CHAPTER 3.

Large-Scale Patterns of Forest Fire Occurrence in the Conterminous United States and Alaska, 2012

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INTRODUCTION

Free-burning wildland fire has been a frequent ecological presence on the American landscape, and its expression has changed as new peoples and land uses have become predominant (Pyne 2010). As a pervasive disturbance agent operating at many spatial and temporal scales, wildland fire is a key abiotic factor affecting forest health both positively and negatively. In some ecosystems, wildland fires have been essential for regulating processes that maintain forest health despite causing extensive tree mortality (Lundquist and others 2011). Wildland fire, for example, is an important ecological mechanism that shapes the distributions of species, maintains the structure and function of fire-prone communities, and acts as a significant evolutionary force (Bond and Keeley 2005).

At the same time, wildland fires have created forest health problems in certain ecosystems (Edmonds and others 2011). Specifically, fire outside its historic range of frequency and intensity in a given forest ecosystem can impose extensive ecological and socioeconomic impacts. Current fire regimes on more than half of the forested area in the conterminous United States have been moderately or significantly altered from historical regimes, potentially altering key ecosystem components such as species composition, structural stage, stand age, canopy closure, and fuel loadings (Schmidt and others 2002). Understanding existing fire regimes is essential to properly assessing the impact of fire on forest health because changes to historical fire regimes can alter forest developmental patterns, including the establishment, growth, and mortality of trees (Lundquist and others 2011).

As a result of intense suppression efforts during most of the 20th century, the number of acres burned annually decreased from approximately 16-20 million ha (40-50 million acres) in the early 1930s to about 2 million ha (5 million acres) in the 1970s (Vinton 2004). In some regions, plant communities have experienced or are undergoing rapid compositional and structural changes because of fire suppression (Nowacki and Abrams 2008). At the same time, fires in some regions and ecosystems have become larger, more intense, and more damaging because of the accumulation of fuels as a result of prolonged fire suppression (Pyne 2010). Such large wildland fires also can have long lasting social and economic consequences, which include the loss of human life and property, smoke-related human health impacts, and the cost of fighting the fires themselves (Gill and others 2013, Richardson and others 2012).

Fire regimes have been dramatically altered, in particular, by fire suppression (Barbour and others 1999) and by the introduction of nonnative invasive plants, which can change fuel properties and in turn both affect fire behavior and alter fire regime characteristics such as frequency, intensity, type, and seasonality (Brooks and others 2004). Additionally, changes in fire intensity and recurrence could result in decreased forest resilience and persistence (Lundquist and others 2011), and fire regimes altered by global climate change could cause large-scale shifts in vegetation spatial patterns (McKenzie and others 1996).

This chapter presents analyses of high-temporal fidelity fire occurrence data, collected nationally by satellite, that map and quantify where fire occurrences have been concentrated spatially across the conterminous United States and Alaska in 2012. It also, within a geographic context, compares 2012 fire occurrences to all the recent years for which such data are available. Quantifying and monitoring such broad-scale patterns of fire occurrence across the United States can help improve the understanding of the ecological and economic impacts of fire as well as the appropriate management and prescribed use of fire. Specifically, large-scale assessments of fire occurrence can help identify areas where specific management activities may be needed, or where research into the ecological and socioeconomic impacts of fires may be necessary.

METHODS

Data

Annual monitoring and reporting of active wildland fire events using the Moderate Resolution Imaging Spectroradiometer (MODIS) Active Fire Detections for the United States database (USDA Forest Service 2013) allows analysts to spatially display and summarize fire occurrences across broad geographic regions (Coulston and others 2005; Potter 2012a, 2012b, 2013a, 2013b, 2014). A fire occurrence is defined as one daily satellite detection of wildland fire in a 1-km^2 pixel, with multiple fire occurrences possible on a pixel across multiple days. The data are derived using the MODIS Rapid Response System (Justice and others 2002, 2011) to extract fire location and intensity information from the thermal infrared bands of imagery collected daily by two satellites at a resolution of 1 km^2, with the center of a pixel recorded as a fire occurrence (USDA Forest Service 2013). The Terra and Aqua satellites' MODIS sensors identify the presence of a fire at the time of image collection with Terra observations collected in the morning and Aqua observations collected in the afternoon. The resulting fire occurrence data represent only whether a fire was active, because the MODIS thermal bands do not differentiate between a hot fire in a relatively small area (0.01 km^2, for example) and a cooler fire over a larger area (1 km^2, for example). The MODIS Active Fire database does well at capturing large fires during cloud-free conditions, but may underrepresent rapidly burning, small, and low-intensity fires, as well as fires in areas with frequent cloud cover (Hawbaker and others 2008). For more information about the performance of this product, see Justice and others (2011).

Analyses

These MODIS products for 2012 were subjected to Geographic Information System (GIS) processing to determine number of fire occurrences per 100 km^2 (10 000 ha) of forested area for each ecoregion section in the conterminous United States (Cleland and others 2007) and Alaska (Nowacki and Brock 1995). This forest fire occurrence density measure was calculated after screening out wildland fires on nonforested pixels using a forest cover layer derived from MODIS imagery by the U.S. Forest Service Remote Sensing Applications Center (USDA Forest Service 2008). The total numbers of forest fire occurrences were also determined separately for the conterminous States and for Alaska.

The fire occurrence density value for each ecoregion in 2012 was then compared to the mean fire density values for the first 11 full years of MODIS Active Fire data collection (2001–11). Specifically, the difference of the 2012 value and the previous 11-year mean for an ecoregion was divided by the standard deviation across the previous 11-year period, assuming normal distribution of fire density over time in the ecoregion. The result for each ecoregion was a standardized *z*-score, which is a dimensionless quantity describing if the fire occurrence density in the ecoregion in 2012 was higher, lower, or the same relative to all the previous years for which data have been collected, accounting for the variability in the previous years. The *z*-score is the number of standard deviations between the observation and the mean of the previous observations. Approximately 68 percent of observations would be expected within one standard deviation of the mean, and 95 percent within two standard deviations. Near-normal conditions are classified as those within a single standard deviation of the mean, although such a threshold is somewhat arbitrary. Those outside about two standard deviations would be considered statistically greater than or less than the long-term mean (at $p < 0.025$ at each tail of the distribution).

Additionally, a Getis-Ord hot spot analysis (Getis and Ord 1992) in ArcMap® 9.2 (ESRI 2006) was employed to identify forested areas in the conterminous United States with higher-than-expected fire occurrence density in 2012. The spatial units of analysis were 3,382 cells of approximately 2500 km^2 from a hexagonal lattice of the conterminous United States, intensified from Environmental Monitoring and Assessment Program (EMAP) North America hexagon coordinates (White and others 1992). This cell size allows for analysis at a medium-scale resolution of approximately the same area as a typical county. Fire occurrence density values for each hexagon were quantified as the number of forest fire occurrences per 100 km^2 of forested area within the hexagon.

The Getis-Ord G_i* statistic was used to identify clusters of hexagonal cells with fire occurrence density values higher than expected by chance. This statistic allows for the decomposition of a global measure of spatial association into its contributing factors, by location, and is therefore particularly suitable for detecting outlier assemblages of similar conditions (i.e., non-stationarities) in a data set, such as when spatial clustering is concentrated in one subregion of the data (Anselin 1992).

Briefly, G_i* sums the differences between the mean values in a local sample, determined in this case by a moving window of each hexagon and its 18 first- and second-order neighbors (the 6 adjacent hexagons and the 12 additional hexagons contiguous to those 6), and the global mean of all the forested hexagonal cells in the conterminous United States. G_i* is standardized as a *z*-score with a mean of 0 and a standard deviation of 1, with values > 1.96 representing significant local clustering of higher fire occurrence densities ($p < 0.025$), and values <-1.96 representing significant clustering of lower fire occurrence densities ($p < 0.025$), since 95 percent of the observations under a normal distribution should be within approximately 2 standard deviations of the mean (Laffan 2006). Values between -1.96 and 1.96 have no statistically significant concentration of high or low values; a hexagon and its 18 neighbors, in other words, have a range of both high and low numbers of fire occurrences per 100 km^2 of forested area. It is worth noting that the threshold values are not exact because the correlation of spatial data violates the assumption of independence required for statistical significance (Laffan 2006). The Getis-Ord approach does not require that the input data be normally distributed because the local G_i* values are computed under a randomization assumption, with G_i* equating to a standardized *z*-score that asymptotically tends to a normal distribution (Anselin 1992). The *z*-scores are reliable, even with skewed data, as long as the distance band is large enough to include several neighbors for each feature (ESRI 2006).

RESULTS AND DISCUSSION

The MODIS Active Fire database captured 138,000 wildland forest fire occurrences across the conterminous United States in 2012, the most of any year of MODIS data collection (fig. 3.1). This number was approximately 77 percent greater than in 2011 (78,235 forest fire occurrences) and more than twice the 64,929 mean annual forest fire occurrences over the previous 11 full years of data collection. In contrast, the MODIS database captured only 687 forest fire occurrences in Alaska in 2012, the third fewest since 2001 and a small fraction of the previous 11-year annual mean of 13,428.

The increase in the total number of fire occurrences across the conterminous States is generally consistent with the official wildland

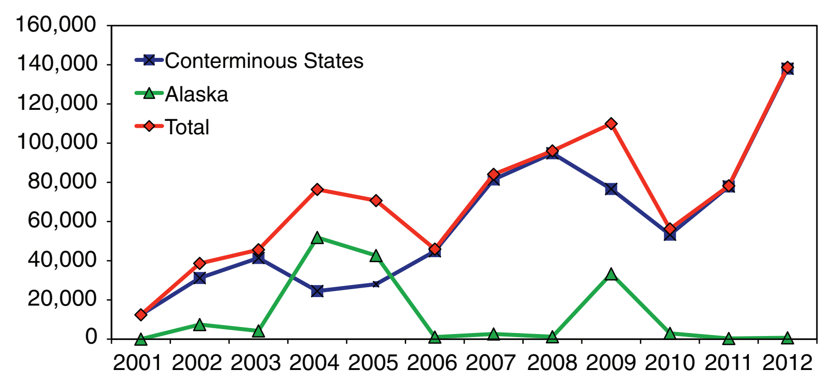


Figure 3.1—Forest fire occurrences detected by Moderate Resolution Imaging Spectroradiometer (MODIS) from 2001 through 2012 for the conterminous United States, Alaska, and the two regions combined. (Data source: U.S. Department of Agriculture Forest Service, Remote Sensing Applications Center)

fire statistics; the area burned nationally in 2012 (3 774 195 ha) was 128 percent of the 10-year average, with 51 fires exceeding 16 187 ha (10 more than in 2011) (National Interagency Coordination Center 2013). The total area burned nationally represented a 7-percent increase from 2011 (3 525 365 ha) (National Interagency Coordination Center 2012). It is important to note that estimates of burned area and calculations of MODIS-detected fire occurrences are different metrics for quantifying fire activity within a given year. Most importantly, the MODIS data contain both spatial and temporal components, since persistent fire will be detected repeatedly over several days on a given 1-km^2 pixel. Analyses of the MODIS-detected fire occurrences, therefore, measure the total number of 1-km^2 pixels each day with fire, as opposed to quantifying only the area on which fire occurred at some point during the course of the year.

In 2012, the highest forest fire occurrence densities occurred in ecoregions of the Interior West (fig. 3.2), where a summer heat wave combined with record to near-record dryness following below-normal winter snowpack. Colorado and Wyoming, for example, had their warmest summers on record, while Wyoming, South Dakota, and New Mexico had one of the driest summers in history (National Interagency Coordination Center 2013). The drought conditions resulted in below-normal fuel moisture and above-normal Energy Release Component indices from New Mexico west to California and north to southern Oregon, Idaho, and Wyoming (National Interagency Coordination Center 2013).

The forested ecoregion with the highest wildland forest fire occurrence density in 2012 (a remarkable 93.5 fires per 100 km^2 of forest) was section M332A–Idaho Batholith (fig. 3.2). This ecoregion section is located in the Eastern Great Basin Geographic Region where official wildland fire statistics recorded nearly 800 000 ha burned (National Interagency Coordination Center 2013), including the 138 179-ha Mustang Complex fire. To the southeast, the M331J–Wind River Mountains ecoregion in western Wyoming experienced a fire occurrence density of 31.9 fires per 100 km^2 of forest. Meanwhile, several ecoregions that contain relatively small amounts of forest (and therefore do not stand out as easily on fig. 3.2) had even higher fire occurrence densities than the Wind River Mountains:

- 331G–Powder River Basin in northeastern Wyoming and southeastern Montana (135.0 fire occurrences per 100 km^2 of forest)
- 331F–Western Great Plains in northwestern Nebraska and southwestern South Dakota (49.6 per 100 km^2 of forest)
- 342B–Northwestern Basin and Range in northwestern Nevada and southeastern Oregon (43.3 per 100 km^2 of forest)
- 331K–North Central Highlands in eastern Montana (38.0 per 100 km^2 of forest)

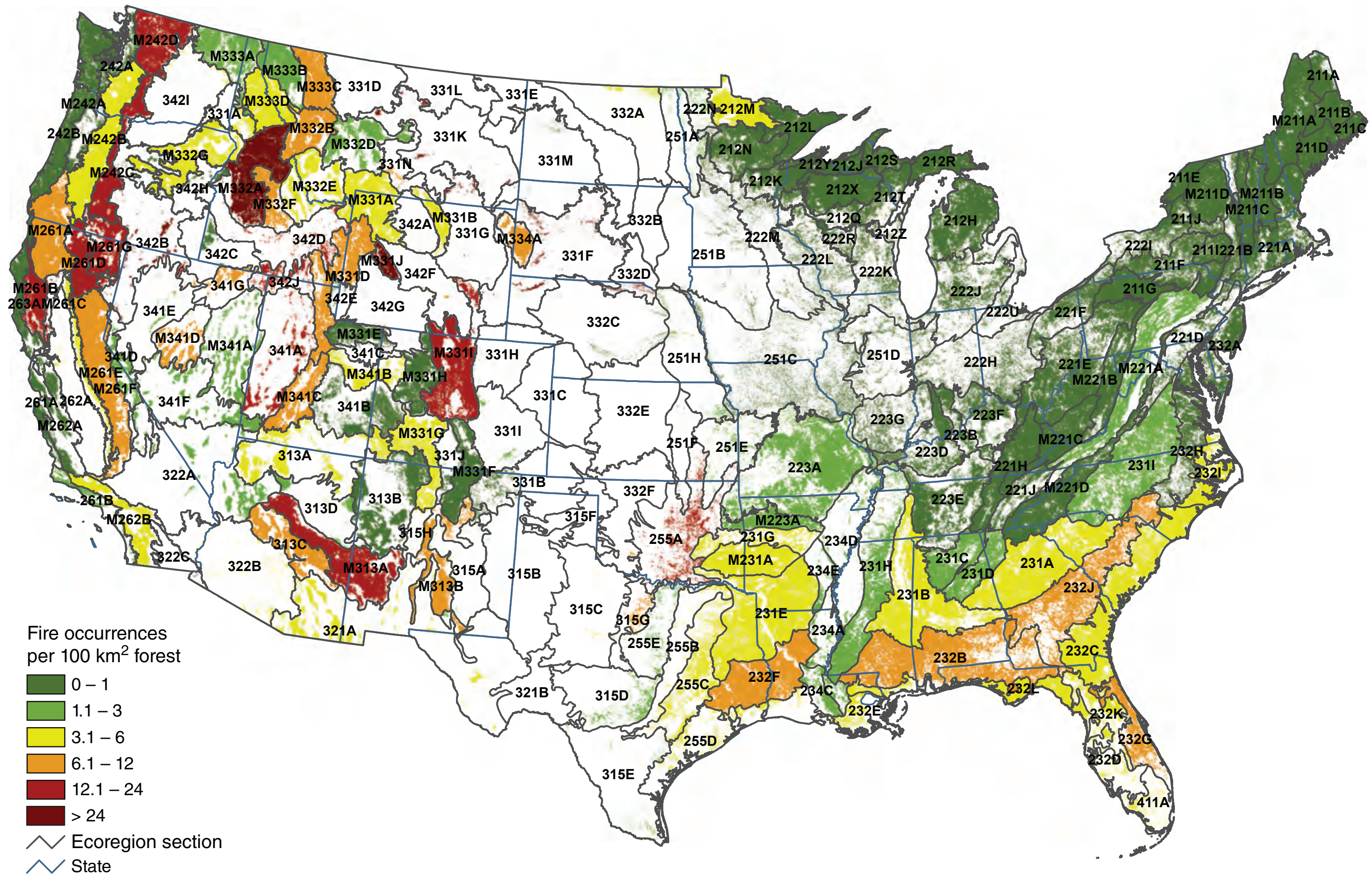


Figure 3.2—The number of forest fire occurrences per 100 km² (10 000 ha) of forested area, by ecoregion section within the conterminous United States for 2012. The gray lines delineate ecoregion sections (Cleland and others 2007). Forest cover is derived from Moderate Resolution Imaging Spectroradiometer (MODIS) imagery by the U.S. Forest Service Remote Sensing Applications Center. (Source of fire data: U.S. Department of Agriculture Forest Service, Remote Sensing Applications Center)

Elsewhere in the West, high fire occurrence densities were detected from northern California (M261C–Northern California Interior Coast Ranges, 24.9 fire occurrences per 100 km^2 of forest; and M261B–Northern California Coast Ranges, 20.5 fire occurrences) along the Cascade Mountains into Oregon and Washington (M261D–Southern Cascades, 18.6 fire occurrences; M261G–Modoc Plateau, 23.4 fire occurrences; M242C–Eastern Cascades, 12.8 fire occurrences; and M242D–Northern Cascades, 12.7 fire occurrences).

Meanwhile, the M313A–White Mountains-San Francisco Peaks-Mogollon Rim ecoregion experienced 18.6 fire occurrences per 100 km^2 of forest, driven in part by the 120 534 ha Whitewater-Baldy Complex fire, the largest in New Mexico history. In north-central Colorado, several fires, including the highly destructive High Park and Waldo Canyon fires, resulted in 12.1 fire occurrences for each 100 km^2 of forest in M331I–Northern Parks and Ranges. High fire occurrence densities were also evidenced in western Utah (18.8 for both 342J–Eastern Basin and Range and 341A–Bonneville Basin).

Ecoregions of the Southeastern United States generally experienced moderate fire occurrence densities in 2012, fewer than recent years in many locations. One exception incorporated the forested areas of central Oklahoma (255A–Cross Timbers and Prairie), where 12.9 fires were detected per 100 km^2 of forest (fig. 3.2). Southeastern ecoregions with relatively high fire densities included 232F–Coastal Plains and Flatwoods-Western Gulf (Louisiana and east Texas, 8.0 fire occurrences), 232G–Florida Coastal Lowlands-Atlantic (eastern Florida, 7.3 fire occurrences), 232B–Gulf Coast Plains and Flatwoods (7.0 fire occurrences), and 232J–Southern Atlantic Coastal Plains and Flatwoods (6.8 fire occurrences).

Fire occurrence densities, meanwhile, were almost universally low in the Northeastern and Midwestern States, with two exceptions: 332A–Northeastern Glaciated Plains (in northern North Dakota, 3.9 fire occurrences) and 212M–Northern Minnesota and Ontario (in northern Minnesota, 3.6 fire occurrences).

Meanwhile, few fire occurrences were detected in Alaska, which experienced near-normal summer temperatures and above-normal precipitation (National Interagency Coordination Center 2013). No Alaskan ecoregion had more than a single fire occurrence per 100 km^2 of forest (fig. 3.3). The M131A–Upper Kobuk-Koyukuk ecoregion had the highest fire occurrence density, with only 0.7 fire occurrences detected per 100 km^2 of forest, followed by 131B–Kuskokwim Colluvial Plain (0.6 fire occurrences per 100 km^2 of forest).

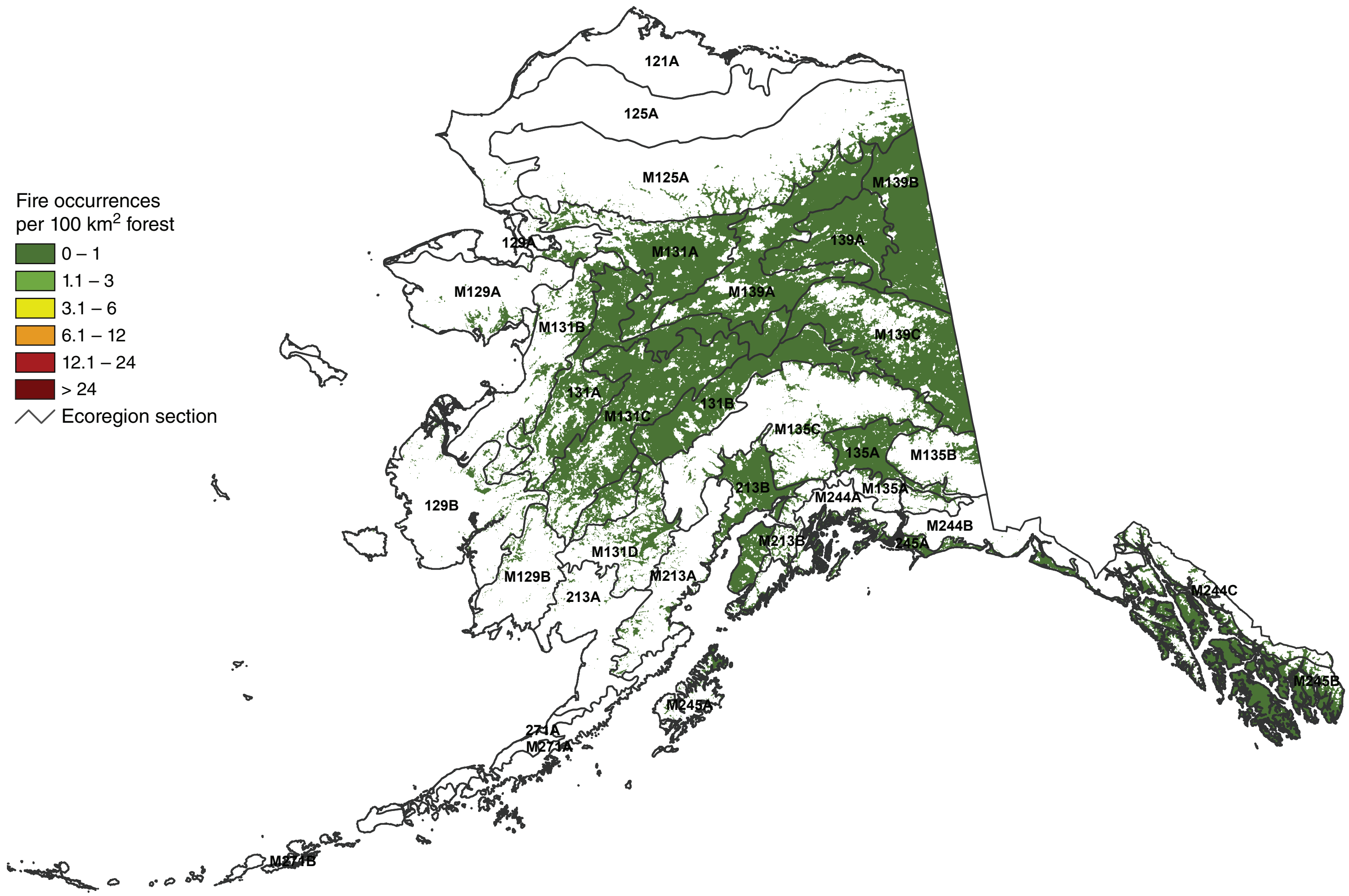


Figure 3.3—The number of forest fire occurrences per 100 km^2 (10 000 ha) of forested area, by ecoregion section in Alaska for 2012. The gray lines delineate ecoregion sections (Nowacki and Brock 1995). Forest cover is derived from Moderate Resolution Imaging Spectroradiometer (MODIS) imagery by the U.S. Forest Service Remote Sensing Applications Center. (Source of fire data: U.S. Department of Agriculture Forest Service, Remote Sensing Applications Center)

Comparison to Longer-term Trends

Contrasting short-term (1-year) wildland forest fire occurrence with longer-term trends is possible by comparing these results for each ecoregion section to the first 11 full years of MODIS Active Fire data collection (2001–11). In general, most ecoregions within the Northeastern, Midwestern, Middle Atlantic, Appalachian, and Central Rocky Mountain regions experienced < 1 fire per 100 km^2 of forest over that period, with means higher in the Northern Rocky Mountain, California, Southeastern, and Southwestern regions (fig. 3.4A). Heavily forested ecoregions that have experienced the most fires on average are located in central Idaho, near the southern California coast, and in north-central Texas (mean annual fire occurrence densities of 6.1–12.0). Ecoregions with the greatest variation in fire occurrence densities over time based on the standard deviation from 2001–11 were also located along the California coast and in central Idaho, with moderate variation in western Montana, central and southeastern Arizona and southwestern New Mexico, and eastern North Carolina (fig. 3.4B). Lesser degrees of variation occurred throughout the Southeast, central California, noncoastal Oregon and Washington, northwestern Wyoming, and northern Minnesota. The least variation was apparent throughout most of the Midwest and Northeast.

In 2012, large areas of the conterminous United States experienced greater fire occurrence densities than normal, compared to the previous 11-year mean and accounting for variability over time based on a standardized *z*-score (fig. 3.4C). This included much of the Rocky Mountain region, and parts of the Pacific Northwest, Middle Atlantic, Great Lakes, and Southeastern regions. Several of these were ecoregions that had very high fire occurrence densities in 2012, including M332A–Idaho Batholith (in Idaho), M331J–Wind River Mountains (in Wyoming), M331I–Northern Parks and Ranges (in Colorado and Wyoming), M313A–White Mountains–San Francisco Peaks-Mogollon Rim (in Arizona and New Mexico), M261D–Southern Cascades (in California and Oregon), M261G–Modoc Plateau (in California and Oregon), and M242C–Eastern Cascades (in Oregon and Washington). Others had moderate fire occurrence densities in 2012 that still deviated considerably from the previous 11-year mean, including 212M–Northern Minnesota and Ontario (in Minnesota), 232F–Coastal Plains and Flatwoods-Western Gulf (in Texas and Louisiana), M331G–Central Highlands (in Colorado and New Mexico), M341C–Utah High Plateau (in Utah), M334A–Black Hills (in South Dakota and Wyoming), M331B–Bighorn Mountains (in Wyoming), and M332E–Beaverhead Mountains (in Montana and Idaho).

Of perhaps greater interest are the many ecoregions across much of the Eastern United States that had low fire occurrence densities in 2012 that were still higher than the longer-term mean, accounting for variability over time (fig. 3.4C). In the Southeast, these included 234C–Atchafalaya and Red River Alluvial Plains

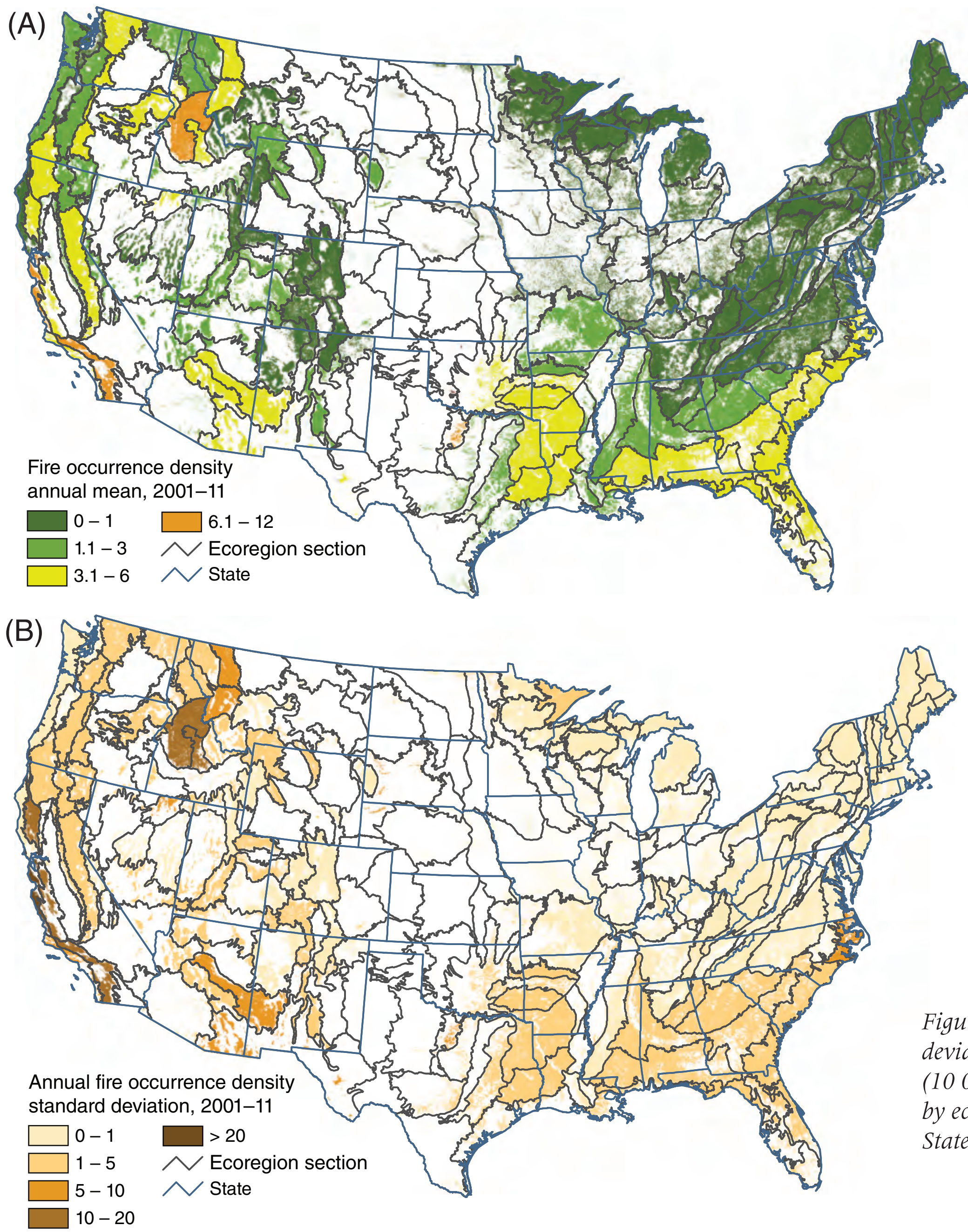


Figure 3.4—(A) Mean number and (B) standard deviation of forest fire occurrences per 100 km^2 (10 000 ha) of forested area from 2001 through 2011, by ecoregion section within the conterminous United States. *(continued on next page)*

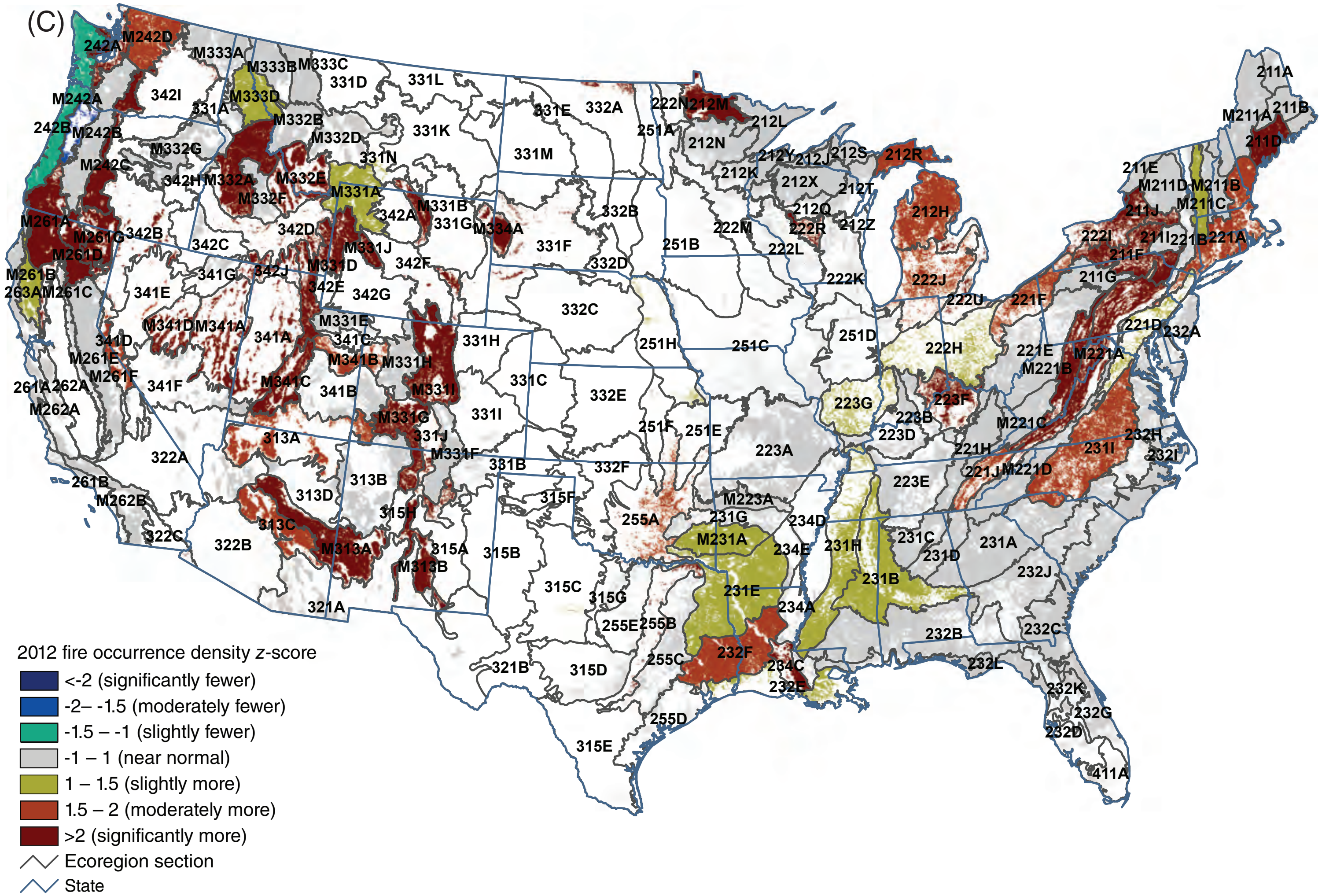


Figure 3.4 (continued)—(C) Degree of 2012 fire occurrence density excess or deficiency by ecoregion relative to 2001–11 and accounting for variation over that time period. The gray lines delineate ecoregion sections (Cleland and others 2007). Forest cover is derived from Moderate Resolution Imaging Spectroradiometer (MODIS) imagery by the U.S. Forest Service Remote Sensing Applications Center. (Source of fire data: U.S. Department of Agriculture Forest Service, Remote Sensing Applications Center)

(in Louisiana), 221J–Central Ridge and Valley (in Tennessee), and 231I–Central Appalachian Piedmont (in North Carolina and Virginia). In the vicinity of the Great Lakes, these included 222R–Wisconsin Central Sands (in Wisconsin); 221F–Western Glaciated Allegheny Plateau (in Ohio and Pennsylvania); 222I–Erie and Ontario Lake Plain (in New York, Pennsylvania, and Ohio); and 212R–Eastern Upper Peninsula, 212H–Northern Lower Peninsula, 222J–South Central Great Lakes, and 222U–Lake Whittlesey Glaciolacustrine Plain (in Michigan). In the Central and Northern Appalachians, there were four such ecoregions: M221B–Allegheny Mountains, M221A–Northern Ridge and Valley, 211F–Northern Glaciated Allegheny Plateau, and 221J–Tug Hill Plateau-Mohawk Valley. In New England, meanwhile, two ecoregions with low fire occurrence density in 2012 had fire densities exceeding the long term mean: 221A–Lower New England and 221D–Central Maine Coastal and Embayment.

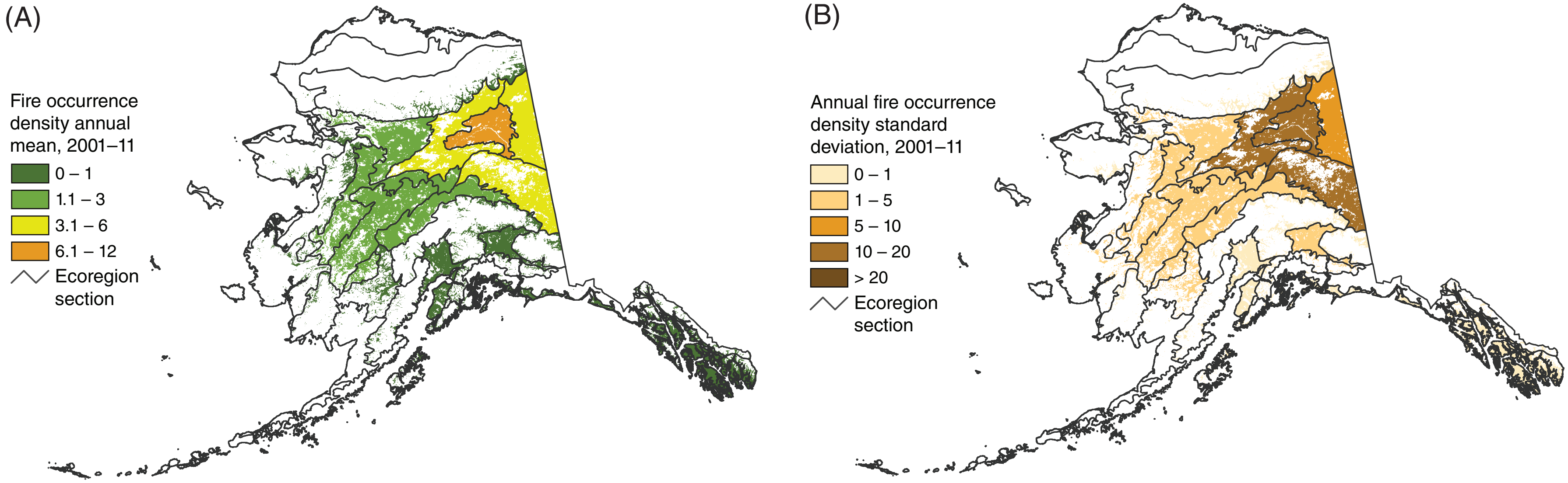
Only one ecoregion in the conterminous United States had a lower fire occurrence density in 2012 compared to the longer-term: M242A–Oregon and Western Coast Ranges (fig. 3.4C). This is a region with a relatively low annual mean fire occurrence density (1.37 fires per 100 km^2 of forest per year) and a low level of variability in that mean. With above-average spring and summer precipitation (National Interagency Coordination Center 2013), it had a fire occurrence density of only 0.72 fires per 100 km^2 of forest in 2012.

In Alaska, meanwhile, the highest mean annual fire occurrence density between 2001 and 2011 occurred in the east-central and central parts of the State (fig. 3.5A) in the 139A–Yukon Flats ecoregion, with moderate mean fire occurrence density in neighboring areas. Many of those same areas experienced the greatest degree of variability over the 11-year period (fig. 3.5B). In 2012, no ecoregions were outside the range of near-normal fire occurrence density, compared to the mean of the previous 11 years and accounting for variability (fig. 3.5C).

Geographic Hot Spots of Fire Occurrence Density

While summarizing fire occurrence data at the ecoregion scale allows for the quantification of fire occurrence density across the country, a geographic hot spot analysis can offer insights into where, statistically, fire occurrences are more concentrated than expected by chance. In 2012, the most intense geographic hot spots of fire density within the conterminous United States were located in the Northern Rocky Mountain region (fig. 3.6). The largest of these occurred across parts of seven ecoregion sections in central Idaho and western Montana:

- M332A–Idaho Batholith
- M332F–Challis Volcanics
- M332E–Beaverhead Mountains
- M332B–Northern Rockies and Bitterroot Valley
- M333D–Bitterroot Mountains
- 331A–Palouse Prairie
- M332G–Blue Mountains



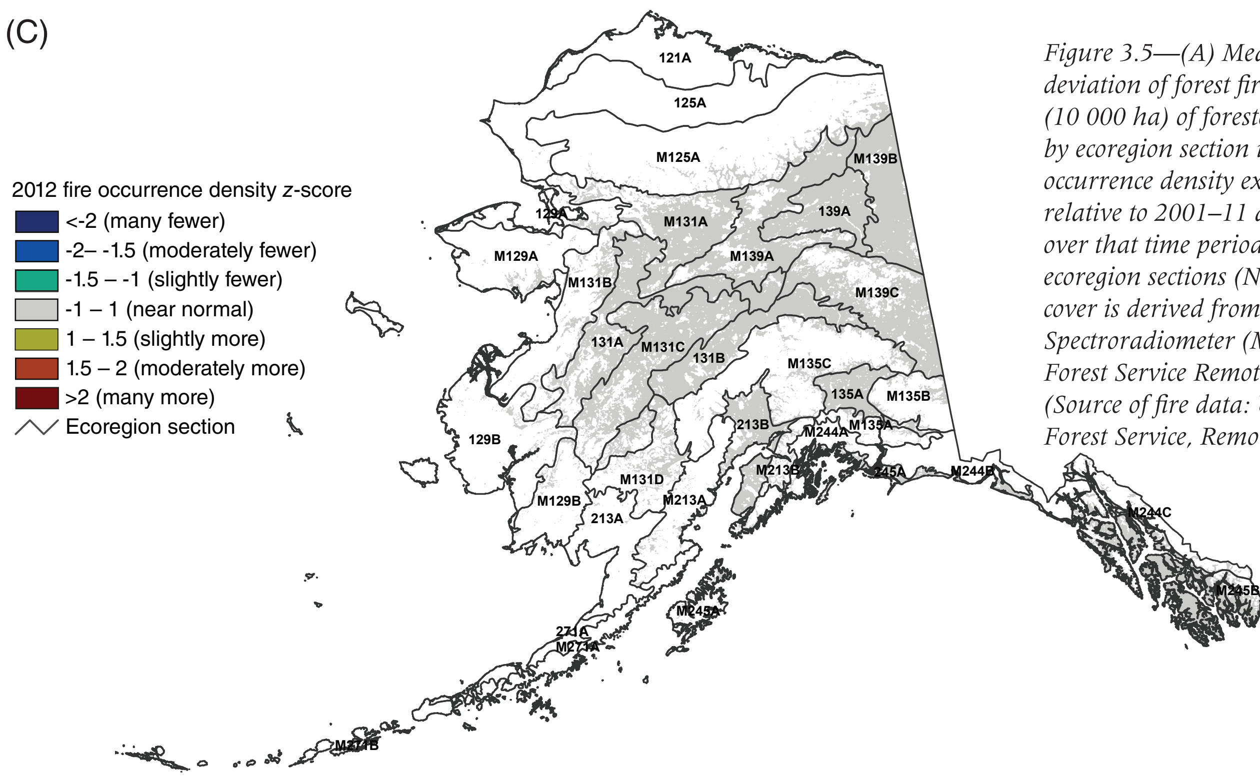


Figure 3.5—(A) Mean number and (B) standard deviation of forest fire occurrences per 100 km^2 (10 000 ha) of forested area from 2001 through 2011, by ecoregion section in Alaska. (C) Degree of 2012 fire occurrence density excess or deficiency by ecoregion relative to 2001–11 and accounting for variation over that time period. The gray lines delineate ecoregion sections (Nowacki and Brock 1995). Forest cover is derived from Moderate Resolution Imaging Spectroradiometer (MODIS) imagery by the U.S. Forest Service Remote Sensing Applications Center. (Source of fire data: U.S. Department of Agriculture Forest Service, Remote Sensing Applications Center)

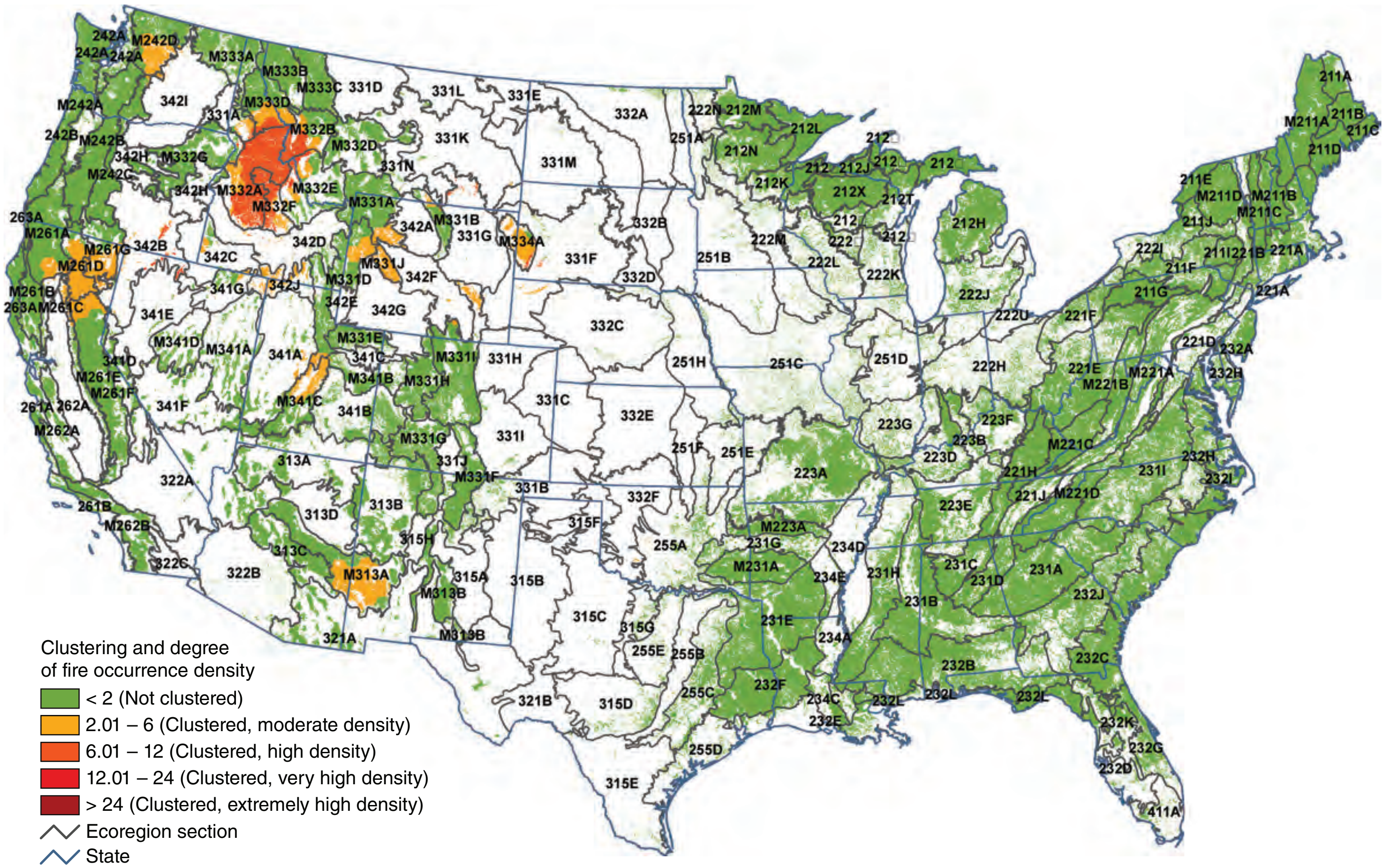


Figure 3.6—Hot spots of fire occurrence across the conterminous United States for 2012. Values are Getis-Ord G_i** scores, with values >2 representing significant clustering of high fire occurrence densities. (No areas of significant clustering of low fire occurrence densities, <-2, were detected.) The gray lines delineate ecoregion sections (Cleland and others 2007). Background forest cover is derived from Moderate Resolution Imaging Spectroradiometer (MODIS) imagery by the U.S. Forest Service Remote Sensing Applications Center. (Source of fire data: U.S. Department of Agriculture Forest Service, Remote Sensing Applications Center)*

About 200 km to the southwest, a smaller but also intense hot spot was located in the forested portions of northwestern Nevada and southeastern Oregon (342B–Northwestern Basin and Range ecoregion). Two other small areas of intense forest fire occurrence clustering were detected in southeastern Montana (331G–Powder River Basin) and western South Dakota (M334A–Black Hills and 331F–Western Great Plains). Several less intense geographic hot spots of fire occurrence density were also detected in the Northern Rocky Mountains, including:

- Western Wyoming (M331J–Wind River Mountains, M331D–Overthrust Mountains, and M331A–Yellowstone Highlands)
- Southeastern Wyoming (M331I–Northern Parks and Ranges)
- Northern Utah, southern Idaho, and northeastern Nevada (342J–Eastern Basin and Range and 341G–Northeastern Great Basin)
- Southwestern Idaho (342C–Owyhee Highlands)
- Central Utah (M341C–Utah High Plateau and 341A–Bonneville Basin)

The Getis-Ord hot spot analysis also detected less-intense concentrations of forest fire occurrence density in western New Mexico/eastern Arizona (M313A–White Mountains-San Francisco Peaks-Mogollon Rim), in north-central Washington (M242D–Northern Cascades and M242C–Eastern Cascades), and in northern California (M261D–Southern Cascades, M261G–Modoc Plateau, M261E–Sierra Nevada, M261F–Sierra Nevada Foothills, and M261A–Klamath Mountains). No hot spots of fire occurrence density were detected in the Eastern United States in 2012.

CONCLUSION

The results of these geographic analyses are intended to offer insights into where fire occurrences have been concentrated spatially in a given year and compared to previous years, but are not intended to quantify the severity of a given fire season. Given the limits of MODIS active fire detection using 1-km resolution data, these products also may underrepresent the number of fire occurrences in some ecosystems where small and low-intensity fires are common. These products can also have commission errors. However, these high-temporal fidelity products currently offer the best means for daily monitoring of wildfire impacts. Ecological and forest health impacts relating to fire and other abiotic disturbances are scale-dependent properties, which in turn are affected by management objectives (Lundquist and others 2011). Information about the concentration of fire occurrences may help to pinpoint areas of concern for aiding management activities and for investigations into the ecological and socioeconomic impacts of wildland forest fire potentially outside the range of historic frequency.

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