

# MAPPING RELATIVE FIRE REGIME CONDITION CLASS FOR THE WESTERN UNITED STATES

**James P. Menakis**, Forester, Fire Effects Unit  
jmenakis@fs.fed.us

**Melanie Miller**, Fire Ecologist,  
(Bureau of Land Management employee stationed at the Fire Sciences Laboratory)  
melaniemiller@fs.fed.us

**Thomas Thompson**, GIS Specialist, Fire Effects Unit  
tthompson01@fs.fed.us  
Fire Sciences Laboratory, Rocky Mountain Research Stations,  
Forest Service USDA, PO Box 8089, Missoula, MT 59813

## ABSTRACT

In 1999, a coarse-scale map of Fire Regime Condition Classes (FRCC) was developed for the conterminous United States (US) to help address contemporary fire management issues and to quantify changes in fuels from historical conditions. This map and its associated data have been incorporated into national policies (National Fire Plan, Forest Health Initiative) and several General Accounting Office (GAO) reports concerning wildfire management issues. While this data layer has been invaluable for approximating changes in fuels conditions on forestlands overtime, it potentially underestimates these conditions for grasslands and shrublands. In order to address these underestimated fuel conditions, we incorporated finer-scale remotely sensed data into the process to create a new map of FRCC for the western US. In the mapping process, we relativized FRCC classes by calculating the percentage of their composition over a geographic area and then assigning color ramps to these percentages (shades of green for FRCC 1, blue for FRCC 2, and red for FRCC 3), to create a map that reflects degrees of the departure from historical conditions. This color shading may portray a more realistic view of FRCC because it takes into account the historical range of variability and compositional differences.

## INTRODUCTION

Over ninety years of fire exclusion (Pyne, 1982) domestic livestock grazing, logging, and widespread exotic species invasions have altered fire regimes, fuel loadings, and vegetation composition and structure (Whisenant, 1990, or Barrett et. al., 1991 or, Brown et. al., 1994 or, West, 1994 or, Ford and McPherson, 1999). As a result, the number, size, and severity of wildfires have significantly changed from historical conditions (Vail, 1994 or, US GAO, 1999), with sometimes catastrophic consequences. In response to these changing conditions, the United States President directed the Secretaries of Agriculture and the Interior to develop a report that recommends how best to: respond to severe wildland fires, reduce fire impact on rural communities, and ensure sufficient firefighting capacity in the future (USDA FS and US DOI, 2000). In 2001, the United States Congress mandated the implementation of the National Fire Plan in the Interior and Related Agencies Appropriations Act (USDA FS and US DOI, 2000), which was soon followed by the Forest Service (FS) and Department of Interior (DOI) 10-year Comprehensive Strategy Implementation Plan (USDA FS and US DOI, 2002) and Cohesive Strategy (USDA FS, 2000).

To implement the National Fire Plan and Cohesive Strategy, federal land management agencies needed national-level data to prioritize, plan, monitor, and allocate money and resources (US GAO, 1999, 2002). In 2000, the Rocky Mountain Research Station Fire Science Laboratory provided coarse-scale spatial data designed to help fire managers assess wildland fire and fuels risk and evaluate differences among regions and groups of states (Hardy et. al., 2001 or, Schmidt et. al., 2002). These data included potential natural vegetation groups, vegetation cover types, historical natural fire regimes, current fire regime condition classes, national fire occurrences from 1986-1996, potential fire characteristics, and wildland fire risk to flammable structures. These data became the foundation for strategic planning at the national level and for responding to congressional questions. In particular, the Fire Regime Condition Class (FRCC) data became the key variable for inferring risk to people and ecosystems.

## Fire Regime Condition Class (FRCC)

FRCC is defined as a qualitative measure of departure from historical natural fire regimes, possibly resulting in alterations of key ecosystem components such as species composition, structural stage, stand age, canopy closure, and fuel loadings, which can cause significant changes in fire behavior (Schmidt et. al., 2002). One or more of the following activities typically cause this departure: fire suppression, timber harvesting, livestock grazing, introduction and establishment of exotic plant species, introduced insects or disease, or other management activities (Schmidt et. al., 2002). FRCCs and descriptions can be found in **Table 1**.

**Table 1.** Fire Regime Condition Classes (FRCCs) and descriptions (Schmidt et. al., 2002).

FRCC	Fire Regime	Example Management Options
FRCC 1	Fire regimes are within an historical range and the risk of losing key ecosystem components is low. Vegetation attributes (species composition and structure) are intact and functioning within an historical range.	Where appropriate, these areas can be maintained within the historical fire regime by treatments such as fire use.
FRCC 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.	Where appropriate, these areas may need moderate levels of restoration treatments, such as fire use and hand or mechanical treatments, to be restored to the historical fire regime.
FRCC 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.	Where appropriate, these areas may need high levels of restoration treatments, such as hand or mechanical treatments, before fire can be used to restore the historical fire regime.

## Acres at Risk to Wildland Fire

In 1999, a General Accounting Office (GAO) report asked federal land management agencies to determine how many acres were at risk from catastrophic wildfire (US GAO, 1999). Using the coarse-scale FRCC data (Schmidt et. al., 2002), the FS and DOI estimated that 301,888 square kilometers (km<sup>2</sup>) (75 million acres) of federal lands were at risk. This number was based on the area in FS and DOI lands estimated to be in FRCC 3 (i.e., significantly departed from historical conditions) (**Table 1**) (Hardy et. al., 2001 or, Schmidt et. al., 2002). However, recent studies have indicated that this 301,888 km<sup>2</sup> estimate may be extremely low, and the percent of FRCC 3 on the landscape is much higher. Results from a recent broad-scale cheatgrass (*Bromus tectorum*) study in the Great Basin (and applied to the coarse-scale) suggested that the coarse-scale FRCC underestimated shrublands and grasslands in FRCC 3 by four percent (increasing the area in the coarse-scale FRCC 3 from the 18 to 22 percent) (Menakis et. al., 2003). In addition, several finer scale studies conduct on smaller geographic areas scatter through out the western United States indicated that the percent of federal lands in FRCC 3 could be anywhere from 8 percent to 75 percent, with an average of about 41 percent (McNicoll and Hann, 2002 or, Hann and Strohm, 2003 or, Hann et. al., 2003b or, Hann, 2004). Based on these studies, Hann et. al. (2003a) estimated about 45 percent of all FS and DOI lands are in FRCC 3, and by multiplying this 45 percent to all FS and DOI lands (1,708,691 km<sup>2</sup>) in the conterminous United States, they estimated that the total area in FRCC 3 could increase from the coarse-scale analysis of 301,888 km<sup>2</sup> (75 million acres) to 768,911 km<sup>2</sup> (190 million acres).

In 2002, the President's Forest Health Initiative cited the 768,911 km<sup>2</sup> (190 million acres) as part of the justification for more active management to reduce the risk of catastrophic wildfires and restore forest and rangeland health (United States, 2002). Building upon the President's initiative, Congress passed the Healthy Forest Restoration Act, which uses FRCC as a measure for prioritization of fuel treatments. Yet, even with this strong

federal direction and legislation, land managers still do not know the accurate number and location of acres at FRCC 3. In this paper, we attempt to provide a more accurate estimate of FRCC acres for the western United States by incorporating into the coarse-scale process improved maps and models that can be used to depict grassland, shrubland and woodland departures from the historic range of conditions. When mapping FRCC, we try to take into consideration the historical range of variability and compositional differences between the data that occurs when incorporating data developed from different methods, legends, and mapping scales.

## METHODS

To integrate the departure from historical conditions of rangelands (grasslands and shrublands) and woodlands into the coarse-scale FRCC map, we built upon the methods used for the coarse-scale analysis (Schmidt et al., 2002). First, we incorporated some of the coarse-scale (around 1 to 1,000,000 – national level) spatial data layers with mid- (around 1 to 250,000 – regional level) to fine-scale (around 1 to 24,000 – local level) existing cover type data developed from several sources. Next, we incorporated expert opinion to create succession diagrams and to assign FRCC to these succession diagrams. Lastly, using the Geographic Information System (GIS), we incorporated the information from the succession diagrams into a look-up table and mapped FRCC by assigning the percentage of each class to each of the red, green, and blue color guns (shadings based on percent) in the GIS display to create the final map.

### Modifying Coarse Scale Spatial Data

In this process we used the Potential Natural Vegetation Groups (PNVG), Current Cover Types (CT), Historical Natural Fire Regimes (HNFR), and FRCC spatial data layers developed during the coarse-scale process (Schmidt et al., 2002). First, we created a mask of all the rangeland and woodland types in the PNVG layer, which allowed us to filter out all forest types and work only with the rangeland and woodland types in the PNVG, HNFR, and CT layers. Next, we divided the Sagebrush PNVG into Warm Sagebrush and Cool Sagebrush PNVGs based on ecological zones and elevation. The ecological zones were based on groupings of the coarse-scale ECOHUC layer (Figure 1) (Schmidt et al., 2002), originally derived from Bailey's Ecoregions sections (Bailey et al., 1994) and modified by 4<sup>th</sup> Code Hydrologic Units (McNab and Avers, 1994). The elevation breaks were defined by expert opinion and based on other data sets. We call this modified PNVG layer the Range PNVG layer.

### Develop Current Cover Types Spatial Data

In order to map departure from historical conditions of grasslands and shrublands, we needed finer-scale data because most of these departures are a result of encroachment of late seral and/or exotic species, a phenomenon that is not well detected at a coarse-scale. We acquired the Gap Analysis Program (GAP) data from each of the eleven western states (Table 2) because national mid-scale existing-vegetation layer did not exist at the resolution that was required. To standardize each of the GAP state legends, we created a standard legend of vegetation types (

Table 3) and then used this to reclassify each of the GAP state layers in the GIS. Next, we resampled and combined these modified state layers into a raster layer at a one-square kilometer pixel size, which then spatially matched the coarse-scale layers. We call this raster layer the GAP CT layer.



**Figure 1.** Ecological Zones for the western United States.

**Table 2.** GAP data sources and versions.

State	Originator	Release Date/Version
Arizona	University of Arizona	N/A
California	University of California - Davis, Dept of Geography	Final Report June 30, 1998
Colorado	Colorado Division of Wildlife	Final Report April, 2000
Idaho	University of Idaho, USGS ID Coop Unit	Version 2.1, February, 1999
Montana	University of Montana, USGS MT Coop Unit	Final Report September, 1998
Nevada	Utah St. U. USGS UT Coop Unit	1996?
New Mexico	New Mexico State U., USGS NM Coop Unit	Final Report 1996
Oregon	Oregon Natural Heritage Program	Final Report 1999
Utah	Utah St. U. USGS UT Coop Unit	Final Report 1995
Washington	University of Washington, USGS WA Coop Unit	Final Report 1997
Wyoming	University of Wyoming, Dept. of Botany	Final Report December, 1996

**Table 3.** Legends for combined GAP Cover Types and GAP/Coarse Scale Cover Types.

<b>Combined GAP Cover Types Legend</b>			
Desert Grassland	Mt. Big Sagebrush	Other Evergreen Shrub	Hardwood Forest
Plains Grassland	WY/Basin Big Sagebrush	Mountain Deciduous Shrub	Alpine Meadows <sup>1</sup>
Prairie Grassland	Black Sagebrush	Riparian Deciduous Shrub	Agriculture <sup>1</sup>
Mountain Grassland	Low Sagebrush	Pinyon - Juniper	Urban <sup>1</sup>
Wetland Graminoid	Other Sagebrush	Pinyon pine	Open Water <sup>1</sup>
Exotics Grassland	Blackbrush	Juniper	Bare Rock/Barren <sup>1</sup>
Desert Shrub	Chaparral	Deciduous Woodland	Perennial Ice <sup>1</sup>
Salt Desert Shrub	Dry Deciduous Shrub	Conifer Forest	Other/Unknown <sup>1</sup>
<b>GAP/Coarse Cover Type Legend</b>			
Desert Grassland	Salt Desert Shrub	Dry Deciduous Shrub	Deciduous Woodland
Plains Grassland	Mt Big Sagebrush	Other Evergreen Shrub	Conifer Forest
Prairie Grassland	WY/Basin Big Sagebrush	Mt Deciduous Shrub	Hardwood Forest
Mountain Grassland	Black Sagebrush	CoarseSc <sup>3</sup> Other Shrub	Alpine Tundra <sup>2</sup>
CoarseSc <sup>3</sup> Grassland	Low Sagebrush	Riparian Deciduous Shrub	Agriculture <sup>2</sup>
Wetland Graminoid	Other Sagebrush	Pinyon - Juniper	Urban <sup>2</sup>
Exotics Grassland	Blackbrush	Pinyon pine	Water <sup>2</sup>
Desert Shrub	Chaparral	Juniper	Barren
<sup>1</sup> Non-vegetative GAP Cover Types used in the hierarchical rules describe in the text. <sup>2</sup> Non-vegetative coarse scale Current Cover Types used in the hierarchical rules describe in the text. <sup>3</sup> CoarseSc = the coarse scale CT only had generic labels for grasslands and shrublands.			

We next standardized the non-vegetative cover type classes (e.g., water) between the coarse-scale Current CT and the GAP CT layers to allow for consistency between the other coarse-scale layers. We then combined these two layers in the GIS and resolved spatial conflicts between the legends using the following hierarchical rules:

- 1) Use the coarse-scale non-vegetative Current CT, except for Barren CT, where they spatially occur).
- 2) Use the coarse-scale Current CT where they spatially co-occur with the non-vegetative GAP CT. These coarse-scale CTs are reclassified to match the GAP CT legend
- 3) Use the GAP CT for the remaining area that has not been populated by 1 or 2 (most of the area)

Finally, we applied the rules in the GIS to generate the final CT layer based on the legend in

## Developing Succession Diagrams

Drawing on the coarse-scale methods (Schmidt et. al., 2002), we mapped FRCC and refined the input spatial data layers using succession diagrams. In a workshop held in November 2002, at the Fire Science Laboratory in Missoula, Montana, regional experts developed succession diagrams for each combination of ECOHUC, Range PNVG, and HNFR within the previously assigned boundaries of the Ecological Zones. The succession diagram consists of a series of stages represented by boxes ordered from early seral through climax. Regional experts filled in these succession boxes with data from summary reports generated in a GIS by combining the following layers within an Ecological Zone boundary: ECOHUCs, HNFR, Range PNVG, and GAP/Coarse CT.

Regional experts completed the succession diagrams using the methods described in the coarse-scale analysis (Schmidt et. al., 2002). First, they transferred the appropriate information from the GIS summary reports to the succession diagrams. At this time, if the experts wanted to map combinations that did not occur in the report or perhaps re-map a specific area, they filled in the succession diagrams with classes other than those provided by the reports. For example, they could create a succession diagram for Cool Sagebrush PNVG if it did not occur in a specific ECOHUC or change the HNFR class.

Once the succession diagrams were created, regional experts then assigned FRCC (**Table 1**) using a similar method to the coarse-scale (Schmidt et. al., 2002). For each succession box, within a succession diagram, experts assigned the percentage of each FRCC for the box. For example, for all the ECOHUCs in the Columbia Plateau Ecological Zone with a Cool Sage Range PNVG and HNFR II (0-35 years; mixed severity), a Juniper CT could be assigned a 0, 10, and 90 percent, for FRCCs 1, 2, and 3, respectively. In this example, the 90 percent in FRCC 3 could be because of juniper encroachment in this PNVG.

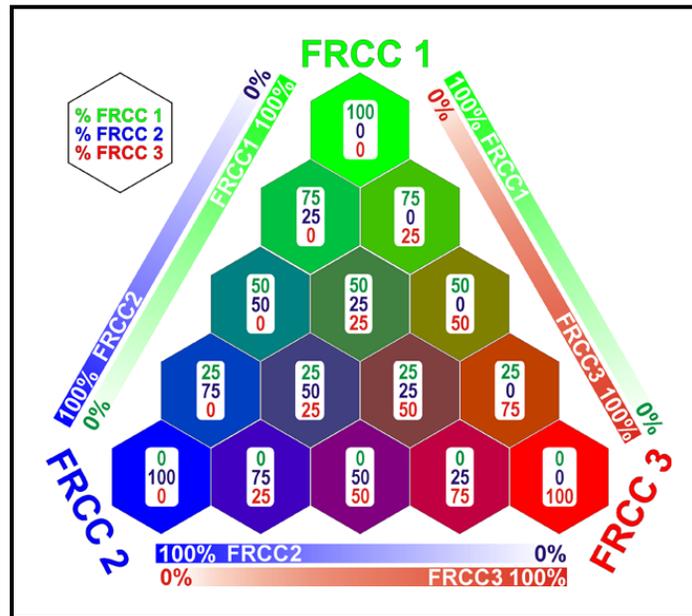
## Mapping Spatial Data Layers from Succession Diagrams

Using the coarse-scale methods (Schmidt et. al., 2002), all succession diagram assignments based on expert opinion were loaded into a database containing all combinations of ECOHUCs, HNFR, Range PNVG, and GAP/Coarse CT located within all the Ecological Zone boundaries, and all were then linked to a master spatial layer. This database also contained changes made to the GAP/Coarse CTs, Range PNVGs, and HNFRs, completed during the succession diagram development. We then generated new spatial data layers of HNFR, Range PNVG, and GAP/Coarse CTs.

## Mapping Relative FRCC Spatial Data Layer

In order to make a continuous map of FRCC for the western United States, the range HNFR, Range PNVG, and GAP/Coarse CT layers (described above) were merged with the forest HNFR, PNVG, and CT layers created in the coarse-scale analysis (Schmidt et. al., 2002), resulting in new HNFR, PNVG, and CT layers. To distinguish them from other versions of these layers, we call them Relative HNFR, Relative PNVG, and Relative CT. These layers were then combined in the GIS with 4<sup>th</sup> Code Hydrologic Units, ECOHUC, and Ecological Zones to create a master database linked to the spatial data. The percent of each FRCC was then compiled in the database for each combination of Ecological Zones, ECOHUCs, 4<sup>th</sup> Code Hydrologic Units, Relative HNFRs, Relative PNVGs, and Relative CTs. The range FRCC percentages were calculated from the database described in the last section, and the forest FRCC percentages were calculated from the coarse-scale data (Schmidt et. al., 2002).

The percentages of each FRCC were then calculated for all database combinations of 4<sup>th</sup> Code Hydrologic Units, Relative PNVGs, and Relative HNFRs and then linked to the spatial layers. Next, using this database in the GIS, we created a spatial data layer for each of the Fire Regime Condition Classes (1, 2, and 3) that delineates the percentage value on the landscape (e.g., FRCC\_1 spatial layer contains values from 0 to 100 percent for FRCC class 1). We will call these layers Relative FRCC. Using the GIS, the Relative FRCC 1, FRCC 2, and FRCC 3 layers were assigned to the green, blue, and red color guns, respectively. We created a relative map of FRCC for the western United States by blending the colors based on the percentage of each FRCC (Figure 2). For example, if a piece of ground is 100 percent FRCC 1, it would be green; 100 percent FRCC 2, it would be blue; and 100 percent FRCC 3, it would be red. In another example, if a piece of ground is 25, 25, and 50 percent for FRCC 1, 2, and 3 respectively, then it would have a darkish brown color as result of the blending (Figure 2).



**Figure 2.** Relative Fire Regime Condition Class (FRCC) legend – the percent of each FRCC class is assigned to a color, colors blend depending on the percent of each FRCC class.

## RESULTS AND DISCUSSION

### Potential Natural Vegetation Groups (PNVG)

The elevation breaks (based on expert opinion) used to separate Cool Sagebrush and Warm Sagebrush PNVGs are listed by Ecological Zones in Table 4. We were unable to distinguish clear elevation breaks from the existing vegetation layers created by individual state GAP projects (Table 2), likewise for the SageStitch layer (Comer et. al., 2002). This could be partially caused by the layer's different resolutions: the GAP and SageStitch layers were developed at the mid-scale, while the elevation layer (used to create these elevations breaks) was developed at the coarse-scale. In addition, elevation breaks might not play as important a role as slope, aspect, and soils in mapping these PNVGs. In the Southwest Desert Ecological Zone, elevation breaks were not developed since there were few sagebrush PNVGs occurring in this area.

During the workshop, the experts added three additional PNVGs: Deciduous Woodland/Shrub, Riparian, and Plains Oaks. The experts mapped these by assigning the succession models to GAP/Coarse CTs from the summary reports, listing all combinations of ECOHUCs, HNFs, Range PNVGs, and GAP/Coarse CTs, within Ecological Zone boundaries. For example, succession models with Riparian PNVG were assigned to combinations with Riparian Deciduous Shrub GAP/Coarse CT within a specific ECOHUC. In addition, the experts shifted much of the Barren PNVG into Desert Shrub PNVG because the GAP/Coarse CT data contained vegetative classes for this area.

**Table 4.** Elevation breaks used to delineate Warm and Cool Sagebrush Potential Natural Vegetation Groups (PNVG) out of the Sagebrush PNVG.

Ecological Zones	Elevation Breaks (meters)	Ecological Zones	Elevation Breaks (meters)
Pacific Northwest	Warm < 1,220 ≥ Cool	Great Basin	Warm < 2,287 ≥ Cool
California	Warm < 1,829 ≥ Cool	Southern Rockies	Warm < 2,515 ≥ Cool
Northern Rockies	Warm < 1,982 ≥ Cool	Colorado Plateau	Warm < 2,134 ≥ Cool
Columbia Plateau	Warm < 2,058 ≥ Cool	Southwest Desert	Sagebrush (no breaks)
Central Rockies	Warm < 2,363 ≥ Cool		

### Current Cover Types (CT)

The methods used to standardize the GAP/Coarse CT layer were only partially successful because of the differences in the individual state GAP legends and mapping procedures (Table 2). State GAP legends were produced independently of each other with no standardization among the legends. While most of the classes in the legends were relatively easy to group into our standardized GAP CT list (

Table 3), some CTs could not be grouped as only a few states chose to map them (e.g., Exotic Grasses CT). These classes were kept in our legend because of the important role they play in mapping departure. To resolve these conflicts, we relied on the experts to adjust their assignments of FRCCs based on the classes occurring in their particular geographic areas. In addition, each of the state GAP projects used different mapping procedures, which could not be resolved through a simpler legend and resampling to a one-kilometer pixel size. For these reasons, we did not produce a final CT map in this effort. Since we chose to relativize FRCC at a higher hierarchical level than CT, we felt these issues were not significant for this project.

### Historical Natural Fire Regimes (HNFR)

The Relative HNFR changed significantly from the coarse-scale analysis of HNFR (Schmidt et. al., 2002), with most of these changes occurring in HNFR class IV (35-100+ years; Stand Replacement) (Table 5). These changes occurred mostly in the Warm Sagebrush and Desert Shrub PNVGs, shifting from HNFR II (0-35 years; Stand Replacement) and III (35-100+ years; Mixed Severity) into HNFR IV (Table 5). HNFR I (0-35 years; Low Severity) had the next greatest increase, with most of the area shifting from HNFR II (Table 5). Barren had the second highest percentage change (Table 5), with most of the area shifting to HNFR IV in the Desert Shrub PNVG.

**Table 5.** Historical Natural Fire Regimes (HNFR) total area comparison of all lands and rangelands/woodlands between the coarse scale (Schmidt et. al., 2002) and the Relative HNFR.

Historical Natural Fire Regimes	All Lands <sup>1</sup>			Rangelands/Woodlands		
	Area (km <sup>2</sup> )		Percent Change	Area (km <sup>2</sup> )		Percent Change
	Coarse Scale	Relative		Coarse Scale	Relative	
I. 0-35 years; Low Severity	668,049	914,972	37	340,445	587,368	73
II. 0-35 years; Stand Replacement	845,363	598,757	-29	840,611	594,005	-29
III. 35-100+ years; Mixed Severity	940,344	547,086	-42	630,917	237,659	-62
IV. 35-100+ years; Stand Replacement	339,145	848,832	150	259,026	768,713	197
V. 200+ years; Stand Replacement	109,366	109,478	0	311	423	36
Barren	136,869	20,011	-85	136,869	20,011	-85

<sup>1</sup> Forest lands were not changed in this effort.

### Fire Regime Condition Class (FRCC)

For all lands in the western United States (Table 6), the area of Relative FRCC 3 increased by more than 200 percent (416,419 km<sup>2</sup>) from the FRCC coarse-scale analysis (Schmidt et. al., 2002). Most of this increase (253,146 km<sup>2</sup>) was due to a decrease in lands reported as FRCC 2, which dropped from 1,004,812 km<sup>2</sup> in the coarse scale, to about 751,666 km<sup>2</sup> in this effort (Table 6). An additional increase (116,856 km<sup>2</sup>) in FRCC 3 was caused by an increase in total land area between the Relative FRCC analysis (approximately 2.6 million km<sup>2</sup>) and the coarse-scale analysis (approximately 2.5 million km<sup>2</sup>) (Table 6). This increase in total area resulted from the reassignment of lands classified during the coarse-scale analysis as Barren PNVG (non-vegetative lands where FRCC cannot be assigned) to Desert Shrub PNVG (where FRCC can be designated). Most of these reassigned PNVG lands were categorized as FRCC 3. The rest of the increase of lands reported as FRCC 3 (46,417 km<sup>2</sup>) came from a decrease in lands that had been reported as FRCC 1 in the coarse-scale analysis (Table 6).

**Table 6.** Comparison of Fire Regime Condition Class (FRCC) by Historical Natural Fire Regimes (HNFR) between the coarse-scale analysis (Schmidt et. al., 2002) and the Relative FRCC and HNFR analyses for the western United States.

Relative Fire Regime Condition Class and Historical Natural Fire Regime Analysis for the Western United States <sup>1</sup>								
Historical Natural Fire Regimes	Area in Fire Regime Condition Class (FRCC)							
	FRCC 1		FRCC 2		FRCC 3		Total Area (km <sup>2</sup> )	Total %
	Area (km <sup>2</sup> )	Row %	Area (km <sup>2</sup> )	Row %	Area (km <sup>2</sup> )	Row %		
0-35 yrs; Low Severity	231,606	28	248,570	30	355,440	43	835,616	32
0-35 yrs; Stand Replacement	246,856	56	84,311	19	110,821	25	441,988	17
35-100+ yrs; Mixed Severity	212,761	42	201,283	40	88,396	18	502,440	19
35-100+ yrs; Stand Replacement	362,213	48	208,343	28	184,213	24	754,770	29
200+ yrs; Stand Replacement	98,874	91	9,158	8	179	0	108,212	4
Column Total; Column %	1,152,310	44	751,666	28	739,049	28	2,643,025	
Coarse Scale Analysis for the Western United States (Schmidt et. al., 2002) <sup>1</sup>								
Historical Natural Fire Regimes	Area in Fire Regime Condition Class (FRCC)							
	FRCC 1		FRCC 2		FRCC 3		Total Area (km <sup>2</sup> )	Total %
	Area (km <sup>2</sup> )	Row %	Area (km <sup>2</sup> )	Row %	Area (km <sup>2</sup> )	Row %		
0-35 yrs; Low Severity	150,789	25	311,510	51	148,521	24	610,820	24
0-35 yrs; Stand Replacement	333,665	51	310,172	48	5,229	1	649,066	26
35-100+ yrs; Mixed Severity	436,895	52	293,289	35	103,956	12	834,140	33
35-100+ yrs; Stand Replacement	178,561	55	80,742	25	64,740	20	324,043	13
200+ yrs; Stand Replacement	98,817	91	9,099	8	184	0	108,100	4
Column Total; Column %	1,198,727	47	1,004,812	40	322,630	13	2,526,169	

<sup>1</sup> Does not included lands mapped in the following Cover Types: Agriculture, Barren, Water, and Urban/Development/Agriculture

On federal lands in the western United States, FRCC 1 had the highest occurrence with 43 percent, followed by FRCC 3 with 30 percent and FRCC 2 with 27 percent. On non federal-lands, FRCC 1 had the highest occurrence with 45 percent, followed by FRCC 2 with 31 percent and FRCC 3 with 24 percent. Federally owned land had approximately 6 percent more lands in FRCC 3, than non-federal. When compared to the coarse-scale analysis, FRCC 3 increased on FS and DOI lands in the western United States by approximately 170 percent, from 277,428 km<sup>2</sup> (18 percent) (Schmidt et. al., 2002) to 465,194 km<sup>2</sup> (30 percent).

Hann et. al. (2003a) estimated approximately 45 percent of FS and DOI lands are in FRCC 3 (the percent used in determining acres at risk in the President’s Forest Health Initiative), while we estimated about 30 percent of the western United States are in FRCC 3. When applying Hann’s et. al.’s (2003a) estimate of 45 percent for FRCC 3 to the total area of FS and DOI lands in the western United States (1,549,599 km<sup>2</sup>), the Relative FRCC is 232,126 km<sup>2</sup> (30 percent) short of the applied estimate of 697,320 km<sup>2</sup>.

The Relative FRCC map for the western United States is shown in Figure 3. This map differs from the pixel-level coarse-scale FRCC map, which assigns one color to one-kilometer pixels according to FRCC class (Schmidt et. al., 2002). By calculating the percentage composition for each FRCC (1, 2, and 3) into broader units (combinations of 4<sup>th</sup> Code Hydrologic Units, Relative PNVGs, and Relative HNFRs), and then assigning the percentage composition for each FRCC to a green, blue, or red color ramp for each of these broader units, we were able to display the data at a resolution more appropriate to the input data scale. This approach addresses the issues of misinterpretation of the coarse-scale results, in which many users thought the maps were accurate to the single one-kilometer pixel regardless of the documentation that stated the data could be applied only at very broad levels (e.g., the western United States). Also this approach takes into account the historical range of variability. By assigning the percentage of each FRCC class over a given area (e.g., FRCC 1, 2, and 3 are mapped at 20, 10, and 70 percent, respectively), we allow for various stand conditions that could have occurred historically (e.g., historical 10 percent of this area was in FRCC 3). This approach differs from the coarse-scale analysis conducted by Schmidt et. al.(2002), which would have assigned the same area one FRCC class (e.g., FRCC 3) and not taken into account that 10 percent of this area that could have been in FRCC 3 historically.

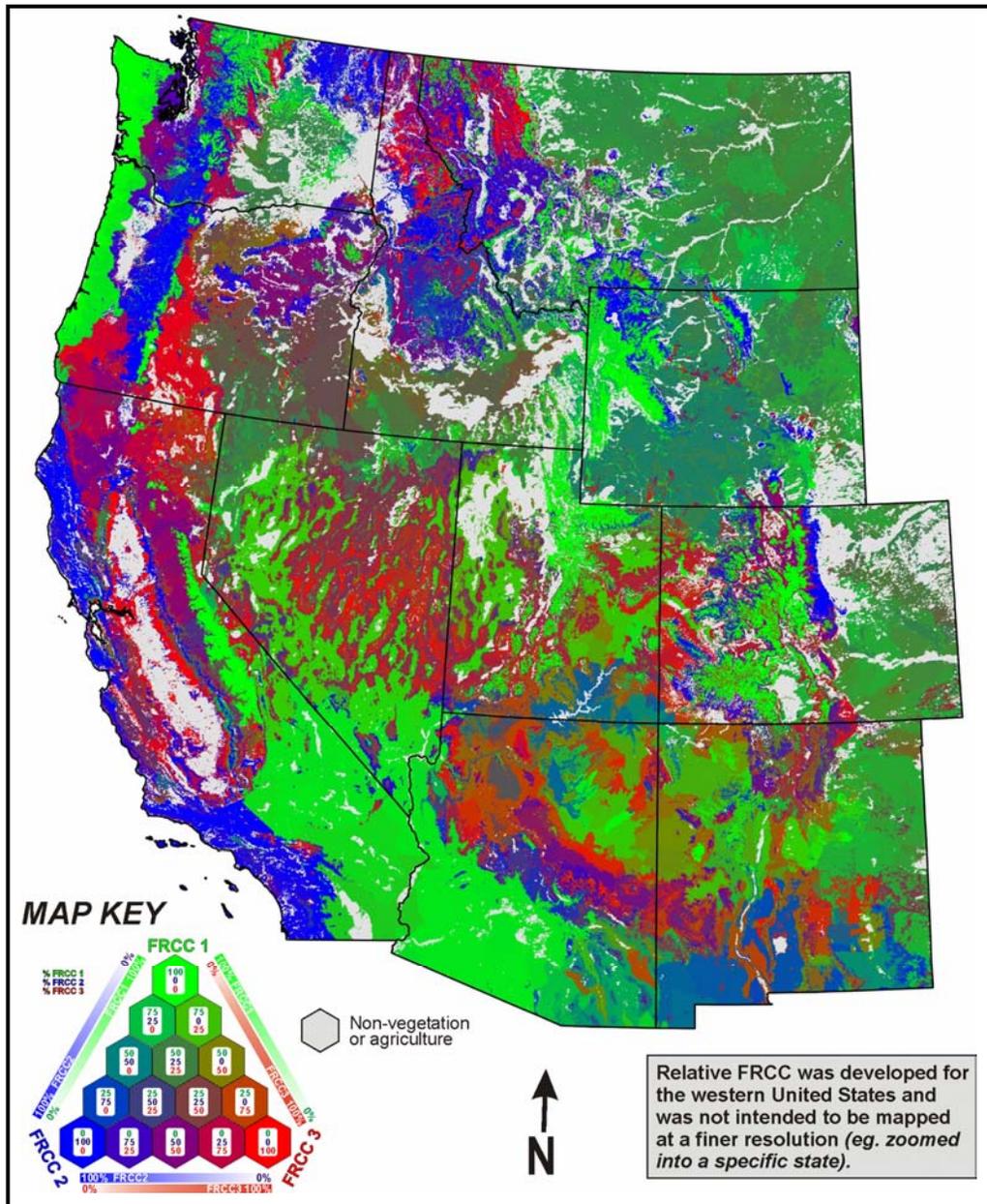


Figure 3. Relative Fire Regime Condition Class for the western United States.

**Table 7.** Relative Fire Regime Condition Classes for the western United States by ownership.

Ownership	Area in Fire Regime Condition Class (FRCC)						Total Area (km <sup>2</sup> )	Total %
	FRCC 1		FRCC 2		FRCC 3			
	Area (km <sup>2</sup> )	Row %	Area (km <sup>2</sup> )	Row %	Area (km <sup>2</sup> )	Row %		
Department of Interior (DOI)	465,100	49	213,252	23	266,940	28	945,292	36
USDA Forest Service (FS)	183,265	30	222,788	37	198,254	33	604,307	23
Subtotal DOI and FS	648,365	42	436,040	28	465,194	30	1,549,599	
Other Federal	146,074	48	73,222	24	81,948	27	301,244	11
Subtotal Federal	794,439	43	509,262	27	547,142	30	1,850,843	
Non Federal	357,871	45	242,404	31	191,906	24	792,181	30
Column Total; Column %	1,152,310	44	751,666	28	739,048	28	2,643,024	

### Accuracy and Verification

No accuracy assessment or field verification of the data layers used in this project was conducted. It is difficult to provide an accuracy assessment for broad-scale projects of one-kilometer pixel size or greater (Loveland et. al., 1991 or, Kloditz et. al., 1998 or, Schmidt et. al., 2002) because ground reference data is difficult and expensive to collect and can only represent a very small portion of the study area (Schmidt et. al., 2002).

## CONCLUSIONS

We created a balanced forestland and rangeland assessment for FRCC at the broad-scale for the western United States by incorporating rangeland and woodland conditions into the original coarse-scale analysis (Schmidt et. al., 2002). This assessment more than doubles the area (739,049 km<sup>2</sup>) of the western United States assigned to FRCC 3 in the coarse-scale analysis (322,630 km<sup>2</sup>) (Schmidt et. al., 2002). On FS and DOI lands, approximately 465,194 km<sup>2</sup> (115 million acres) are designated FRCC 3 for the western United States. This value begins to approach the 768,911 km<sup>2</sup> (190 million acres) cited in the President's Forest Health Initiative, which was based on the analysis by Hann et. al. (2003a). For the western United States, Hann's et. al.'s (2003a) estimate of 45 percent (697,320 km<sup>2</sup>/172 million acres) of DOI and FS lands in FRCC 3 appears high, when compared with the results from this analysis of 30 percent (465,194 km<sup>2</sup>/115 million acres) for the same lands.

The biggest difference between this effort and that of Hann et. al. (2003a) is scale. This assessment is a broad-scale, national-level analysis of FRCC, while Hann's et. al.'s (2003a) assessment is a fine-scale, project-level analysis of FRCC. Certain FRCC departures that are difficult or even impossible to map at the broad-scale (e.g., high-grading, over-grazing, invasion of exotics), could be mapped at finer scales. For this reason we will not know how much FRCC 3 we have on the landscape until we have mid-scale, regional-level data available for the nation. In addition, we feel there are several research and management issues regarding FRCC that need to be addressed before it can be fully integrated into the management process. These issues include but are not limited to: 1) The appropriate scale at which to use and develop FRCC; 2) The long- and short-term effects of prioritizing fuel treatments according to FRCC 3 while assigning less significance to FRCC 1 and 2, especially in the southeast United States; and 3) Whether FRCC represents a risk, hazard, or value, which directly relates to the way managers use it in their decision-making processes.

## DISCLAIMER

Fire Regime Condition Classes were developed for the western United States and were not intended to be mapped or summarized at a finer level (e.g., mapped or summarized for a single state), which could provide misleading results.

## ACKNOWLEDGEMENTS

We would like to thank Wendel Hann of the Forest Service (FS) Fire and Aviation Management, Ayn Shlisky of The Nature Conservancy, Doug Havlina of the Bureau of Land Management, and George Gruell, retired FS research ecologist, for their willingness to participate in the expert panel workshop. In addition, we would also like to thank Tracey Frescino of the FS Forest Inventory and Analysis Program, Rocky Mountain Research Station (RMRS), Chuck McHugh of the FS Fire Behavior Project, RMRS, and Lisa Holsinger of the FS Fire Effects Project, RMRS, for their technical review of this paper; Christine Frame of the System for Environmental Management for her editor review of this paper; and lastly Dennis Simmerman of the FS Fire Effects Project, RMRS, for helping to develop the graphics and maps.

## REFERENCES

- Bailey, R. G., P. E. Avers, T. King, and W. H. McNab. (1994). Ecoregions and subregions of the United States. [Map]. Washington, DC: USDA, Forest Service. (1:7,500,000).
- Barrett, S. W., S. F. Arno, and C. H. Key. (1991). Fire regimes of western larch-lodge pole pine forests in Glacier National Park, Montana. *Canadian Journal of Forest Research*, 21:1711-1720.
- Brown, J. K., S. F. Arno, S. W. Barrett, and J. P. Menakis. (1994). Comparing the prescribed natural fire program with presettlement fires in the Selway-Bitterroot Wilderness. *Int. Journal of Wildland Fire*, 4(3):157-168.
- Comer, P., J. Kagan, M. Heiner, and C. Tobalske. (2002). Current distribution of sagebrush and associated vegetation in the western United States (excluding NM and AZ) – Feb. 15, 2002. [Map]. Interagency Sagebrush Working Group; NatureServe, Boulder, CO.
- Ford, P. L., and G. R. McPherson. (1999). Ecology of fire in shortgrass communities of the Kiowa National Grassland. in C. Warwick, editor. *Fifteenth North American prairie conference proceedings* – 1996 October. The Natural Areas Association, St. Charles, IL. Bend, OR. pp. 71-76
- Hann, W. J. (2004). Mapping fire regime condition class: a method for watershed and project prioritization, planning, and implementation. in R. T. Engstrom, K. E. M. Galley, and W. J. de Groot, editors. *Proceedings of the 22nd Tall Timbers Fire Ecology Conference: Fire in Temperate, Boreal, and Montane Ecosystems* – October 1999. Tall Timbers Research Station, Tallahassee, Florida, [In Press].
- Hann, W. J., M. Beighley, P. Teensma, T. Sexton, and M. Hilbruner. (2003a). A cohesive strategy for protecting people and sustaining natural resources: predicting outcomes for program options. Presented at Fire, Fuel Treatments, and Ecological Restoration Conference – April 16-18, 2002; Fort Collins, CO. [Electronic publication on [www.frcc.gov](http://www.frcc.gov)].
- Hann, W. J., and D. J. Strohm. (2003). Fire regime condition class and associated data for fire and fuel planning: methods and applications. in L. A. Joyce, editor. *Fire, fuel treatments, and ecological restoration* – April 16-18, 2002; Fort Collins, CO. RMRS-P-29. USDA, Forest Service, Rocky Mountain Research Station, Fort Collins, CO. pp 397-434
- Hann, W. J., M. J. Wisdom, and M. M. Rowland. (2003b). Disturbance departure and fragmentation of natural systems in the interior Columbia basin. Research Paper RP-PNW-545, USDA, Forest Service, Pacific Northwest Research Station, Portland, OR.
- Hardy, C. C., K. M. Schmidt, J. P. Menakis, and N. R. Sampson. (2001). Spatial data for national fire planning and fuel management. *Int. Journal of Wildland Fire*, 10: 353-372.
- Kloditz, C., A. Boxtel, E. Carfagna, and W. van Deursen. (1998). Estimating the accuracy of coarse scale classification using high scale information. *Photogrammetric Engineering and Remote Sensing*, 64(2):127-133.
- Loveland, T. R., J. M. Merchant, D. O. Ohlen, and J. F. Brown. (1991). Development of a landcover characteristics database for the conterminous U.S. *Photogrammetric Engineering and Remote Sensing*, 57(11):1453-1463.
- McNab, W. H., and P. E. Avers. (1994). Ecological subregions of the United States: section descriptions. Ecosystem Management: WO-WSA-5, USDA, Forest Service, Washington D.C.
- McNicoll, C. H., and W. J. Hann. (2002). Multi-scale planning and implementation to restore fire adapted ecosystems, and reduce risk to the urban/wildland interface in the Box Creek Watershed. in R. T. Engstrom, K. E. M. Galley, and W. J. de Groot, editors. *Proceedings of the 22nd Tall Timbers Fire Ecology Conference: Fire in Temperate, Boreal, and Montane Ecosystems* – October 1999. Tall Timbers Research Station, Tallahassee, Florida, [In Press]
- Menakis, J. P., D. Osborne, and M. Miller. (2003). Mapping the cheatgrass-caused departure from historical natural

- fire regimes in the Great Basin, USA. *in* P. N. Omi and L. A. Joyce, editors. *Fire, fuel treatments, and ecological restoration*; April 16-18, 2002. RMRS-P-29. USDA, Forest Service, Rocky Mountain Research Station, Fort Collins, CO. pp. 281-287
- Pyne, S. J. (1982). *Fire in America – A Cultural History of Wildland and Rural Fire*. Princeton University Press.
- Schmidt, K. M., J. P. Menakis, C. C. Hardy, W. J. Hann, and D. L. Bunnell. (2002). Development of coarse-scale spatial data for wildland fire and fuel management. *Gen. Tech. Report RMRS-GTR-87*, USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO.
- United States. (2002). *Healthy forests -- an initiative for wildfire prevention and stronger communities* – August 22, 2002; The White House, United States Government, Washington DC.
- US GAO. (1999). Western National Forests; a cohesive strategy is needed to address catastrophic wildfire threats. Report to the subcommittee on forest and forest health, committee on resources, *House of Representatives. GAO/RCED-99-65*, United States General Accounting Office.
- US GAO. (2002). Severe Wildland Fires – Leadership and Accountability Needed to Reduce Risks to Communities and Resources. *GAO-02-259*, United States General Accounting Office.
- USDA FS. (2000). Protecting People and Sustaining Resources in Fire Adapted Ecosystems - A Cohesive Strategy - The Forest Service Management Response to the General Accounting Office Report GAO/RCED-99-65. USDA, Forest Services.
- USDA FS, and US DOI. (2000). *A Report to the President, In Response to the Wildfires of 2000, September 8, 2000 -- Managing the Impact of Wildfires on Communities and the Environment*. USDA, Forest Services and Department of the Interior.
- USDA FS, and US DOI. (2002). The National Fire Plan -- Implementation in FY 2002 -- Overview. *in*. USDA, Forest Services and Department of the Interior.
- Vail, D. (1994). Symposium introduction: management of semiarid rangelands-impacts of annual weeds on resource values. *in* S. B. K. Monsen, Stanley G., editor. *Proceedings on ecology and management of annual rangelands* – May 18-22, 1992. USDA, Forest Service, Intermountain Research Station., Odgen, UT. pp. 3-4
- West, N. E. (1994). Effects of fire on salt-desert shrub rangelands. *in* S. B. K. Monsen, Stanley G, editor. *Proceedings on ecology and management of annual rangelands* –May 18-22, 1992. *Gen. Tech. Report. INT-GTR-313*. USDA, Forest Service, Intermountain Research Station, Odgen, UT. pp. 71-74
- Whisenant, S. G. (1990). Changing fire frequencies on Idaho's Snake River Plains: Ecological and management implications. *in* M. E.D., editor. *Proceedings on cheatgrass invasion, shrub die off, and other aspects of shrub biology*. USDA Forest Service. pp. 4-10