Baker and Kipfmueller (Baker and K. F. Kipfmueller 2001), Baker and Ehle (Baker and D. Ehle 2001), Romme (Romme 1977), Romme and Knight (Romme and Knight 1981), Veblen and Lorenz (Veblen and Lorenz 1991), Veblen *et al.* (Veblen, Kitzberger et al. 2000), Veblen *et al*. (Veblen, K. S. Hadley et al. 1994.), Knight (Knight 1987) and (Knight 1994).

Romme (Romme 2002) reconstructed the range of natural variability in subalpine landscape structure that existed before 1900 in the Bighorn Mountains of north-central Wyoming. There is a lack of fire history information for the Bighorn Mountains, so there was a need for a proxy landscape and reference period. A benchmark or reference period of ecological integrity provides useful ecological information to compare with the present (Leopold 1966). Romme's (Romme 2002) approach was to extrapolate from the subalpine landscape of Yellowstone National Park (YNP), where conditions are generally similar to the Bighorn Mountains and from where a substantial body of fire-related research findings is available. For most of the Rocky Mountain region, the several hundred years just prior to the arrival of European settlers in the mid to late nineteenth century provides such a benchmark (Romme 2002). So, using the same approach as Romme (Romme 2002), the MBNF can be compared to YNP. The subalpine forests of YNP and the MBNF have similarities in elevation, climate, topography, soils, most important disturbance agent, fire regime and cover types. YNP is located within the southern part of the Northern Rockies Ecoregion while MBNF is located within the northern portion of the Southern Rockies Ecoregion.

Table B-52. Similarity between YNP and MBNF subalpine forest ecosystems.

Ecological Element	YNP	MBNF
Ecoregion TNC Bailey WWF	Utah-Wymong Rockies M331 NA0528	Southern Rockies M331 NA0511
Elevation	2,100 – 3,000 m (6,900 – 9,800 feet) (Romme 2002)	1540-3660 m (5,046 – 12,013 feet)(MBNF GIS
Climate*	Cold snowy winters, short summers, precipitation peak in late winter, early summer with low precipitation in late summer. (Romme 2002)	Cold snowy winters, short summers, precipitation peak in late winter, early summer with low precipitation in late summer. (Dillon, Knight et al. 2003)
Topography	Plateaus of low slope cut by canyons (Rignot, Despain et al. 1999)	Plateaus of low slope cut by canyons, except steep slopes in the Laramie Peak Range (Von Ahlefeldt and Speas 1996)
Soils	Rhyolite and tuff (Romme 2002)	Volcanic, granitic, sedimentary with some glaciation (Von Ahlefeldt and Speas 1996)
Most Important Disturbance Agent+	Fire (Romme 2002)	Fire (Dillon, Knight et al. 2003)
Fire Regime	Predominantly Stand Replacement (Romme 1980), (Romme 1982), (Romme and Despain 1989)	Predominantly Stand Replacement (Dillon, Knight et al. 2003)
Cover Types	Lodgepole, Aspen, Spruce-Fir (Total of 80%) (Rignot, Despain et al. 1999), (Turner, Romme et al. 1997)	Lodgepole, Aspen, Spruce-Fir (Total of 86%) (MBNF RIS)

Many types of natural disturbances influenced landscape structure and dynamics, but the most important disturbance for YNP appears to have been fire (Romme 2002), Romme and Despain 1989, Meyer and Knight 2001}. Similarly for the MBNF, the most important disturbance appears to have been fire (Dillon, Knight et al. 2003), (Veblen, Kitzberger et al. 2000).

A fire regime is the characteristic frequency, extent, intensity, severity, and seasonality of fires in an ecosystem (FEMAT (Forest Ecosystem Management Assessment Team) 1993). A fire regime consists of ranges and sizes of fires, the patterns the fires form on the landscape, how frequently the fires occur and what type of fire occurs (how the fire interacts with the vegetation *e.g* stand replacement). Natural, historical fire return intervals in Yellowstone are 300 years or more for lodgepole pine forests on the central plateau and subalpine whitebark pine stands (Romme 1980)and (Romme 1982), (Romme and Despain 1989). Dillon *et al.* (Dillon, Knight et al. 2003) document long fire return interval stand replacement fire to be the dominant stand replacement mechanism for subalpine forests of the MBNF.

Thus, the YNP system seems a reasonable surrogate for portions of the MBNF system. In particular, the nearly continuous lodgepole pine forests of the central, southern, and western portions of YNP (Romme and Despain's study area – (Romme and Despain 1989)) appear generally comparable to the nearly continuous lodgepole pine and spruce-fir forests in the Sierra Madre and Snowy Range of the MBNF. However, Romme and Despain's (Romme and Despain 1989) study area probably is not as applicable to the forests in the Laramie Peak and Pole Mountain areas where the forest cover types are less dominantly lodgepole or spruce-fir and where the forest stands are not as continuous.

The empirical data sets that Romme (Romme 2002) used for reconstructing the range of natural variability in subalpine landscapes of the Bighorn National Forest are Romme and Despain's (Romme and Despain 1989) reconstruction of fire history and landscape structure in Yellowstone National Park, and Renkin and Despain's (Renkin and D. G. Despain 1992)analysis of fires in YNP that were allowed to burn without interference from 1972 – 1987. These represent "ordinary" climatic conditions. Romme (Romme 2002) describes "ordinary" climatic conditions as those that prevail most of the time:

> "In YNP, "ordinary" conditions would apply to all of the twentieth century, except 1988 which was an extreme year. Even if no fire suppression occurred, *most fires would remain small (< 100 ha)* because of wet weather conditions throughout most fire seasons (Renkin and D. G. Despain 1992). However, *moderate to large sized fires (> 100 ha) would be expected in 2 – 4 years out of every decade.* This estimate is based on the observed occurrence of 5 fires of this size during the 15-year period from 1972 – 1987 in YNP when no fire suppression actions were taken (Meyer and D. H. Knight 2001). In addition, *moderately severe fire seasons (> 500 ha burned / 100,000 ha forest) would occur once every 2 – 3 decades.* This estimate is based on the observed occurrence of 3 fires of this size from 1900 – 1970 in YNP (Meyer and D. H. Knight 2001). A large landscape (e.g., 100,000 ha) may exist in a quasi-equilibrium state under this "ordinary" fire regime (Turner, W.H. Romme et al. 1993), i.e., proportions of each successional stage will vary within a relatively limited range as indicated in the table. However, such an equilibrium is unlikely to characterize the landscape over long periods of time, because of rare "extreme" fire events."

This analysis for MBNF also uses Rothermel *et al.* (Rothermel, Hartford et al. 1994) analysis of fire growth for the 1988 Yellowstone fires and local data sets. This data set would represent "extreme" fire events. Romme (Romme 2002) describes "extreme" fire events:

"Extreme" fire events are exemplified by the 1988 Yellowstone fires, and also by the extensive fires that occurred in YNP in the early 1700s. Such conditions may occur only once or twice in every century or two. These fires, though infrequent, will create long-lasting legacies in landscape structure by burning as much as 25 – 50 % of the landscape area, and will likely cause even large landscapes (e.g., 100,000 ha) to function over long time periods as non-equilibrium systems (Johnson, Wiens et al. 1992), Turner *et al.* 1993}. It should be emphasized that extreme fire events like the 1988 Yellowstone fires are *not* "unnatural" or "abnormal" for subalpine ecosystems like those in YNP or the Bighorns. They are natural and normal, but occur at such long intervals that they may appear extraordinary when viewed within a limited time scale (Romme and Despain 1989)."

Data from Rothermel *et al.* (Rothermel, Hartford et al. 1994) is summarized in the following table.

Table B-53. Yellowstone fires, 1988.

Fire	Fan	North Fork	Clover-Mist	Hell-roaring	Storm Creek	Mink	Snake	Huck	Total*
Total Acres	27,346	531,182	396,268	101,996	143,661	144,698	222,871	120,387	1,688409
Acres Canopy Burn	4,372	190,526	99,655	18,826	38,033	24,610	57,192	29,106	462,321
% Canopy burn	16.0%	35.9%	25.1%	18.5%	26.5%	17.0%	25.7%	24.2%	27.4%
Acres Other than canopy burn	7,018	172,707	105,502	26,628	35,482	41,294	79,277	37,930	505,837
% Other than canopy burn	25.7%	32.5%	26.6%	26.1%	24.7%	28.5%	35.6%	31.5%	30.0%

*Source:from Rothermel et al (Rothermel, Hartford et al. 1994). *Total percent uses weighted average.*

Romme (Romme 2002) identifies that the 1988 fires in YNP occurred during "extreme" conditions. These fires burned over 1,688,409 acres (683,305 ha). 506,522 acres (31%) of that area was outside YNP boundaries, leaving about 1,165,665 acres within YNP. This is the equivalent of 53% of YNP's 2,200,000 acres. Total estimated canopy burn (stand-replacement) acres from Rothermel *et al.* (Rothermel, Hartford et al. 1994) is 462,321 acres, with about 69% within YNP (320,414 acres). Thus canopy burn (stand-replacement fire) occurred on about 15% of YNP's 2,200,000 acres in 1988 and non-stand replacement fire occurred on about 16% of YNP's total acres. Romme (Romme 2002) identifies that the 1988 fires in YNP occurred during "extreme" conditions.

Over time, for YNP, the cumulative acres burned in "ordinary years" approaches that of "extreme" events (Romme 1982).

Turner *et al.* (Turner, Romme et al. 1997) and Turner *et al.* (Turner, Romme et al. 1994) document large patches of about 9,000 acres (3600 ha) that were created by the Yellowstone Fires of 1988.

Extensive fires that created large areas of more or less even-aged lodgepole forest may be within the historic range of variability for drier portions of the Snowy Range and Sierra Madre mountains (Dillon, Knight et al. 2003). Fire records, for the MBNF from 1945 –1993 summarized by Von Ahlfeldt and Speas (Von Ahlefeldt and Speas 1996), indicate that 1.6% (possibly as much as 3% of the forest cover type acres) of the Snowy Range and Sierra Madre was burned by wildfires. Two hypotheses for the low incidence are effective fire suppression and absence of drought within the 50-year period (Dillon, Knight et al. 2003). During 1988, a drought year on the MBNF, similar to YNP, 43 fires were ignited on the forest. All were extinguished before they burned more than a few acres. From the Fire and Fuels Analysis, the probability of smaller fire events is greater and would be expected to create composition changes in a large number of small patches whereas the probability of large events is small but would result in composition changes in a fewer number of large patches across the landscape.

Process for Development of Potential Natural Vegetation Coverage:

The PNV coverage was created using soils, existing vegetation and plant association.

1. Where plant association was available, it was used to derive PNV. This data only exists where on the ground surveys have been done and was considered to be the most accurate representation of PNV. The plant association codes where evaluated by Kathy Roche, Ecologist, against the following publication to assign a PNV code: Forest Vegetation on National Forests in the Rocky Mountain and Intermountain Regions: Habitat Types and Community Types. General Technical Report RM-162, Robert R. Alexander, July 1988.
2. Where no plant association data as available, the soils where used to derive PNV. (see notes below)
3. Where PNV from soils was equal to grass, no plant association existed and photo interpreted existing vegetation equaled a tree species, that tree species was used for PNV (except for Laramie Peak, where the soils data was thought to be more accurate with regards to non forested sites, as the photo interpreted existing vegetation polygons did not always break out grass inclusions).

4. Where PNV from soils was equal to Aspen, no plant association existed and the photo interpreted existing vegetation was equal to Lodgepole, Spruce/Fir or Douglas Fir, those species where used as the PNV.

PNV was derived from soils as follows:

Using Soil Layer for developing PNV, 5/30/02, Tommy John, Soil Scientist made a call on PNV based on information listed for the different soil mapping units. If a soil mapping unit had more than one PNV, then the main one (in term of percent of acreage) was used.

Sierra Madre and Snowy Range Area:

- Spruce Fir: #11, 12, 13, 14, 17, 18, 19, 20, 26, 27, 28, 29, 31, 32, 33, 34, 42, 43, 44, 46, 47, 62, 63, 64, 76, 80, 81, 82, 104, 105, 106, 107, 108, 109, 110, 111, 112, 114, 115.
- Lodgepole Pine: #15, 16, 24, 25, 30, 41, 66, 67, 68.
- Rangeland: 21, 22, 23, 35, 36, 37, 38, 39, 40, 487, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 65, 69, 75, 77, 78, 79, 86, 87, 93, 94, 95, 96, 97.
- Aspen: 70, 71, 72, 73, 74, 83, 84, 98, 99.
- Riparian: 85, 89, 92.
- Spruce Fir – Krummholz: 45,100,101,102,103,113.

Laramie Peak Area:

- Rangeland: 128, 227CK, 237BK, 290A, 560A, 702B.
- Ponderosa Pine: 228BK, 239B, 240BK, 240CK, 291BK, 291CK, 292BK.
- Spruce Fir: 535A, 712B, 712BK, 712CK.
- Riparian: 701A.
- Limber Pine: 707BK, 709CK

Pole Mountain Area:

- Rangeland: 104,105, 406, 410, 412, 436, 504, 507, 602, 603, 610, 611.
- Rangeland/Scattered Pine:1L3, 1M3, 505, 506, 601.
- Ponderosa Pine: 613.

Cover type codes were used to represent the PNV as follows:

Aspen = TAA

Limber Pine = TLI

Lodgepole Pine = TLP

Ponderosa Pine = TPP

Rangeland = GRA

Rangeland/Scattered Pine = GRA

Riparian = GRA

Spruce/Fir = TSF

Spruce/Fir – Krummholz = SKR

Amount of the MBNF within a specified distance of Level 2, 3, 4, and 5 Roads.

The analysis of the amount of the MBNF within a specified distance of level 2, 3, 4, and 5 roads used the MBNF GIS coverage for level 2, 3, 4, and 5 roads. Each road was buffered (on each side) by the specified distance. The amount of NFS system land within the buffer and outside of the buffer was computed with the ARC-view GIS system. The buffers distances were selected to provide comparison to the results for these buffer distances reported in the State of the Southern Rockies Ecoregion (Shinneman, McClellan et al. 2000).

Insect and Disease Existing Occurrence Analysis

Existing occurrence and trend information are valuable for assessing the potential impacts of changes in insect and disease levels . The information regarding the incidence of insects and diseases over the last 5 years was developed from aerial surveys completed by Forest Health Management Staff.

Insect Risk Analysis

There were two sources for insect risk analysis. The bug-risk field of the RMRIS database and the insect risk evaluation based on hazard rating procedures.

Insect Risk Analysis from RMRIS Using Bug Risk

The Bug Risk field is the numeric beetle risk rating for each stand based upon forest cover type. The valid values cover the following range: 0 –not computed; 1-low, 2-medium low, 3-medium; 4-medium high; and 5 high.

The information in the bug-risk field is calculated from stand exams based upon Research Note RM 393 (Logan, Schmid et al. 1980) for Spruce-fir. For ponderosa pine, the estimate is based on Research Note RM 385 (Stevens, McCambridge et al. 1980). For lodgepole pine, the estimate is based on INT-36 (Amman, McGregor et al. 1977).

This information was only available for stands where a stand examination (inventory) has been completed.

Insect Risk Analysis Using Hazard Rating Procedures:

Introduction: This section describes the analyses that were conducted in association with the evaluation of insect risk.

Explanation of Codes for the GIS product titled "Medbow/Routt –TSF, TLP HAZ

The GIS product was produced by Jim Caulkins and Steve Williams. The Coding explanation was prepared by Kathy Roche.

Only the Medicine Bow National Forest is shown on this GIS product (map). Codes for the Medicine Bow National Forest are shown below.

The following table has an explanation of the codes for the Insect Hazard Maps for lodgepole pine, ponderosa pine and spruce/fir cover types.

Table B-54. Explanation of cover type codes.

Code	Explanation
TSF	Spruce/fir cover type (land with tree cover and Engelmann Spruce and Subalpine Fir the predominant species)
TLP	Lodgepole pine cover type (land with tree cover and lodgepole pine the predominant species)
TPP	Ponderosa pine cover type (land with tree cover and ponderosa pine the predominant species)

Table B-55. Explanation of the risk rating system as applied to lodgepole pine.

Map Code	Literature Rating Description	GIS Methodology
TLP Haz (Amman, McGregor et al. 1977)	Hazard rating for mountain pine beetle for timber stands with lodgepole cover type	See GIS Methodology table below.
High	High risk for mountain pine beetle attack and an expectation of greater than 50% mortality based upon the following risk factors: • See high risk on latitude/elevation chart below; • Greater than 80 years old; • Greater than 8 inches average dbh.	
Medium	Medium risk for mountain pine beetle attack and an expectation of 25% - 50% mortality based upon the following risk factors: • See medium risk on latitude/elevation chart below; • 60-80 years old; • 7-8 inches average dbh.	
Low	Low risk for mountain pine beetle attack and an expectation of less than 25% mortality based upon the following risk factors: • See low risk on latitude/elevation chart below; • Less than 60 years old; • Less than 7 inches average dbh.	

Table B-56. Calculations of latitude and elevation risk factors for insect risk in lodgepole pine.

Latitude/Elevation Risk Factor calculations for Lodgepole Pine								
Latitude			**Elevation**					
Degrees	Minutes		Low Risk	Medium Risk				High Risk
40	52.5	>	9700	8651	to	9700	<	8650
41	0	>	9650	8601	to	9650	<	8600
41	7.5	>	9600	8551	to	9600	<	8550
41	15	>	9550	8501	to	9550	<	8500
41	22.5	>	9500	8451	to	9500	<	8450
41	30	>	9450	8401	to	9450	<	8400
41	37.5	>	9400	8351	to	9400	<	8350
41	45	>	9350	8301	to	9350	<	8300
41	52.5	>	9300	8251	to	9300	<	8250
42	0	>	9250	8201	to	9250	<	8200
42	7.5	>	9200	8151	to	9200	<	8150
42	15	>	9150	8101	to	9150	<	8100
42	22.5	>	9100	8051	to	9100	<	8050
42	30	>	9050	8001	to	9050	<	8000
42	37.5	>	9000	7951	to	9000	<	7950
42	45	>	8950	7901	to	8950	<	7900
42	52.5	>	8900	7851	to	8900	<	7850
43	0	>	8850	7801	to	8850	<	7800

Table B-57. Explanation of the Risk Rating GIS methodology as applied to Lodgepole pine.

Risk Factor	**Low = Mult Factor 1**	**Medium = Mult Factor 2**	**High = Mult Factor 3**
MedBow TLP Haz(Amman, McGregor et al. 1977)			
Latitude and Elevation	Use latitude/elevation chart above	Use latitude/elevation chart above	Use latitude/elevation chart above
Tree Diameter where available and HSS where age is not available	Tree size E and S where available and HSS 1 and 2 for the rest	Tree size M where available and HSS 3 for the rest	Tree Size L and V where available and HSS 4 and 5 for the

Risk Factor	**Low = Mult Factor 1**	**Medium = Mult Factor 2**	**High = Mult Factor 3**
			rest
Age as represented by HSS	Use age < 60 where available and HSS 1 and 2 for the rest	Use age 60-80 and HSS 3a and 3b	Use age >80 where available and HSS 3c, 4a, 4b, 4c and 5
Overall Score from multiplying risk factors above	1-9	12-18	27
GIS Map/spreadsheet Summary Code	1	3	5

Table B-58. Explanation of the risk rating GIS methodology as applied to ponderosa pine.

Risk Factor	Low = Mult Factor 1	Medium = Mult Factor 2	High = Mult Factor 3
MedBow TPP Haz (Stevens, McCambridge et al. 1980)			
Stand Structure where available	Stand structure code 5	Two stories stand structure code of 2 or 3	Single Story = stand structure code = 1
Tree Diameter where available and HSS where age is not available	Tree size S where available and HSS 1 and 2 for the rest	Tree size M where available and HSS 3 for the rest	Tree Size L and V where available and HSS 4 and 5 for the rest
Basal Area	<80 where basal area available and HSS 1,2, 3a or 4a for the rest	80-150 where basal area available and HSS 3b or 4b for the rest	>80 where basal area available and HSS 3c, 4c or 5 for the rest
Overall Score from multiplying risk factors above	2-6 (<6??)	8-12 (7-17??)	18-27 (= or >18??)

Table B-59. Explanation of the Risk Rating GIS methodology as applied to Spruce/fir.

Map Code	Literature Rating Description	GIS Methodology
MedBow TSF Haz (Schmid and Frye 1976)	Hazard rating for spruce beetle for timber stands with spruce/fir cover type	
Very High		Cover_type TSF and tree_size (t_s) V with ccp > 40 = TSF haz 4.
High	High risk for spruce beetle attack based upon the following risk factors: • Well drained sites in creek bottoms; • Greater than 16 inches dbh; • Greater than 150 square feet of basal area in the stand; • Greater than 65% spruce in the canopy.	Cover_type TSF and t_s L = TSF haz 3, t_s V with ccp <= 40 = TSF haz 3
Mod	Moderate risk for spruce beetle attack based upon the following risk factors: • Site index of 80-120; • 12 - 16 inches dbh; • 100 - 150 square feet of basal area in the stand; • 50 - 65% spruce in the canopy.	Cover_type TSF and t_s S with ccp > 60 = TSF haz 2, t_s M = TSF haz 2,
Low	Low risk for spruce beetle attack based upon the following risk factors: • Site index of 40-80; • Less than 12 inches dbh; • Less than 100 square feet of basal area in the stand; • Less than 50% spruce in the canopy.	Cover_type TSF and (t_s) E = TSF haz 1; t_s S with crown_cover_pc <= 60 = TSF haz 1
Very Low	Very low risk for spruce beetle attack	Cover_type TSF and t_s N = TSF hazard 0

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