

# MONITORING TRENDS AND BURN SEVERITY (MTBS): MONITORING WILDFIRE ACTIVITY FOR THE PAST QUARTER CENTURY USING LANDSAT DATA

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**Abstract.**—The Monitoring Trends in Burn Severity (MTBS) project is mapping the extent, size, and severity of all large fires greater than 1,000 acres in the west and 500 acres in the east over the conterminous United States (CONUS), Alaska, and Hawaii. In 2012 the project reached a milestone, completing the mapping for all fires between 1984 and 2010. The MTBS project produces geospatial and tabular data using a consistent protocol for fire trend analysis at a range of spatial, temporal, and thematic scales. This paper reviews the objectives of the MTBS project, describes the data sets and information provided, and presents results of the analysis of the 1984-2010 MTBS data set for the United States.

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## INTRODUCTION

The Monitoring Trends in Burn Severity (MTBS) project has mapped all large wildland fires in the conterminous United States, Alaska, and Hawaii from 1984 through 2010 using Landsat imagery. This 5-year project was completed in April 2012 by analysts at the U.S. Forest Service, Remote Sensing Applications Center and the U.S. Geological Survey, Earth Resources Observation and Science Center. This paper presents the first analysis of the complete 1984-2010 data set and presents broad-scale trends observed in the MTBS data record. Over this period, 14,945 fires were mapped in the conterminous United States (CONUS), Alaska, and Hawaii. In addition, this paper demonstrates how MTBS data can be used to compare different regions of the country in terms of fire frequency, burned area, and burn severity.

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## METHODS

For the purposes of this short paper, Geographic Area Coordination Center (GACC) boundaries are used to define the geographic regions. These GACC regions are defined by an interagency fire management organization made up of Federal and state wildland fire directors and have been chosen because the authorizing body for the MTBS project was the executive-level Wildland Fire Leadership Council. Undoubtedly there are more ecologically relevant alternatives to this tessellation of the United States.

### Burn Severity Mapping

Burn severity in the MTBS project refers to “degree to which a site has been altered or disrupted by fire; loosely, a product of fire intensity and residence time” (National Wildfire Coordinating Group 2005). Burn severity is mapped by the MTBS project using Landsat Thematic Mapper and Enhanced Thematic Mapper Plus data and the differenced Normalized Burn Ratio (dNBR) (Eidenshink et al. 2007). Analysts use dNBR images to delineate fire perimeters and to determine the dNBR thresholds for distinguishing between severity classes based on both scientific protocol and experience (Schwind 2008). For each fire, burned area is classified into one of four burn severity classes: unburned to low, low, moderate, or high (Fig. 1).

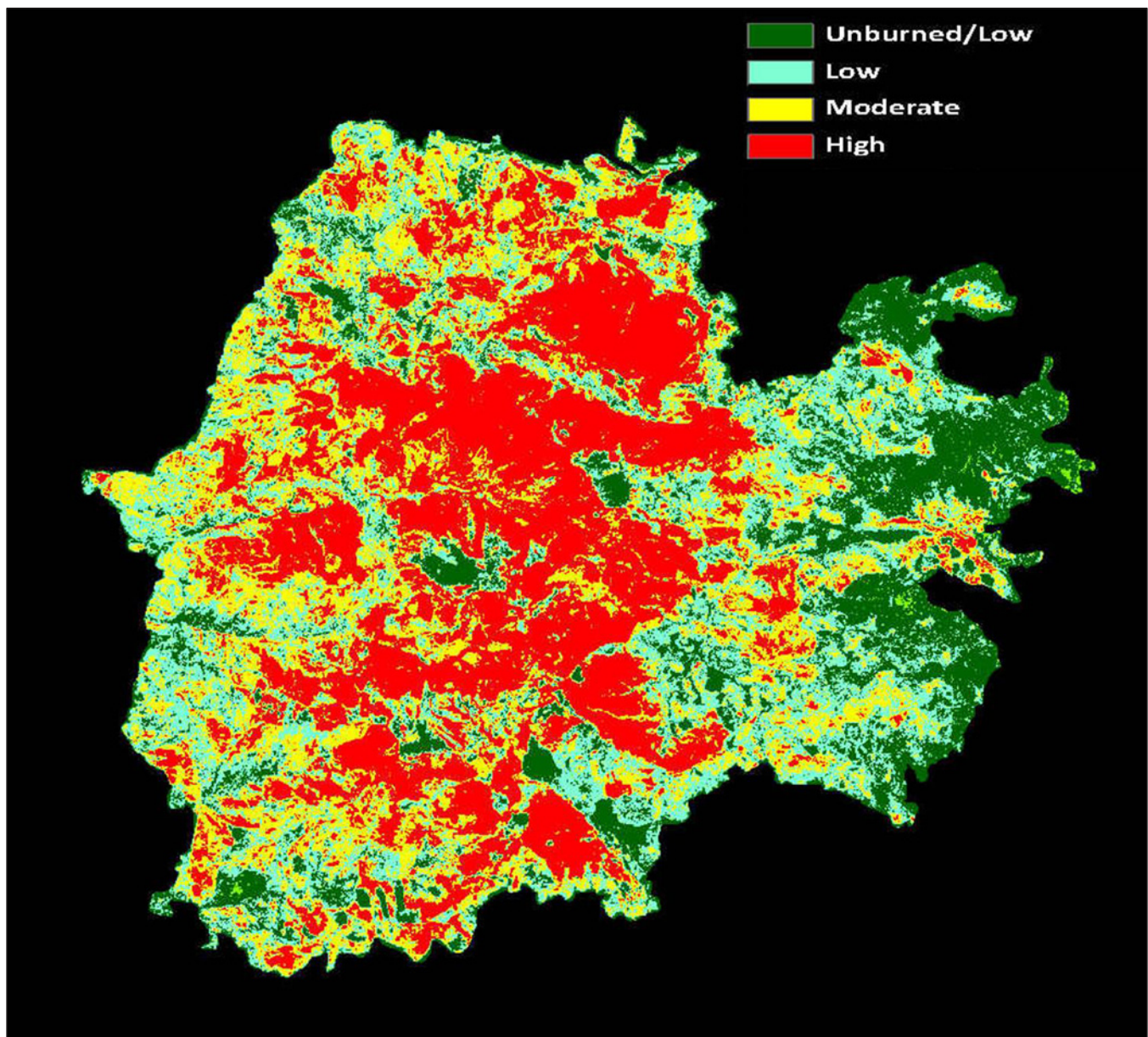


Figure 1.—Example of a burn severity map developed by the MTBS project.

## Data and Analysis Methods

### MTBS Fires Analyzed

The objective of the MTBS project is to provide a consistent and continuous source of 30-m resolution burn severity data for all fires greater than 1,000 acres in the western CONUS and 500 acres in the eastern CONUS, but many fires smaller than these size limits were mapped (MTBS 2012). For consistency in our analysis, this paper adheres to the original size limits. The number of fires was thus reduced to 13,400 and

burned area to about 110 million acres over the 27-year data record.

The MTBS data record also contains both documented wildland fires and prescribed fires, as noted in the MTBS fire occurrence database. Because this paper's focus is on the potential influences of biophysical, geographic, and climatic factors on natural fire behavior, only wildland fires were analyzed. Excluding prescribed fires further reduced the number of fires to 10,874 and burned area to about 104.6 million acres.

## Analysis Methods

The burned area and burn severity information for all large wildland fires was compiled in a database along with other attributes, such as fire name, type, and ignition date. Tabular and geographical summaries were generated from this database. This database is publicly accessible through a Web portal at [www.mtbs.gov/data/search.html](http://www.mtbs.gov/data/search.html). Statistical summaries available through the Web portal include burn severity by state, GACC, vegetation cover type, and administrative ownership.

The MTBS database was used to aggregate large wildland fires on a yearly basis to derive trends of fire frequency, size, and burn severity for each of the 11 regions (R Core Team 2012). In this paper we compare trends in large fire frequency and size for the Eastern Great Basin GACC and the Southern California GACC. We selected the Northwest GACC and Southwest GACC for comparison of trends in burn severity.

## NATIONAL AND REGIONAL WILDFIRE TRENDS

Between 1984 and 2010 approximately 22 percent of the area burned in CONUS was in the unburned to low burn severity class, 42 percent in the low class, 23 percent in the moderate class, and 12 percent in the high class. The following four figures show national and regional wildland fire trends in fire frequency, size, and burn severity.

### Fire Frequency and Size

The MTBS project mapped 10,137 large wildland fires with a total burned area of about 79.5 million acres in CONUS between 1984 and 2010. Generally, both fire frequency and size exhibited trends between 1984 and 2010 towards a larger number of fires and greater burned area despite large annual fluctuations (Fig. 2). The Nation experienced the largest fire year in 2006 in terms of both frequency and burned area, reaching a frequency of 843 fires and burned area of

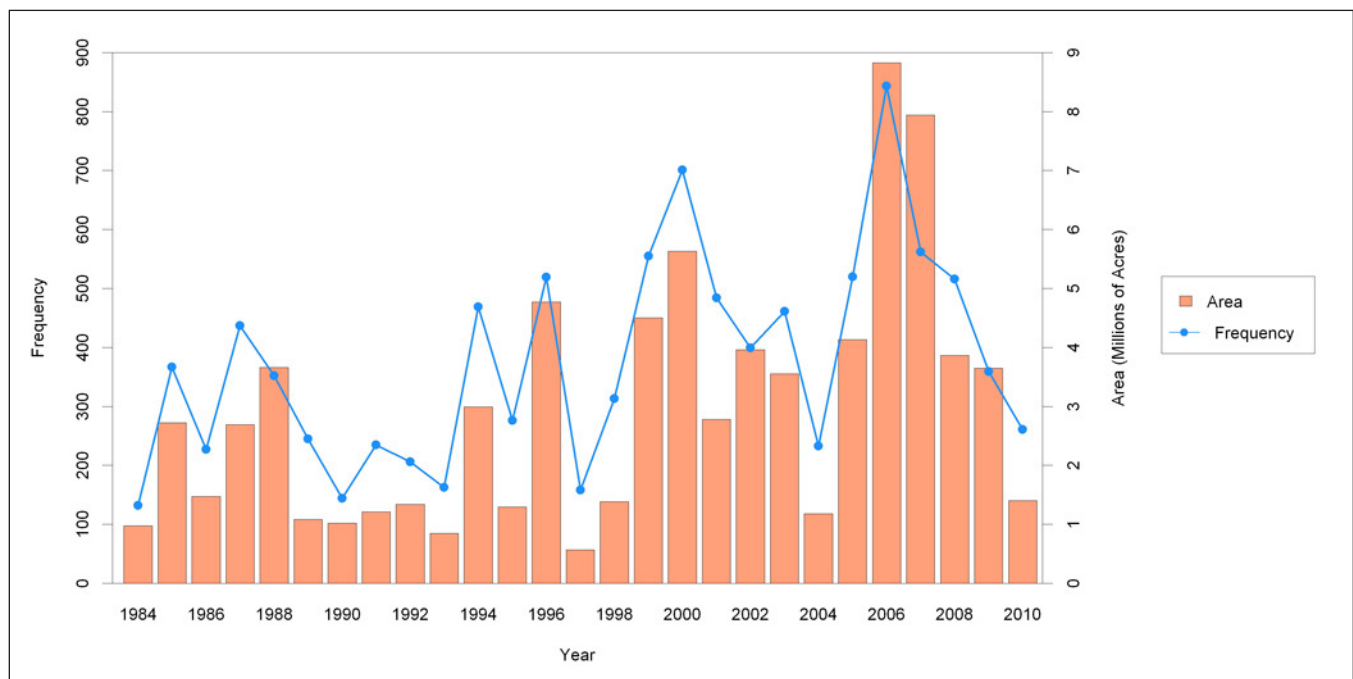


Figure 2.—Large fire frequency and size for CONUS, 1984-2010.



8.8 million acres. Outside of 2006, the years with the largest number of fires were, in descending order, 2000 (701), 2007 (562), and 1999 (555). The years with greatest burned area in descending order were 2007 (8 million acres), 2000 (5.6 million acres), and 1996 (4.8 million acres). The trend of burned area has a positive correlation ( $R^2 = 0.835$ ) with fire frequency. The largest mean fire size, 14,000 acres, occurred in 2007. The smallest, 3,600 acres, was in 1997. The 27-year mean fire size was about 2,500 acres and frequency was approximately 375 fires per year.

We compared trends in large fire frequency and size between the Eastern Great Basin GACC (EGB) and the Southern California GACC (SC) (Fig. 3). Although these regions have few biophysical similarities, using these two GACCs demonstrates how MTBS data can capture the variability in fire activity and acres burned between regions. While beyond the scope of this paper, comparison and evaluation of results can be made in the context of land cover and administrative ownership; immediate and long-term effects of weather, climate, and ecological conditions; and land management strategies.



Figure 3.—Large fire frequency and size in the EGB and SC, 1984-2010.

The EGB showed a small increasing trend in fire frequency in the EGB, while the SC did not show an obvious trend towards greater number of fires. The burned area in both GACCs slightly increased from 1984 to 2010. The EGB had a larger burned area and greater number of fires in most of the years than SC. The EGB also had a wider range in terms of both burned area and frequency, which parallels the cyclical nature of the fire seasons in that part of the country.

In the EGB, the largest burned area was about 2.56 million acres in 2007 and the smallest burned area was about 0.027 million acres in 1993. The highest fire frequency, 121 fires, occurred in 2006. The lowest number of fires was nine in 1993. In the SC, the largest burned area was in 2003 (0.8 million acres), and the smallest was about 0.014 million acres in 1991. The year 1996 had the largest fire frequency with 61 fires and 1991 had the smallest with 5. The mean fire size increased in recent years and reached the highest in 2007 in both GACCs (the same year of the largest mean fire size in CONUS): about 25,000 acres in the EGB, and 24,000 acres in the SC. The overall mean fire size over 27 years is slightly higher in the EGB

(about 10,000 acres) than in the SC (about 8,500 acres), both being much higher than that of CONUS (2,500 acres). Approximately 53 fires occur annually in the EGB and about 31 in the SC. The fire frequency is more correlated with burned area in the EGB ( $R^2 = 0.696$ ) than in the SC ( $R^2 = 0.325$ ), indicating a more stable yearly mean fire size in the EGB and episodic occurrences of megafire activity in SC. The trends of burned area and frequency in both GACCs do not fully correspond ( $R^2 = 0.183$  for burned area;  $R^2 = 0.095$  for frequency). Notable outliers were found in 1991 and 2000 for frequency, and in 2003 for burned area.

## Regional Differences in Burn Severity

Burn severity trends were analyzed and compared for the Northwest GACC (NW) (Fig. 4) and the Southwest (SW) GACC (Fig. 5). The mean percentage of severely burned area (moderate or high burn severity) in the NW was 32 percent, slightly above the CONUS average (28 percent) and significantly higher than that of the SW, which was about 24 percent. The NW also showed a wider range and fluctuation in the percentage

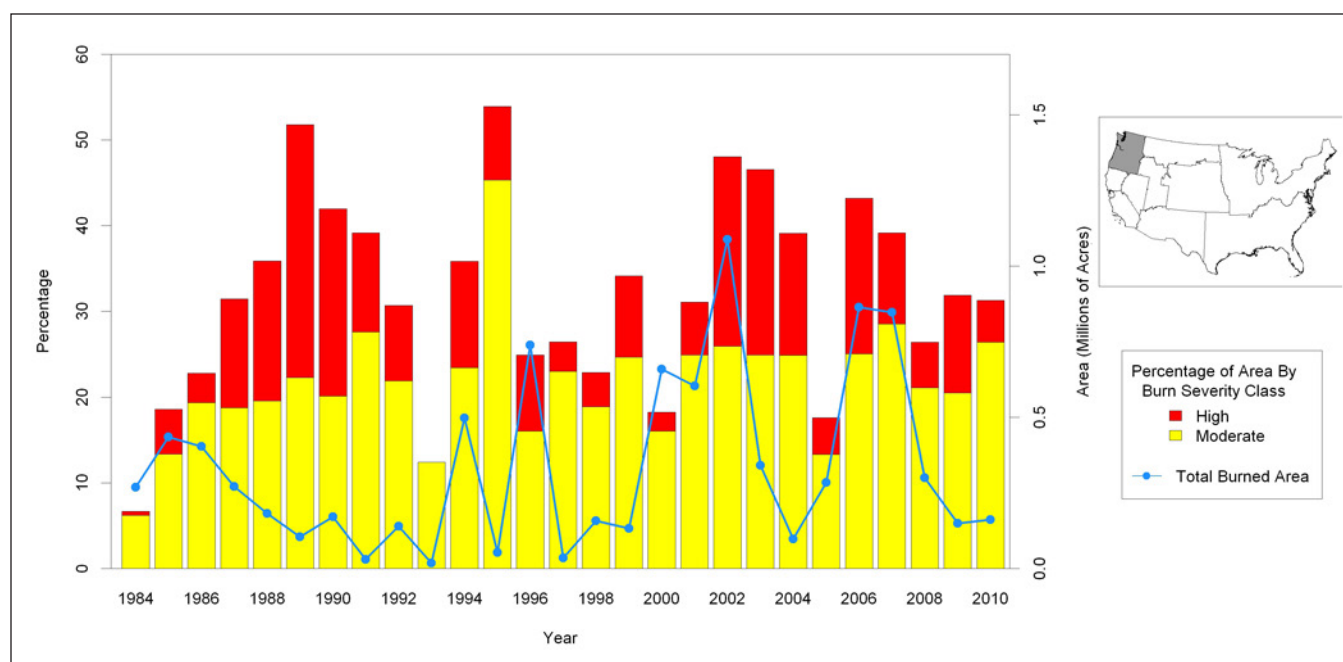


Figure 4.—Percentage of severely burned area (area with moderate or high burn severity) (scale on left axis) and total burned area (scale on right axis) in the Northwest GACC, 1984-2010.

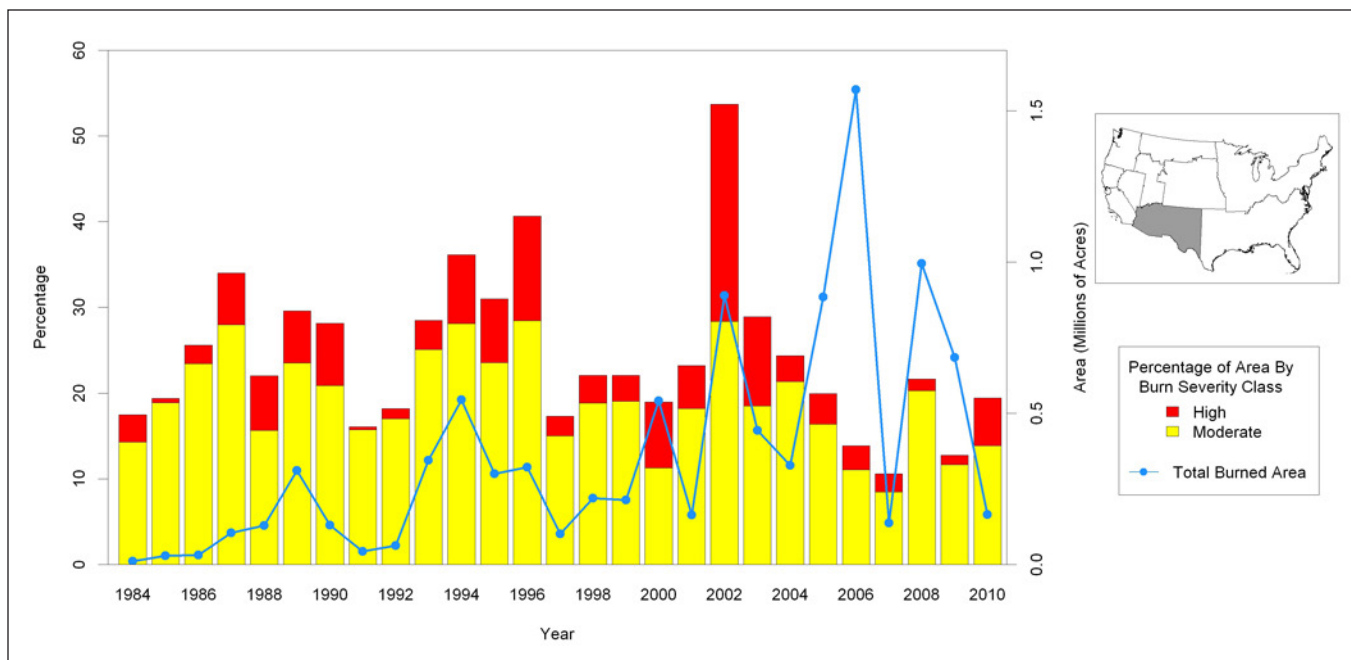


Figure 5.—Percentage of severely burned area (area with moderate or high burn severity) (scale on left axis) and total burned area (scale on right axis) in the Southwest GACC, 1984-2010.

of severely burned area. In the SW, the total burned area showed an increasing trend throughout the data record while in the NW, the total burned area decreased in the 1980s and early 1990s, and then greatly increased thereafter. In both GACCs, total burned area fluctuated more sharply from year to year in more recent years.

Because of the higher proportion of forest and biomass in the NW, that region burned more severely than the SW. The SW showed a trend toward lower burn severity; 2002 was an anomaly. Trends in burn severity and burned area did not correspond between the NW and SW, which is likely due to different weather and climate patterns, vegetation composition, and fire management. The  $R^2$  between the burned area and the sum of the percentage of area in the moderate and high burn severity classes was 0.202 for the NW and 0.085 for the SW. In both GACCs, the years with higher burn severity were not necessarily the years with larger burned areas. For example, in the NW, the most severely burned year was 1995, when the percentage of severely burned area was 54 percent, but the area burned in that year was among the smallest, only about 0.052 million acres.

## DISCUSSION

For scientists interested in understanding regional and national trends in wildland fire, the MTBS dataset has no peer. As with any data set, however, a clear understanding of how the MTBS data were created and what fires are included is important before analyzing trends. Without this knowledge, the trends observed could be an artifact of the data selected for analysis or the data generation process.

When appropriately filtered, the data show clear fluctuations and trends in fire frequency, size, and burn severity, both nationwide and between regions. Our analysis showed a trend toward increasing fire size (though very cyclical), but not such a clear trend toward increasing fire severity. Comparison of fire frequency, size, and severity for different geographic areas highlights what we hypothesize to be biophysical and climatic differences between the regions in this time period. Further analysis is required to substantiate these causal relationships.

## ACKNOWLEDGMENTS

The authors would like to acknowledge the cross-Deputy funding that comes to the MTBS project from the Forest Service's Information Resources Decision Board.

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