LANDSCAPE ECOLOGY STARS REPORT

CHAPTER 5

The Development of Key Broadscale Layers and Characterization Files

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INTRODUCTION

Several broadscale layers were created to map current and historical ecological conditions and ecological processes across the Interior Columbia River Basin (ICRB). They were developed to meet the criteria of the Interior Columbia Basin Ecosystem Management Project (ICBEMP) as described by Keane (1996), which required that (1) each layer be mapped continuously across the ICRB, (2) each layer be developed with the same methodology, and (3) the layers be available for analysis for Spring 1995. This chapter will focus on the development of several key layers and characterization files for the ICBEMP.

Overview

In this Chapter, a layer is a logical set of data that classify a unique theme within in a given raster map or vector map. A raster map is a grid of square cells arranged in a pattern of rows and columns that delineates related pieces of ground. Each cell, called a pixel, is assigned an identifying character based on the theme of the layer. Vector maps represent a geographic feature using the coordinates of points, lines and polygons. Maps are graphic representations of the physical features of part of the earth's surface (Montgomery and Schuch 1993). Broadscale layers represent large pieces of ground that depict themes, such as soils, cover types, and roads. They were delineated for the ICBEMP in both raster and vector maps at a coarse scale of one square kilometer (km^2) pixel and a map scale resolution of approximate 1:1,000,000. All layers were integrated into the Geographic Information

System (GIS) using ARCINFO (ESRI ???) and GRASS software (USA CERL 1990).

The ICBEMP broadscale layers are described by two groups: ecological condition and ecological process. Ecological condition (or state) simply describes the structural or compositional characteristics of the ICRB landscape (Keane and others 1996a). Layers described in this chapter characterize distributions of current and historical cover type and road density. Ecological process maps describe the major processes that affect the condition of an ecosystem (Keane and others 1996a). Processes layers described in this chapter include geomorphology, potential vegetation, structural stage, and fire.

The ICBEMP layers were mapped continuously (or wall-to-wall) to include all land types and ownerships within the ICRB or assessment area. The ICRB boundary covers approximately 820,000 km^2 in eight states, and extends beyond the Columbia River basin watershed (Appendix G) to map complete ecosystems and their associated issues. For example, the Columbia River basin watershed divides the Greater Yellowstone Ecosystem. To adequately address issues relating to wolves or grizzly bears in this area, the complete ecosystem was included in the ICRB. This extended boundary was based on the Section layer, delineated by Nesser and Ford (1996) as part of the Ecological Mapping Unit (ECOMAP 1993) effort, and will be described in the BASE LAYER section. The ICBEMP includes two Environmental Impact Statement (EIS) analysis areas mapped within the ICRB (Gravenmier and others 1996) and was used to develop the draft ICBEMP EIS report (Appendix G).

Each broadscale layer was mapped with approximately the same methodology, for consistency in the evaluation of trends across the landscape. It is difficult to contrast trends across management areas when maps are not created with the same procedures. For example, if several National Forests mapped whitebark pine cover type in the Northern Rockies using different methods (such as satellite imagery, photo interpretation, field mapping), it would be difficult to detect the geographic decline of whitebark pine by ecological processes like succession and whitebark pine blister rust. Field mapping could show greater decline in whitebark pine then satellite imagery or photo interpretation, giving the impression that the decline is localized to a National Forest, when in fact the decline might be distributed across a larger area. By mapping the geographic area with the same methodology, any observed trends in the decline of whitebark pine are based on that observation. Such would not be the case if a National Forest mapped their whitebark pine differently.

All broadscale layers had to be developed within a very short time period (Spring 1995), making it logistically difficult to collect new field data to meet the requirements of continuous wall-to-wall coverage and development with the same methodology. Instead, broadscale layers were developed from existing layers and databases, opinions of expert panels collected through a series of workshops, and from computer models. Because of the limited time frame, many layers were developed in parallel, which forced certain developers to use early versions of other broadscale layers that were ultimately inferior to the final versions.

This chapter documents the methods used in developing key broadscale spatial layers and characterization files in five sections. The first section, BASE LAYERS, briefly defines important existing spatial layers used in the development of broadscale layers. The second section, CRBSUM LAYERS, describes the creation of the vegetation layers needed to run the Columbia River Basin SUccessional Model (CRBSUM). The third section, ROAD DENSITY LAYER, discusses the methods used in delineating the total length of roads within 1 kilometer (km^2) pixels. The fourth section, FIRE LAYERS, briefly describes the development of three layers that characterize wildland fire in the ICRB. The final section, CHARACTERIZATION FILES, reviews the methods used in creating a database that summarizes several broadscale layers to the sub-watershed.

BASE LAYERS

ICBEMP base layers represent both elements that affect vegetation on the landscape and actual vegetation mapping. The developers of base layers included Forest Service scientists and staff, and the following ICBEMP cooperators: The Nature Conservancy, University of Montana, University of Idaho, and several independent researchers. The following is a general discussion on the creation of key base layers used in developing broadscale layers and databases described in this chapter.

Provinces and Sections

The Forest Service's National Hierarchical Framework of Ecological Units, stratifies the Earth into progressively smaller units of similar ecological potentials based on biotic and environmental factors (ECOMAP 1993). Provinces (often called Ecoregions) broadly delineate ecological climatic zones and vegetational macrofeatures, while the nested Sections delimit broad land surface forms and climax plant series (Bailey 1983, 1995). Both ICBEMP's Province and Section vector layers were created from the aggregation of Subsections developed by Nesser and Ford (1996), and differ slightly from the Ecological Subregions defined by McNab and Avers (1994) because Subsections were mapped at a finer scale. Subsections were mapped for the ICRB, at a scale of 1:500,000, during a series of workshops attended by soil scientists and ecologists (Nesser and Ford 1996).

Regional Biophysical Settings

In cooperation with ICBEMP, The Nature Conservancy developed two layers that delineate temperature and moisture gradients by three broad lifeforms: Forest, Shrub, and Herb (Reid and others 1995). A 4 x 4 matrix was created for each lifeform, where each cell in the matrix was assigned a temperature/moisture gradient category (Figure 1). The rows in the matrix identify a temperature gradient from cold to hot, while the columns identify a moisture gradient from wet to very dry. Each cell in the matrix was assigned a group of climax plant communities (defined by habitat types and plant associations) that matched the temperature/moisture gradient of that cell (Reid and others 1995).

The Section Biophysical Settings raster layer consists of a set of matrices for each of the 24 Sections in the ICRB (72 matrices), and was mapped by Subsection (Nesser and Ford 1996) using a heuristic model of elevation, aspect, and slope classes. Each model was developed by local area ecologists and spatially mapped using a GIS at one km^2 pixel size (Reid and others 1995). The Regional Biophysical Setting raster layer was developed by the aggregation of the Section Biophysical Settings layer into one set of matrices (one for each lifeform) for the ICRB (Reid and others 1995).

Current Cover Types

Hardy and others (1996) classified existing vegetation composition (circa 1990) into broad vegetative cover types by modifying a satellite imagery map of vegetation. The EROS Data Center created the Land Cover Characterization (LCC) map, an existing vegetation map derived from satellite imagery, for the entire United States (Loveland and others 1991, Eidenshink 1992). Area ecologists refined and modified the LCC map into broad vegetative cover types through a series of workshops for the ICRB. Most forest cover types are defined by the Society of American Foresters (Eyre 1980) and the range cover types are defined by the Society of Range Management (Shiflet 1994). Hardy and others (1996) reduced the 158 cover type categories in the LCC map to 48 cover types specific to the ICRB.

Historical Cover Types

Losensky (1994) mapped vegetation existing at the turn of the century (circa 1900) by broad cover type classes at 1:1,000,000 map scale. The layer was compiled from varying map scales of archived maps and historical records published around the turn of the century and as late as the 1930's. Since some data sources were from as recent as the 1930's, there was a certain amount of backdating required in standardizing this layer to the same target year. A tabular report of structural stages by cover type and Section was also compiled, and used in developing the historical structural stage layer.

CRBSUM VEGETATION LAYERS

Several broadscale vegetation layers were specifically created from the base layers to serve as input layers into the Columbia River Basin Successional Model (CRBSUM) developed by Keane and others (1996b). CRBSUM simulates broadscale landscape changes as a consequence of various land management policies (Keane and others 1996b). Two sets each of potential vegetation type, cover type, and structural stage layers were developed for both historical and current CRBSUM runs (Keane and others 1996b). A potential vegetation type is a unique and stable climax plant community created by grouping similar habitat types and plant associations (Keane and others 1996b, Pfister and others 1977). Cover types are similar to the cover types used by Hardy and Others (1996) that were described in the BASE LAYER section. A structural stage represents the developmental changes in a plant community's vertical structure (Oliver and Larson 1990, Keane and others 1996b). A list of potential vegetation types, cover types, and structural stages are presented in appendix A, B, and C, respectively.

Base layers were modified to meet the requirements of CRBSUM. The Regional Biophysical Setting layer was used to create CRBSUM Potential Vegetation Types (PVT) layer. The Current Cover Types base layer was used to create CRBSUM

Current Cover Types (CT) layer, and the Historical Cover Types layer base was used to create CRBSUM Historical CT layer. CRBSUM Current Structural Stages (SS) was created from a discriminant analysis and CRBSUM Historical SS was created from a stochastic model.

CRBSUM Requirements

Information mapped by CRBSUM vegetation layers was constrained by the successional pathways used by CRBSUM (Keane and others 1996b, Long and others 1996). When PVT, CT, and SS layers are overlaid on top of each other, the unique combinations of values for a specific pixel need to match the combinations found in the successional pathways. This spatial matching of different layers will be called spatial agreement. For example, a pixel having a Dry Douglas-fir potential vegetation type in the PVT layer might have Subalpine Fir cover type in the CT layer and Stem Exclusion Single Strata structural stage in the SS layer. Since the Dry Douglas-fir potential vegetation type successional pathway does not contain the Subalpine Fir cover type, either the PVT or CT layer would have to be modified. The modification could be to switch the PVT layer to Dry Spruce-Fir potential vegetation type, or the CT layer to Douglas-fir cover type. Another example for structural stage, is that a Stem Exclusion Open Canopy structural stage can only occur in dry PVT, and a Stem Exclusion Closed Canopy structural stage can only occur in moist PVT. Methodology used in development of the base layers and the relationship of vegetation types between the base layers, formed the basis of all modifications from the base layers to the CRBSUM layers.

Limitations And Spatial Agreement

The methods used in developing the Regional Biophysical Setting layer had a few limitations in the assignment of the lifeforms. The temperature/moisture matrix for each lifeform was selected based on the combination of elevation, aspect, and slope classes, for a given geographic area (Reid and others 1995). Occasionally, these combinations would delineate large areas with two lifeforms almost equally represented in that area. The lifeform that occupied the greatest area was always selected, and the other lifeform was not mapped. For example, in the Lamar Valley of Yellowstone National Park, both forest and herbaceous lifeforms occur in the same pixels for given elevation, aspect, and slope classes. Since the forest lifeform is slightly more dominant then the herbaceous lifeform, the forest lifeform was selected and the herbaceous lifeform was not mapped in the Lamar Valley.

The Current Cover Type base layer was developed by modification of the LCC map created from satellite imagery (Hardy and others 1996). One limitation of mapping with satellite imagery data is the occasional difficulty in distinguishing between cover types with similar spectral signatures (or similar reflectance). For instance, both ponderosa pine and whitebark pine cover types could be classified as one cover type, because they have similar spectral signatures.

The limitations of both the Regional Biophysical Setting layer and the Current Cover Type layer were resolved when overlaying the layers. Overlaid is a common GIS method of comparing layers by cross referencing pixels in the same geographic location, studying their interaction, and potentially generating a new layer. The Current Cover Type base layer was used to distinguish between lifeforms that were lost in the Regional Biophysical Setting layer because of the broad elevation, aspect, and slope classes. For example, in the Lamar Valley example described above, forest and herbaceous lifeforms could be delineated based on cover types found in the Current Cover Type base layer. The Regional Biophysical Setting layer was used to separate cover types with similar spectral signatures. For example, ponderosa pine and whitebark pine cover types were separated because they occur in different temperature/moisture gradient classes found in the Regional Biophysical Setting layer.

Potential Vegetation and Cover Type Layers

A draft CRBSUM PVT layer and CRBSUM Current CT layer were created by overlaying the Province, Regional Biophysical Settings, and Current Cover Type base layers. The overlay produced a "combine layer" with 2,617 unique combinations containing the attributes of each base layer. For example, Table 1 shows that 5,364 pixels of the combine layer value 536 had a Province value of M331, a Regional Biophysical Setting value of Forest 43 (Hot, Dry), and a Current Cover Type value of Interior Ponderosa Pine. Area ecologists then assigned a CRBSUM PVT and CRBSUM Current CT to each combination of the combine layer, based on the types found in the CRBSUM succession pathways. For example, in value 536 the draft CRBSUM PVT was assigned an Interior Ponderosa Pine potential vegetation type, based on the plant associations or habitat types used to delineate Forest 43 of the Regional Biophysical Setting layer

(Table 1). The draft CRBSUM Current CT was assigned an Interior Ponderosa Pine cover type based on the value of the Current Cover Type base layer. The assigned values were modified for spatial agreement (described above and shown in Table 1).

The Historical Cover Type base layer, the draft CRBSUM PVT, the draft CRBSUM Current CT layer, and the combine layer were overlaid to create a layer with 3,951 unique combinations (which will be called the final combine layer). For each unique combination of values in the final combine layer, the final assignments of CRBSUM PVT, CRBSUM Current CT, and CRBSUM Historical CT were completed. The combine layer was included in the final combine layer to help track potential problems with the above assignment. To illustrate, a potential problem would exist if large areas of the Historical Cover Types base layer conflicted with the assignment in the draft CRBSUM PVT layer, based on the comparison to the successional pathways. Such conflicts were usually the result of an incorrect assignment made in the combine layer.

About one-quarter of the unique combinations in the final combine layer did not match the succession pathway information used by CRBSUM. The mismatches occurred when values from the Historical Cover Type base layer were compared with values from the draft CRBSUM PVT and draft CRBSUM Current CT layers. They were usually the result of the Historical Cover Types base layer having been mapped at a coarser map scale then the Current Cover Types and Regional Biophysical Setting base layers. Conflicts were resolved by selecting another type based on comparing values of adjacent pixels; by incorporating ecological processes (like fire) that would be associated with potential vegetation types and cover types; and by reviewing the draft CRBSUM maps, other maps, and literature. For example, Table 2 shows that 367 pixels were mapped in the final combine layer (value 1,283) composed of the following attributes: Dry Douglas-Fir with Ponderosa Pine potential vegetation type from the draft CRBSUM PVT, Douglas-fir cover type from the draft CRBSUM Current CT, and Subalpine-fir cover type from the Historical Cover Types base layer. Subalpine-fir does not occur in this potential vegetation type based on the successional pathway information used by CRBSUM (Keane and others 1996b, Long and others 1996). The Dry Douglas-Fir with Ponderosa Pine potential vegetation type historically had high fire frequency. Since the Ponderosa Pine cover type is fire resistant and occurred in the adjacent pixels, it was assigned as the CRBSUM Historical CT value. This example was common in the lower mountain ranges of the Rocky Mountains, where the map scale of the Historical Cover Types base layer was too broad to distinguish the division of the valleys.

In the creation of CRBSUM vegetation layers, the values assigned to pixels might have changed from the original base layers, when comparing similar cover types. The Current Cover Type base layer changed by 17 percent (135,858 km^2), when overlaid with CRBSUM Current CT layer. The Historical Cover Type base layer changed by 29 percent (237,180 km^2) when overlaid with CRBSUM Historical CT layer. Estimates on percent change from the Regional Biophysical Setting base layer to the CRBSUM PVT layer could not be determined because of the layer's different classes.

Model cover types--The final combine layer was assigned model cover types for input cover type layers for CRBSUM runs (Table 2). These model cover types are a finer classification of vegetation then the CRBSUM CT, and were used in the development of the successional pathways that drive CRBSUM (Keane and others 1996b, Long and others 1996). The model cover types were aggregated to the CRBSUM CT (Appendix B) when generating all maps and databases for the ICBEMP.

CRBSUM Current PVT and CRBSUM Historical PVT--Two potential vegetation layers were created because of changes to potential vegetation communities caused by urban development and agriculture. These landscape changes were added to the CRBSUM PVT layer to match the successional pathway information used by the Current CRBSUM runs (Keane and others 1996b, Long and others 1996). The CRBSUM Current PVT layer was created by replacing pixels in the CRBSUM PVT layer with pixels that delineate Rural and Agricultural cover types from the CRBSUM Current CT layer. This process created both a Rural and an Agricultural potential vegetation type. The CRBSUM PVT layer was renamed to CRBSUM Historical PVT layer.

Potential Vegetation Groups--To facilitate the analysis used in the ICBEMP, 15 classes of Potential Vegetation Groups (PVG) were created by the aggregation of CRBSUM PVT (Appendix A). PVG represents broad ecological processes stratified by lifeform. For example, Dry Forest PVG was created from the aggregation of the CRBSUM PVT that delineates dry forest communities (Appendix A). These forest communities are usually found in areas of low elevation with light to moderate precipitation, and moderate to high fire frequency.

Structural Stages Layers

CRBSUM Current SS layer was produced from a discriminant analysis using the structural stage layer developed for the Midscale Subsample Data (Hessburg and Smith 1996) and other broadscale data layers. The Midscale Subsample Data effort mapped potential vegetation types, cover types, and structural stages from 1950 and 1990 aerial photography over a cluster of watersheds scattered throughout the ICRB (Hessburg and Smith 1996). This data set represents less then 3 percent of the ICRB land area. The structural stage vector layer was converted to a 100 meter pixel raster layer. This raster layer was then resampled to 1 km^2 pixel size by selecting the modal structural stage when overlaid with a 1000 meter pixel size grid. The modal structural stage was selected when at least 60 percent of the 100 meter pixels, with the same structural stage, occupied a 1000 meter pixel (at least 60 out of 100 pixels). This produced the Midscale Structural Stage layer.

The discriminant analysis was stratified by forest, woodland, and range structural stages. The Midscale Structural Stage layer was the dependent variable; several continuous ancillary layers, including topographical, climatic, and vegetational indices, were the independent variables. Topographical layers of elevation, aspect, and slope were derived from 500 meter Digital Elevation Model (USGS 1990a). The climate layers' independent values included total precipitation for each weather year 1982, 1988, and 1989, and minimum and maximum temperature, dew point, and solar radiation for normal weather year 1989 (Thorton and others 1996). Vegetational indices were taken from the layers of monthly Normalized Difference Vegetation Index (NDVI) for January, March, May, August, and September, of 1991. NDVI is an indicator of the total amount of photosynthetic biomass. The layers were produced from Advanced Very High Resolution Radiometer (AVHRR) imagery by the EROS Data Center (Gallo and Heddinghaus 1989).

The overall accuracy of the discriminant function by percent of the total observations was 28.6 percent for forest structural stages, 78.18 percent for woodland structural stages, and 57.4 percent for range structural stages. Young Multi-Strata Woodland and Old Single-Strata Woodland structural stages were not mapped during the modal resampling of the midscale data, because they represented less then 60 percent of a 1 km^2 pixel, and were not included in the discriminant function. One potential explanation for the low accuracies in the discriminant function could be the small sample size (about 3 percent) of the Midscale Data to the ICRB.

The CRBSUM Current SS layer was then generated by applying the derived discriminant functions across the entire ICRB for each of forest, range, and woodland settings. The discriminant functions were constrained by the CRBSUM successional pathway information (Keane and others 1996b), where only those structural stages relevant to specific CRBSUM Current PVT and CRBSUM Current CT combinations were assigned to a pixel. Since the woodland discriminant function did not occur for Young Multi-Strata Woodland and Old Single-Strata Woodland structural stages, they were assigned when they were the only possible structural stage for a specific CRBSUM Current PVT and CRBSUM Current CT combination.

The CRBSUM Historical SS layer was developed from a stochastic model based on summaries associated with the Historical Cover Types base layer (Losensky 1994). Losensky summarized the percent occurrence of each structural stage by cover type and Section. Based on these percentages, structural stages were stochastically generated across the ICRB by using a sub-model inside CRBSUM.

Midscale Comparison

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EIS Updates to CRBSUM Vegetation Layers

The CRBSUM vegetation layers were slightly modified for the EIS analysis. Agricultural vegetation types mapped on federal lands were reclassified to other vegetation types. The CRBSUM Current PVT layer was modified by replacing Agricultural potential vegetation types with CRBSUM Historical PVT layer that occurred on federal lands. The CRBSUM Current CT layer and CRBSUM Current SS layer were modified by selecting cover types and structural stages that could have been confused with an agriculture vegetation type. The modification process was based on reviewing the CRBSUM Historical PVT layer, the CRBSUM Historical CT layer, the CRBSUM Historical SS layer, and the succession pathway information used by CRBSUM. A total of 7,473 km^2 were reclassified, with most cover types going from Agricultural cover type to Exotic Forbs / Annual Grass cover type (56 percent) and Agropyron Bunchgrass cover type (26 percent).

All CRBSUM vegetation layers were modified to match the geographic extent of

EIS boundary. The CRBSUM vegetation layers were clipped to the EIS boundary, where the ICRB boundary was outside the EIS boundary. A total of 688 km^2 of the CRBSUM vegetation layers were extended to the EIS boundary, because the EIS boundary was outside the ICRB boundary. This difference occurred mostly as one pixel wide slivers along the Cascade crest, and was the result of the EIS boundary having been mapped at a finer scale. These areas were filled by assigning a value to a pixel based on the most common value found in the surrounding pixels. These modified layers will be called EIS-CRBSUM vegetation layers.

ROAD DENSITY

The Road Density layer describes the total length of roads (km) within a pixel (km^2) by six road density classes (Table 4). The layer was developed using a rule-based approach on the midscale roads layer and several broadscale layers. This rule-based model was selected over the 1:100,000 Digital Line Graph (100k DLG) Roads layers developed by U.S. Geological Survey (USGS 1990b), because the mapped roads were delineated more than twenty years ago making them unsuitable for describing rural and forested lands (especially logging roads). The Road Density layer includes all road types from highway to logging roads.

Midscale Road Density Layer

The Subsample Roads layer was created from inventory databases (TMS, RMS ???), digital maps, and aerial photography, at a 1:24,000 map scale (Hessburg and Smith 1996). The layer mapped about 3 percent of the sub-watersheds scattered throughout the ICRB, and was developed as part of the Midscale Subsample Data effort (Hessburg and Smith 1996). A Midscale Road Density layer was created from the Subsample Roads layer by summing the total length of roads that fell within each cell of a 1 km^2 grid. When a pixel divided watershed boundaries, thus creating pixels only partially represented, road densities were adjusted for the reduced sample area. Adjustments were calculated by multiplying the road density by the difference between the areas. For example, when a pixel split the outer edge of a watershed in half, the total road density summed from the roads data area was multiplied by two. Unreasonably high road densities were occasionally produced by pixels having only a small percent of area with roads data. Those few pixels were deleted because the adjusted road densities were higher then most of the non-adjusted road densities (pixels with complete roads data).

Development and Analysis of Broadscale Layers

The completed Midscale Road Density layer was compared with several broadscale layers to determine which broadscale classes would best predict road density across the ICRB. The midscale analysis was completed by overlaying each broadscale layer with the Midscale Road Density layer. For each road density class, the total number of midscale pixels that occurred within a broadscale layer were summarized for each broadscale class. These summaries were then used to aggregate the broadscale classes into distinctive classes that best predicted road density. The layers selected for developing the rule-based model were Land Use (created from Management Regions, Management Area Categories and Roadless Areas), Lifeforms (created from CRBSUM Current Cover

Types), Elevation, Slope, and United Parcel Service Roads.

Land Use layer--To address issues associated with management and ownership, a Land Use layer was developed by combining the following layers: Management Regions, Management Area Categories (MAC), and Roadless Areas. The Management Regions layer (Gravenmier and others 1996) delineates six major ownership groups (Table 5) for the ICRB, and was developed for the CRBSUM assessment runs described by Keane and others (1996b). The Forest Service (FS) and Bureau of Land Management (BLM) classes in the Management Region map were further stratified by MAC and Roadless Area layers. This stratification was used to delineate roadless areas outside wilderness areas.

The MAC layer mapped FS/BLM lands within the EIS boundary based on similar management objectives ranging from wilderness to active management (Gravenmier and others 1996). The management objectives were aggregated into three classes. The first class consisted of MAC 1 and 2 categories that represented wilderness and designated wilderness areas. The second class contained MAC 3 and 4 categories that represented areas not suitable for active management or areas maintained because of scenic concerns. The last class consisted of MAC 5 through 8 categories that represented areas of active management, such as timber management zones. The MAC layer was mapped at a finer scale then Management Regions and Roadless Area layers.

The Roadless Area layer was based on Forest Plans and RARE II delineations of roadless and non-roadless areas (Gravenmier and others 1996). The layer was used to map areas outside the EIS boundary that were not represented by the

MAC layer. The Roadless Area layer was mapped at a coarser scale then the Management Regions and MAC layers.

Fourteen classes were created in the Land Use layer, by overlaying and combining Management Regions, MAC, and Roadless Area layers (Table 5). A few conflicts occurred between the layers because of the different map scales used in developing the layers. These conflicts were resolved by selecting the layer mapped at a finer map scale. For example, Land Use class 3 has both wilderness areas from the Management Region layer, and active management areas from the MAC layer. Since the MAC layer was mapped at a finer resolution, road density classes were assigned based on active management.

Analysis of the Land Use layer to the Midscale Road Density layer showed those FS/BLM classes with either MAC 1 and 2, MAC 3 and 4, or Roadless usually had road density classes of None to Very Low. The National Park Service class had road density classes of None to Very Low; however, this class was represented by a small sample size due to very little overlap with the midscale layer. The rest of the Land Use classes had a range of road densities, and required additional information from other layers (discussed below) before road densities were estimated.

Lifeform layer--The CRBSUM Current Cover Types layer was aggregated into five lifeform classes (Table 6). These classes were used to predict road densities based on the types of management activities that could occur in these lifeform classes. Overall, the road densities were usually lower in both Agricultural and Range lifeform classes based on analysis of the Midscale Road Density layer. The Forest lifeform class had a wide range of road densities, while the Rural lifeform class usually had higher road densities. The Water lifeform class always had road density class of None, except for the few pixels where the midscale and broadscale layers did not match due to different mapping methodologies (see CRBSUM LAYERS above).

Elevation and Slope layers--The 500 meter Digital Elevation Models (DEM) layer (USGS 1990a) was classified into five classes to create the Elevation layer (Table 7). Four slope classes were generated from the Slope layer created from the 90 meter DEM (Table 8). Road densities usually decreased with an increased elevation and/or slope, based on analysis of the midscale data.

United Parcel Service (UPS) Roads layer--This layer was developed by adding additional roads to the 100k DLG Roads map in rural and urban areas (Gravenmier and others 1996). The UPS Roads layer was used mostly for road densities associated with rural and urban lands, because roads added to the 100k DLG Roads map did not usually include other areas like forest and range lands. Two classes were created from this layer, High To Extremely High road densities and None To Moderate road densities. The UPS road layer appeared to be the best indicator of road densities associated with populated areas, based on the midscale analysis.

The rule-based model

A rule-based model was developed to predict road density classes across the ICRB, based on the midscale analysis of the broadscale layer. The Land Use, Lifeform, Elevation, Slope, and UPS aggregated broadscale layers, when overlaid with the Midscale Road Density layer, produced a total of 808 unique combinations. Each combination was assigned a road density class (Table 4) based on the midscale analysis of the broadscale classes, and the road density class that was best represented by the Midscale Road Density layer. For example, a High road density class was assigned to the combination of: Land Use class 8 (FS/BLM - Non Wilderness - MAC 5 through 8), Lifeform class 2 (Forest), Elevation class 2 (3,000 to 5, 000 feet), Slope class 1 (0 to 10 percent), and UPS class 1 (none to moderate road densities), because the High road density class had the highest frequency of observations when overlaid with the Midscale Road Density layer. The High road density class also fit the midscale analysis of the broadscale classes, where high road densities could occur in actively managed forest lands at low elevation with gentle slopes. A higher road density class was always selected over a lower road density class when there was a choice between two or more classes.

About 500 of the rule-based combinations did not have Midscale Road Density layer information when overlaid with the broadscale layers. Road density classes for these combinations were based on the trends observed in the midscale analysis of the broadscale classes. For example, a None road density class was assigned to the combination of: Land Use class 4 (FS/BLM - Wilderness - Roadless), Lifeform class 2 (Forest), Elevation class 4 (7,000 to 9, 000 feet), Slope class 3 (30 to 50 percent), and UPS class 1 (none to moderate road densities). The None road density class would occur in roadless areas at high elevation with steep slopes, based on the midscale analysis of the Land Use, Elevation, and Slope layers.

Limitations

The final Road Density layer (Figure 2) had a few classification problems because of incomplete data layers, limitations of the sampling design of the Subsample Roads layer, and the limitations of a rule-based model. An example of an incomplete data layer occurred along the south fork of the Flathead River in the Bob Marshall Wilderness. The south fork of the Flathead River is designated a Wild and Scenic River. Unfortunately, the Roadless Area layer did not map Wild and Scenic Rivers as roadless, even if they were in the wilderness areas. The south fork of the Flathead River was classified with a Low road density class, because it was delineated as Non-Roadless in the Roadless Area layer. The river should have been classified as a None road density class, because it is in the Bob Marshall Wilderness Area. This problem could have been resolved if MAC were developed for the ICRB and not just the EIS.

The Midscale Subsample Data was designed to map vegetation, not to predict road density. The sample size was both small (about 3 percent of the ICRB) and did not capture the entire range of road densities across the ICRB. This was evident by the small number of midscale observations found inside National Park Service lands, and the large number of combinations without subsample roads data (about 500 combinations). Also, roads were only mapped to the watershed boundary that often split a 1 km^2 pixel, creating incomplete observations that were either deleted or modified to create a complete observation. These split pixels should have been deleted, but the sample size was already too small.

A few road types could not be predicted using this rule-based approach. For instance, Yellowstone National Park was assigned a road density class of None, because there were no unique rule-based model combinations for predicting the park's road system. Roads inside the park are based on human recreational interests, which was not accounted for in this rule-based model. This limitation potentially could have been resolved with a layer delineating only major roads, such as Interstate and State Highways.

Road Density Layer Limitations

The methodology used in developing road density classes is not a substitute for actually mapping roads. However, the rule-based model approach does provide a tool for predicting road densities across a large landscape, when existing roads data are incomplete or out of date. Also, the rule-based model assures that the methodologies used in developing road densities was consistent throughout the ICRB.

FIRE LAYERS

Fire Regimes

Historical (circa 1900) and Current (circa 1990) Fire Regime raster maps were developed by Morgan and others (1995) for the ICBEMP. Fire Regime classes were described by fire frequency and fire intensity classes (Morgan and others 1995). Fire frequency classes (Table 9) were based upon the mean fire interval (MFI) as interpreted from fire-scarred trees, and forest and shrub age structures. In shrub and herbaceous vegetation types, fire frequency was determined from fire scars in adjacent vegetation or the ecology of the dominant plants (Morgan and others 1995). Fire severity classes (Table 10) reflect the direct effects of the fire on the dominant vegetation, and is based on a comparison of burned and unburned vegetation within the first three years after the fire (Morgan and others 1995).

Morgan and others (1995) classified and mapped fire regimes by dominant vegetation types and biophysical settings. The classification was based upon published literature, a fire history database (Barrett 1995b), and expert opinion. The dominant vegetation type for the Current Fire Regime map was based on CRBSUM Current CT layer, and for the Historic Fire Regime map was based on CRBSUM Historic CT layer. The biophysical settings were generalized from the Section Biophysical Setting (Reid and others 1995) base layer into four classes: cool & moist, cool & dry, warm & moist, and warm & wet. For example, in the Historic Fire Regime classification, the Interior Douglas-fir cover type was assigned a Mixed/Frequent fire regime for the cool & moist and warm & moist biophysical setting classes, and a Nonlethal/Frequent fire regime for the cool & dry and warm & dry biophysical setting classes.

Two sets of decision rules were created from the classification, and used to map fire regimes for each of the 24 Sections mapped in the Subsection base layer (Nesser and Ford 1996). One set of decision rules were used to map Historical Fire Regimes. A separate set of decision rules were developed for the Current Fire Regimes map to reflect the effects of fire suppression, invasions of the exotics, and other human influences (Morgan and others 1995).

For example, in the Interior Douglas-fir cover type and cool & moist biophysical setting class, the fire regimes changed from Mixed/Frequent in the historic decision rules to Stand-replacement/Infrequent in the current decision rules. Table 11 shows a comparison between Current and Historic Fire Regimes.

The Historic Fire Regimes map and Current Fire Regime map were used to derive Changes In Fire Frequency map and Changes In Fire Severity map. The Changes In Fire Frequency map (Figure 3) was created by summarizing the transitions from historic fire frequency to current fire frequency. Fire frequency transitions were created by overlaying the Historic Fire Regimes map and the Current Fire Regime map, and classifying each unique combination of historic and current fire frequencies that overlapped spatially. Table 12 shows the Changes In Fire Frequency classes summarized by area.

The Changes In Fire Severity map (Figure 4) was developed using the same methodology as the Changes In Fire Frequency map. The transitions were summarized by fire severity from overlaying the fire regimes maps. Table 13 shows the Changes In Fire Severity classes summarized by area.

Fire Occurrence

The Fire Occurrence layer maps the location of all fire starts that occurred between the years of 1986 and 1992 in the ICRB (Hartford and Bradshaw 1996). This vector layer maps the starting location of fires and is linked to a database containing the total fire size and source of ignition. The ICBEMP used this layer in developing the disturbance information for CRBSUM (Long and others 1996) and comparing recent fire frequency trends by ownerships and sub-watersheds. Hartford and Bradshaw (1996) created the layer from several databases maintained by federal land management agencies throughout the ICRB. The contributing agencies include the USDA Forest Service, Bureau of Land Management, Bureau of Indian Affairs, U.S.Fish and Wildlife Service, National Park Service, California Department of Forestry, Idaho Department of Lands, Montana Department of State Lands, Oregon Department of Forestry, Utah Department of Natural Resources, and Washington State Department of Natural Resources.

Fire History

The Fire History layer delineates the locations of historic fires between the years 1500 and 1940. Barrett (1995a, 1995b) compiled this vector layer based on 108 fire history studies that sampled 979 stands scattered across the ICRB. The sampled stands were summarized into a database of 321 sites that mapped historic fires by discrete latitudinal and longitudinal coordinates. One fire record was recorded into the database for each fire year observed in the study area’s fire chronology. Each record included the year of the fire, the fire severity, and the dominant vegetation type. Fire dates were estimated from fire scars on trees, and from the ages of trees that regenerated after stand replacement. The Fire History layer was used by Morgan and others (1995) in developing the Fire Regime layers.

CHARACTERIZATION FILE

The characterization file is a series of databases that defines sub-watersheds by variables that represent ecological states and ecological processes, and were compiled based on summaries of several broadscale layers. The databases were used by the ICBEMP in grouping sub-watersheds, based on similar ecological features, to address specific land management questions. The sub-watersheds were delineated by the ICBEMP (Gravenmier 1996) at the Sixth Level of the Hydrologic Unit Code (6th Code HUC), based on the methodology developed by U.S. Geological Survey's Office of Water Resources Council (Seaber and others 1987). More than 10,000 sub-watersheds were mapped in the ICRB, with an average size of 100 km^2 (Gravenmier 1996).

Broadscale layers that mapped unique classes (like cover types) were summarized to the 6th Code HUC by calculating the area and the percent of area for each class within a sub-watershed. The area was calculated by summing the total area in km^2 for each class in a sub-watershed. The percent of the area was calculated by dividing the area of each class in a sub-watershed by the total area for that sub-watershed. A unique characterization file database was created for each of the following broadscale layers that mapped discrete classes: Subsection, Section, Province, Section Biophysical Setting, Regional Biophysical Setting, CRBSUM Historic CT, CRBSUM Current CT, and CRBSUM Historic PVT. The Subsection layer database was appended to the Subsection Characterization File, and included landform, surface geology, and bedrock geology (Nesser and Ford 1996).

Topographic and climate broadscale layers were summarized into two characterization databases by calculating the average, maximum, minimum, and standard deviation of the values assigned to all pixels within a sub-watershed, for each layer. The topographic characterization database included elevation and slope derived from the 500 m^2 and 90 m^2 DEM (USGS 1990a), respectively. The climatic characterization file was calculated from the broadscale climate layers developed by Thorton and others (1996). The broadscale climate layers were created using a spatial model that calculates daily weather information for a given year, based on weather station data collected throughout the ICRB (Thorton and others 1996). The layers used in the characterization file were for the normal weather year of 1989, and included: precipitation, minimum temperature, maximum temperature, average daily temperature and solar radiation. The normal weather represents a year that depicts the normal weather conditions found in the ICRB. Broadscale climate layers for the dry weather year (1988) and wet weather year (1982) were also created by Thorton and others (1996), but were not included in the characterization database. The normal weather year climate layers were summarized into the database by three stratifications: complete weather year, four seasons (winter, spring, summer, fall), and growing seasons (June through September). The total precipitation by the stratification was also included into the database.

CONCLUSION

The layers described in this chapter were developed to meet the objectives of the ICBEMP (Keane 1996). These objectives included that (1) each layer is developed using a uniform methodology, (2) each layer is mapped across the entire ICRB, and (3) the layers are available for analysis in Spring 1995. To meet these objectives, and because these layers were developed at the broadscale, a few limitations apply when interpreting these layers.

Limitations

1. The vegetation for the base layers was not always mapped at a consistent map scale. The map scale of the Historic Cover Type base layer was variable, and generally broader than the other base layers. Although attempt was made to correct the different map scales in development of CRBSUM vegetation layers, the inconsistencies might still account for some observed changes between historic and current vegetation layers.

2. A 1 km^2 pixel is often composed of several classes for a given layer. However, a single class must characterize the entire pixel. Classes were assigned based on the class occupying the greatest area of the pixel, which could range from 10 to 100 percent. For example, if ponderosa pine cover type represented 30 percent of a given pixel for a cover type layer, Douglas-fir cover type 28 percent, shrub cover type 25 percent, and grass cover type 17 percent, then ponderosa pine cover type would be assigned to the pixel because it occupied the greatest area.

3. The 1 km^2 pixel size was too large to map effectively and to evaluate trends in vegetation types that are usually found in small areas. For instance, wetlands and riparian areas were usually not mapped in the

broadscale vegetation layers because they often represent a small percent of a 1 km^2 pixel. Caicco and others (1995) found that some riparian types were underestimated when mapped at a map scale of 1:500,000. Additionally, Leonard and others (1992) found that riparian communities were better identified at map scales of 1:2,000 to 1:4,000. In the ICBEMP, any analysis to evaluate trends associated with small areas (like riparian areas) would be limited, and would be dependent on additional ancillary data found in other layers and databases.

Closing

A detailed accuracy analysis of the layers described in this chapter has not been completed, due to the tight time constraints of the ICBEMP. Based on a review of these layers by the different users, and comparisons made to the Midscale Subsample Data, it appears that the spatial accuracy of these layers varies by geographic area. Also, since the layers were mapped at a broadscale, and because of the limitation described above, these layers are best interpreted when summarized over large geographical areas like watersheds. When summarized across large areas, the trends observed between layers appear realistic when compared with layers mapped at a finer scale.

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Figure Captions

Figure 1--Temperature/Moisture Matrix used in creating the Regional Biophysical Setting layer.

Figure 2--Road Density layer.

Figure 3--Changes in Fire Frequencies layer.

Figure 4--Changes in Fire Severities layer.

Table Captions

Table 1--Examples of attributes in the combine layer used in developing CRBSUM vegetation layers.

Table 2--Examples of attributes in the final combine layer used in developing CRBSUM vegetation layers.

Table 4--Road Density classes summarized by the area in the ICRB.

Table 5--Land Use classes used in creating the Road Density layer, summarized by the area in the ICRB. The classes were created by combining the Management Region layer, Management Area Categories layer, and Roadless layer.

Table 6--Lifeform classes used in creating the Road Density layer, summarized by the area in the ICRB.

Table 7-- Elevation groups used in creating the Road Density layer, summarized by the area in the ICRB.

Table 8--Slope groups used in creating the Road Density layer, summarized by the area in the ICRB.

Table 9--Fire Frequency classes used for the fire regime classification. The mean fire interval is the average number of years between fires recurring at a point within a small area.

Table 10--Fire severity classes used for the fire regime classification. Fire severity is determined based upon
the extent of mortality of dominant vegetation.

Table 11--Comparison of Current and Historic FireRegimes,summarized by area for the ICRB.

Table 12--Changes in Fire Frequency, based on a comparison of Historic and Current Fire Regimes, and summarized by percent change in forest and non-forest cover types, and by the area in the ICRB.

Table 13--Changes in Fire Severity based on a comparison of Historic and

Current Fire Regimes, and summarized by percent change in forest and non-forest cover types, and by the area in the ICRB.

TEMP: \ MOISTURE:	**WET (1)**	**MOIST (2)**	**DRY (3)**	**VERY DRY (4)**
COLD (1)	COLD/WET	COLD/MOIST	COLD/DRY	COLD/VERY DRY
COOL (2)	COOL/WET	COOL/MOIST	COOL/DRY	COOL/VERY DRY
WARM (3)	WARM/WET	WARM/MOIST	WARM/DRY	WARM/VERY DRY
HOT (4)	HOT/WET	HOT/MOIST	HOT/DRY	HOT/VERY DRY

Figure 1. Temperature / Moisture Matrix used in the Regional Biophysical Setting Layer.

Figures 2, 3, and 4 not available

Table 1.--Examples of attributes in the combine layer used in developing CRBSUM vegetation layers.

Combine Value	Province	Regional Biophysical Setting	Current Cover Type	Assigned Draft CRBSUM: Potential Vegetation Tyes	Assigned Draft CRBSUM: Current Cover Types	Area
						km^2
536	M331	F43 (Forest-Hot, Dry)	SAF237 Interior Ponderosa Pine	Interior Ponderosa Pine	SAF237 Interior Ponderosa Pine	5364
537	M331	F33 (Forest-Warm, Dry)	SAF210 Interior Douglas-fir	Dry Douglas-fir with PP*	SAF210 Interior Douglas-fir	2567
538	M331	S33 (Shrub-Warm, Dry)	SAF210 Interior Douglas-fir	Dry Douglas-fir with PP**	SAF210 Interior Douglas-fir	837
539	M331	F33 (Forest-Warm, Dry)	SAF208 Whitebark Pine	Dry Douglas-fir with PP	SAF237 Interior Ponderosa pine***	45

*PP - Ponderosa pine.
**Dry Douglas-fir with PP (Ponderosa Pine) was selected over a shrub potential vegetation type.
***SAF239 Interior Ponderosa Pine was selected over SAF208 Whitebark Pine.

Table 2.--Examples of attributes in the final combine layer used in developing CRBSUM vegetation layers.

		Draft CRBSUM			Assigned Final CRBSUM			Model Cover Types		
Unique ID	Combine Layer	PVT*	Current CT**	Historic CT	PVT	Current CT	Historic CT	Current	Historic	Area
										km²
1283	537	DF with PP	SAF210 Interior DF	SF	DF with PP	SAF210 Interior DF	SAF237 Interior PP***	2003	2018	367
1284	537	DF with PP	SAF210 Interior DF	PP	DF with PP	SAF210 Interior DF	SAF237 Interior PP	2003	2018	1150
1285	537	DF with PP	SAF210 Interior DF	DF	DF with PP	SAF210 Interior DF	SAF210 Interior DF	2003	2003	50
1286	538	DF with PP	SAF237 Interior PP	PP	DF with PP	SAF210 Interior DF	SAF237 Interior PP	2018	2018	630
1287	538	DF with PP	SAF237 Interior PP	DF	DF with PP	SAF210 Interior DF	SAF210 Interior DF	2018	2003	207
1288	539	DF with PP	SAF237 Interior PP	PP	DF with PP	SAF237 Interior PP	SAF237 Interior PP	2018	2018	45

*PVT -Potential Vegetation Group
**CT - Cover Type
***SAF237 - Interior Ponderosa pine was selected over Subalpine fir

DF - Douglas-fir
PP - Ponderosa pine
SF - Subalpine fir

Table 4.--Road Density classes summarized by area in the ICRB.

Value	**Road Density**	**mile / mile²**	**km / km²**	**Area**
				km²
1	None	0.00 - 0.02	0.00 - 0.0124	168,432
2	Very Low	0.02 - 0.10	0.0124 - 0.0621	103,653
3	Low	0.10 - 0.70	0.0621 - 0.4350	109,716
4	Moderate	0.70 - 1.70	0.4350 - 1.0560	234,413
5	High	1.70 - 4.70	1.0560 - 2.9206	174,386
6	Extremely High	4.70 - +	2.9206 - +	30,740

Table 5.--Land Use classes used in creating the Road Density layer, summarized by area in the ICRB. The classes were created by combining the Management Region layer, Management Area Categories layer, and Roadless layer.

	Broadscale Layers			
Value	Management Regions	*MAC	**Roadless	Area (km²)
1	FS / BLM - Wilderness	MAC 1 AND 2	X	37088
2	FS / BLM - Wilderness	MAC 3 AND 4	X	41
3	FS / BLM - Wilderness	MAC 5 - 8	X	20
4	FS / BLM - Wilderness	X	Roadless	239
5	FS / BLM - Wilderness	X	Non-Roadless	9893
6	FS / BLM - Non-Wilderness	MAC 1 AND 2	X	34341
7	FS / BLM - Non-Wilderness	MAC 3 AND 4	X	47206
8	FS / BLM - Non-Wilderness	MAC 5 - 8	X	181574
9	FS / BLM - Non-Wilderness	X	Roadless	1570
10	FS / BLM - Non-Wilderness	X	Non-Roadless	102513
11	National Park	X	X	16249
12	Other Public Lands	X	X	40108
13	Tribal	X	X	26808
14	Private	X	X	309573

*MAC - Management Area Categories layer
**Roadless - Roadless Area layer
FS - Forest Service
BLM - Bureau of Land Management
X - Layer not used in this category

Table 6.--Lifeform classes used in creating the Road Density layer, summarized by area in the ICRB.

Value	**Lifeform**	**Area**
		km^2
1	Agriculture	118,363
2	Forest	393,617
3	Range	300,687
4	Rural	1,143
5	Water	7,550

Table 7.-- Elevation groups used in creating the Road Density layer, summarized by area in the ICRB.

Value	**Elevation Groups**	**Area**
	Feet	**km²**
1	0 - 3,000	136,787
2	3,000 - 5,000	304,282
3	5,000 - 7,000	274,366
4	7,000 - 9,000	85,885
5	9,000 +	20,036

Table 8.--Slope groups used in creating the Road Density layer, summarized by area in the ICRB.

Value	**Slope Groups**	**Area**
	Percent	**km^2**
1	0 to 10	561,724
2	10 to 30	242,267
3	30 to 50	17,193
4	50 +	158

Table 9.--Fire Frequency classes used for the fire regime classification. The mean fire interval is the average number of years between fires recurring at a point within a small area.

Class	**Mean Fire interval (MFI)**
Very Frequent	Less than 25 years
Frequent	26-75 years
Infrequent	76-150 years
Very Infrequent	151-300 years
Extremely Infrequent	Greater than 300 years

Table 10.--Fire severity classes used for the fire regime classification. Fire severity is determined based upon the extent of mortality of dominant vegetation.

Fire Severity	Description
Nonlethal	More than 70% of the basal area or more than 90% of the canopy cover that existed prior to the burn is alive after the burn.
Mixed	Fires of intermediate effects, often consisting of fine-grained spatial patterns resulting from a mosaic of varying severity.
Stand-replacement	Less than 20% of the basal area or less than 10% of the canopy cover of the overstory vegetation remains after the fire.
Rarely burns	Fires very seldom occur and are not one of the primary disturbance factors affecting vegetation structure, composition, and succession.

Table11.--Comparison of Current and Historic Fire Regimes, summarized by area for the ICRB.

FIRE REGIMES		**AREA**	
Severity	**Frequency**	**Historical**	**Current**
		km²	
Nonlethal	Very Frequent	180653	11378
Nonlethal	Frequent	62202	20116
Nonlethal	Infrequent	20938	81861
Mixed	Very Frequent	3722	0
Mixed	Frequent	45836	39440
Mixed	Infrequent	70963	134278
Mixed	Very Infrequent	8441	256
Lethal	Very Frequent	0	103157
Lethal	Frequent	183442	43671
Lethal	Infrequent	163101	275418
Lethal	Very Infrequent	27113	61698
Lethal	Extremely	41360	35368
Rarely	NA	13589	14719

Table12.--Changes in Fire Frequency, based on a comparison of Historic and Current Fire Regimes, and summarized by percent change in forest and non-forest cover types, and by the area in the ICRB.

CHANGES IN FIRE FREQUENCY	-- Percent -- Forest	Non-Forest	Total Hectares
0-25 MFI to 151-300 or 300+ MFI	70	30	221,700
26-75 MFI to 151-300 or 300+ MFI	98	2	1,425,700
0-25 MFI to 76-150 MFI	71	29	14,160,700
26-75 MFI to 76-150 MFI	54	46	15,801,800
76-150 MFI to 151-300 MFI	99	1	2,514,800
0-25 MFI to 26-75 MFI	20	80	3,311,900
151-300 MFI to 26-75 MFI	100	0	7,500
300+ MFI to 26-75 MFI or 76-150 MFI	0	100	685,500
76-150 MFI to 0-25 MFI	0	100	3,872,300
76-150 MFI to 26-75 MFI	16	84	1,758,100
151-300 MFI to 76-150 MFI	100	0	1,424,000
26-75 Mfi to 0-25 MFI	0	100	6,865,300
All Frequency Classes to Rarely Burns	34	66	113,00
No Change	43	57	29,973,700

Table 13.--Changes in Fire Severity based on a comparison of Historic and Current Fire Regimes, and summarized by percent change in forest and non-forest cover types, and by the area in the ICRB.

	-- Percent --		Total
CHANGES IN FIRE SEVERITY	Forest	Non-Forest	Hectares
Non Lethal to Lethal	38	62	10,002,200
Mixed to Lethal	92	8	6,964,900
Non Lethal to Mixed	71	29	7,723,100
Lethal to Non Lethal	46	54	2,107,700
Lethal to Mixed	64	36	4,364,800
Mixed to Non Lethal	42	58	616,900
Severity (All) to Rarely Burns	34	66	113,000
No Change	36	64	50,243,400