Indicator 3.16:

Area and percent of forest affected by abiotic agents (e.g., fire, storm, land clearance) beyond reference conditions

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What is the indicator and why is it important?

This indicator quantifies the effects of selected abiotic agents that affect forested ecosystems. Various abiotic agents, both natural and human-induced, can change forest structure and species composition. Where such change goes beyond some critical threshold, forest ecosystem health and vitality may be significantly altered, and its ability to recover from disturbance is reduced or lost, often meaning a reduction or loss of benefits associated with that forest ecosystem. Monitoring the area and the percentage of forests affected by abiotic agents beyond reference conditions may provide information needed in the formulation of management strategies to mitigate risk.

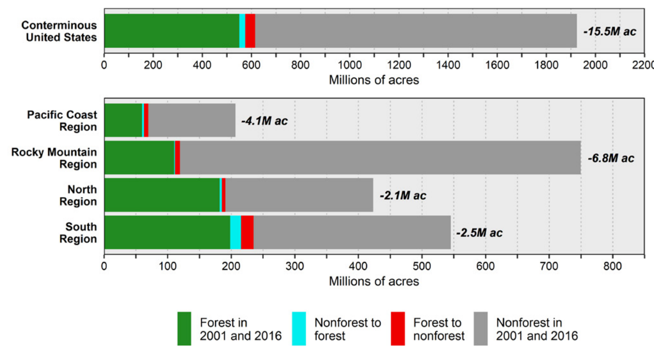

Figure 16-1—Forest/nonforest land cover change from 2001 to 2016 for the conterminous United States and four regions. The 15-year net area change of forest cover is indicated for the conterminous United States and each region. Alaska, Hawaii, and the District of Columbia are excluded. Data Source: National Land Cover Data, U.S. Geological Survey.

What does the indicator show?

Three abiotic agents in particular have major impacts across the United States: land cover change, fire, and drought. Various other agents, many of which are weather-related, may also affect forests. A few agents documented in the previous report, such as ozone, have no new information to present. The acidification effects of air pollution on soils and surface waters are reviewed in Indicators 4.19 and 4.21.

The balance between forest cover losses and forest cover gains serves as a useful summary metric of land cover change impacts on forested ecosystems. Forest cover changes can be temporary, like those related to timber harvest or other disturbances, or result in more permanent changes to forests, like land development or shifts to and from agricultural land uses. Other criteria and indicators presented elsewhere in this report rely on forest land use measures, which are not directly comparable to forest cover measures. “Forest cover” describes biophysical

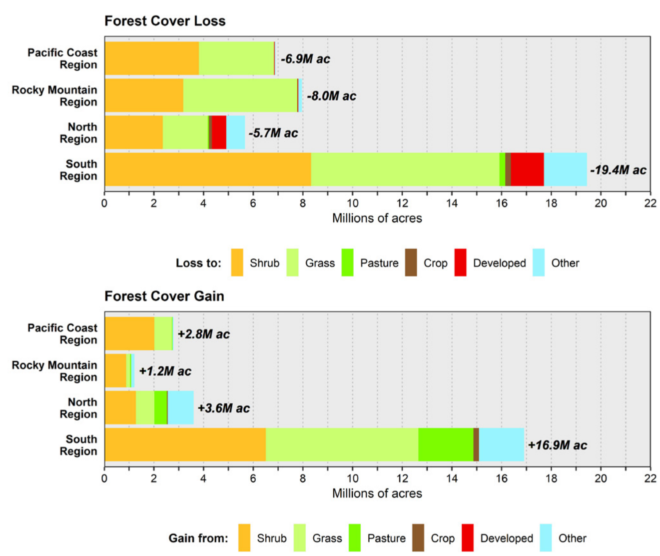

Figure 16-2—Gross forest cover loss and gross forest cover gain from 2001 to 2016 for four regions. The 15-year total area of loss or gain is indicated for each region. Alaska, Hawaii, and the District of Columbia are excluded. Data source: National Land Cover Data, U.S. Geological Survey.

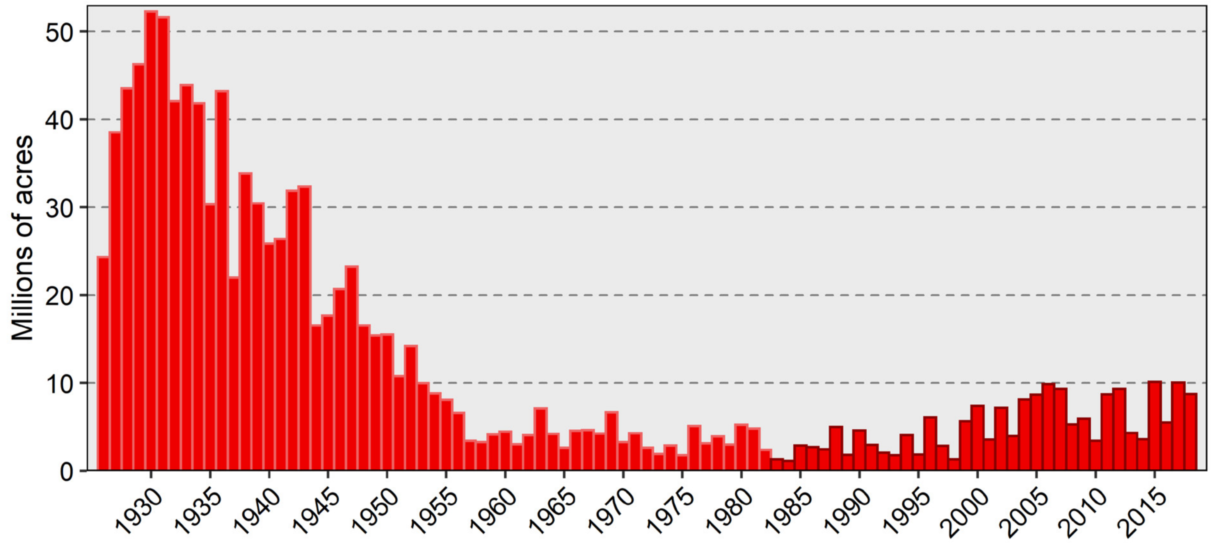

Figure 16-3—Total acres burned by wildland fire in the United States from 1926 to 2018. Totals are for all lands, including grasslands. Data prior to 1983 (bars with light red border) were not compiled under the current reporting process; some information sources are unknown or unconfirmed. Statistics for Alaska and Hawaii became available in 1960 and for all 50 States in 1966, when Arizona joined the Cooperative Forest Fire Control Program. Data source: National Interagency Coordination Center at the National Interagency Fire Center.

characteristics determined by direct observation of the Earth's surface, while "forest use" describes land use designations and includes lands that may not currently exhibit forest cover but are expected to do so in the future. Although the area of forest use increased between 2001 and 2016, the conterminous United States experienced a net overall loss in forest cover of 15.5 million acres, or 2.6 percent (fig. 16-1); nationwide, the area converted from forest cover was 63.1 percent higher than the area converted to forest. Irrespective of geographic region, most forest cover losses during this period were to shrub or grass land cover (fig. 16-2). As noted, many of these losses are probably temporary, a point emphasized further by the fact that most forest cover gains also came from the shrub and grass land cover categories. Forest cover patterns are reviewed in more detail in Indicator 1.03, which considers forest fragmentation.

Fire is a dominant abiotic agent in terms of area affected and mortality across the landscape, yet it is an integral part of many forested ecosystems. Figure 16-3 shows the estimated total acreage burned by wildland fire annually from 1926 to 2018 for all U.S. lands, including grasslands. (Recent data suggest that forests account for about 55 percent of the total burned area, on average.) Through the early 1940s, the area burned each year regularly exceeded 30 million acres. Beginning in the 1950s, fire suppression substantially reduced the area burned annually. Indeed, after 1953, burned area totals did not approach 10 million acres until 2006, when 9.9 million acres burned across the country. Burned area totals exceeded 10 million acres in

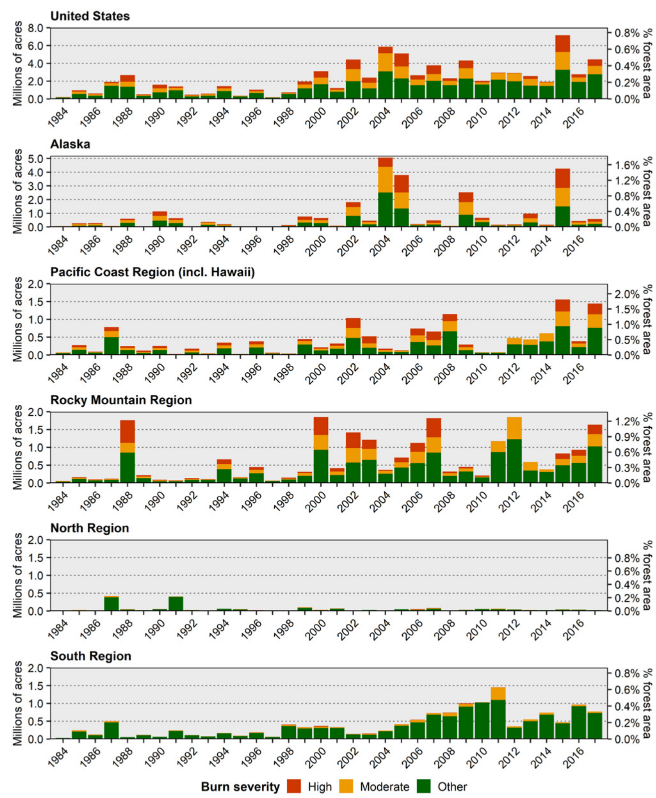

Figure 16-4—Total forest acres (and percent of total forest area) burned annually from 1984 to 2017, summarized by burn severity category. Numbers for Hawaii are included in the Pacific Coast Region. The burn severity category "Other" includes areas of low burn severity as well as areas of green-up (i.e., vegetation regrowth) after fire. Data source: Monitoring Trends in Burn Severity Program, U.S. Geological Survey, and USDA Forest Service.

recent years (2015 and 2017), but these were still far below the totals recorded in the first half of the 20th century.

Monitoring trends in burn severity (MTBS) geospatial data describing wildfire severity are available from 1984 to 2017. Figure 16-4 shows, for forested lands in the United States and five regions, proportions of the annual burned acreage that were associated with moderate- and high-severity fires. Nationally, there has been a general trend through time toward a greater burned area extent and higher-severity fires. This trend is only somewhat apparent at the regional scale, primarily because burned area extent can vary widely from year to year.

Drought can cause considerable stress to trees, especially when it co-occurs with periods of abnormally high temperatures. In some cases, prolonged drought stress can lead to tree mortality. More commonly, drought stress makes trees vulnerable to a variety of biotic and abiotic agents. Together, these direct and indirect drought effects can lead to considerable changes in forest health and productivity. Figure 16-5 shows drought trends over a 100-year period (1918–2017) for forested areas of the conterminous United States and four regions. The trends are depicted in terms of annual percentages of the total forest area that were in each of six ordered categories of the moisture difference z-score (MDZ) metric. For a given year in the data period, the MDZ value indicates the degree of departure during that year and the previous 4 years (i.e., a 5-year window) from average moisture conditions over 100 such windows, one for each year in the period. The ordered categories in figure 16-5 range from extreme moisture deficit (MDZ < -2) to moisture surplus (MDZ > 0.5). Since 1968—the midpoint of the data period—the percentage of the forest area in the conterminous United States that experienced mild or worse moisture deficits has exceeded 50 percent only twice: in 1990 (50.9 percent) and 2002 (55.5 percent). By comparison, this threshold was exceeded 16 times prior to 1968. Nevertheless, it is worth noting that the percentage of conterminous U.S. forests experiencing at least a mild moisture deficit has remained consistently above 20 percent since 2000.

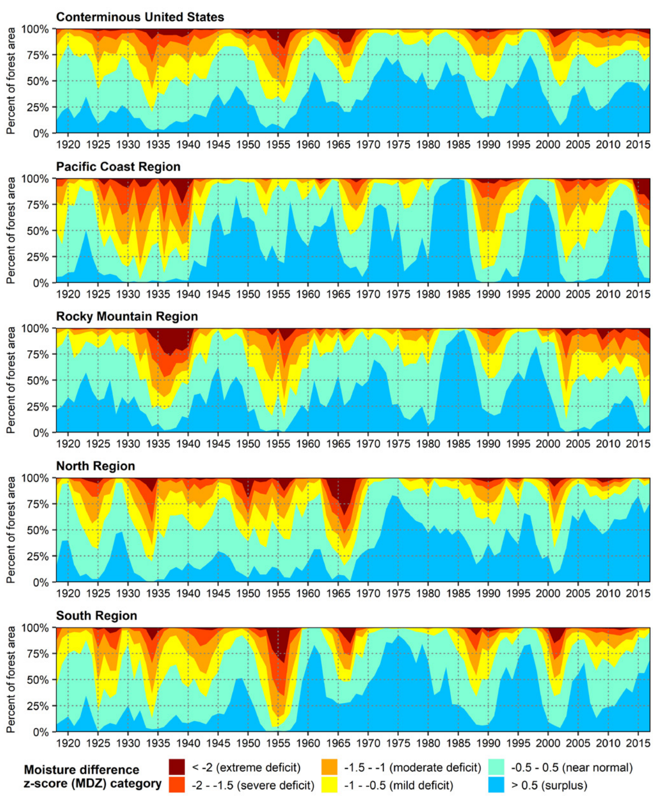

Figure 16-5—For the conterminous United States and four regions, the percentage of the total forest area in each moisture difference z-score (MDZ) category, 1918–2017. The percentages in a given year are based on MDZ values calculated over that year and the previous 4 years (i.e., a 5-year window). Alaska and Hawaii are excluded. Data source: PRISM Climate Group, Oregon State University.

Forested ecosystems are affected by various other phenomena, including flooding, hail, wind, and frost. Figure 16-6 summarizes, for the 2008–2012 and 2013–2017 periods, total forest acres in the conterminous United States with mortality caused by abiotic agents, as documented in Insect and Disease Survey (IDS) data. Similarly, figure 16-7 summarizes the total forest acres in Alaska that experienced mortality due to abiotic causes during the 2008–2012 and 2013–2017 periods. Fire, harvest, and human activities (e.g., land clearing, herbicide application) are excluded from these totals. Between the two periods, total acres with forest mortality caused by abiotic agents other than fire, harvest, and human activities increased 87.9 percent in the conterminous United States and 64.3 percent in Alaska.

What has changed since 2010?

Based on available summary metrics, there appear to be no drastic changes for this indicator since 2010, as compared to the previous decade. Moreover, with respect to drought and wildland fire—two aspects of forest health for which there are long-term data—conditions since 2010 have not approached the worst levels seen during the first half of the 20th century. However, as just noted, the IDS data show a sizeable increase between the 2008–2012 and 2013–2017 periods in the area of forest with mortality caused by abiotic agents. In the conterminous United States, most of the increase was associated with drought; other abiotic agents decreased in impact during the latter

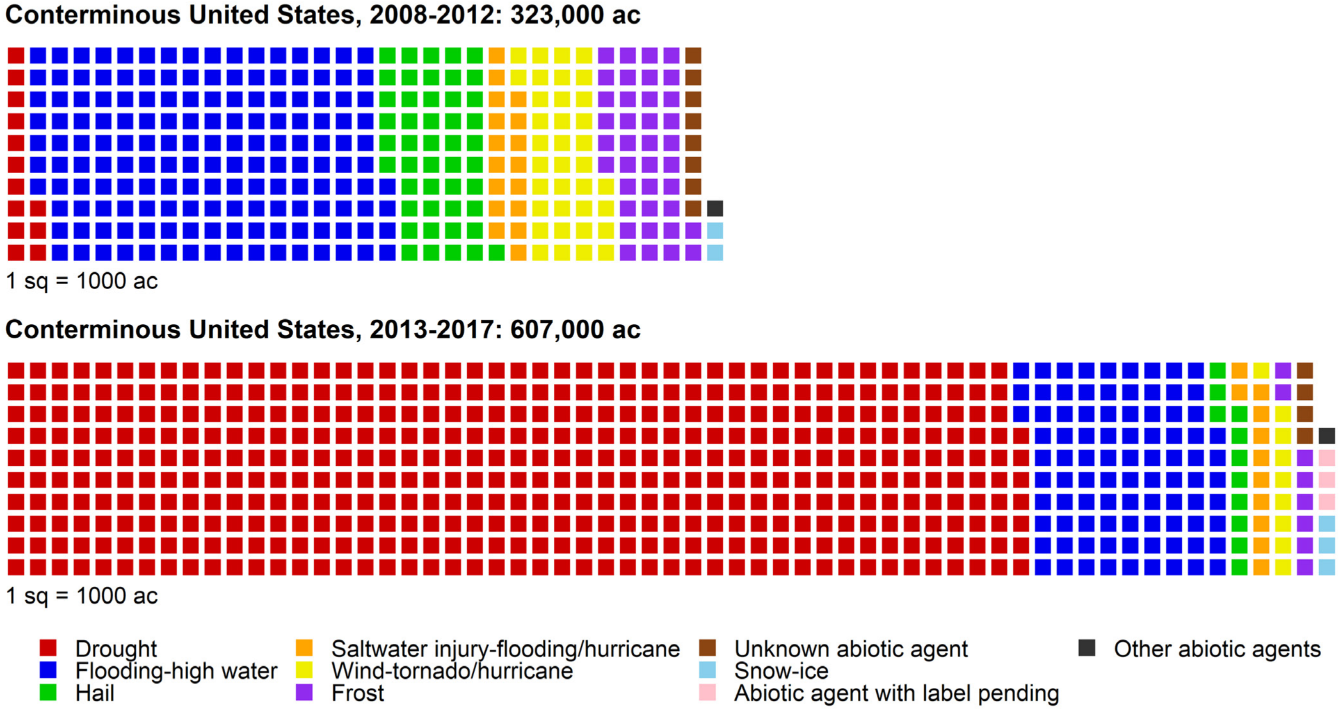

Figure 16-6—Forest acres in the conterminous United States with mortality caused by abiotic agents during the 2008–2012 and 2013–2017 periods. Total mortality for each period is partitioned according to causal agent. The “Other abiotic agents” category includes agents that accounted for less than 1,000 combined acres with mortality during the period of interest. For 2008–2012 (in order of impact): avalanche, mud-land slide, chemical, abiotic agent with label pending, air pollutants, lightning, nutrient imbalances, and winter injury. For 2013–2017: mud-land slide, salt damage, and avalanche. Fire, harvest, and human activities (e.g., land clearing, herbicide application) are excluded. Data source: Forest Health Protection, National Insect and Disease Survey Database.

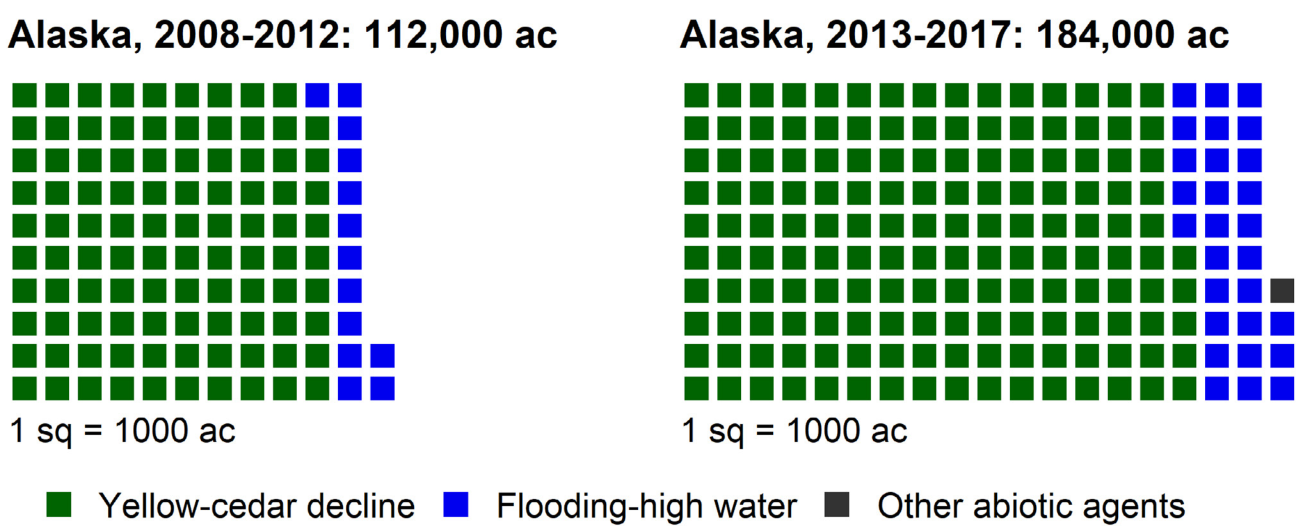

Figure 16-7—Forest acres in Alaska with mortality caused by abiotic agents during the 2008–2012 and 2013–2017 periods. Total mortality for each period is partitioned according to causal agent. The “Other abiotic agents” category includes agents that accounted for less than 1,000 combined acres with mortality during the period of interest. For 2008–2012: no other agents recorded. For 2013–2017 (in order of impact): wind-tornado/hurricane and mud-land slide. Fire, harvest, and human activities (e.g., land clearing, herbicide application) are excluded. Data source: Forest Health Protection, National Insect and Disease Survey Database.

period. In Alaska, the increase was mostly associated with yellow-cedar decline. Originally believed to be caused by a biotic agent, yellow-cedar decline has since been linked to climate change. In short, warming temperatures have reduced snow-pack depth, exposing tree roots to freeze injury because the surrounding soil is no longer insulated.

Are there important regional differences?

At a regional scale, the Pacific Coast and Rocky Mountain Regions had the largest net forest cover losses between 2001 and 2016 (fig. 16-1). The impacts of these losses may be magnified because forest cover represents a relatively small proportion of the total land cover in both regions. By comparison, the South Region saw the largest forest cover losses but also the largest gains, and in relation to a much larger forest cover proportion than either the Pacific Coast or Rocky Mountain Region. Although transition between forest and shrub or grass cover explained most of the gross losses and gains (fig. 16-2)—and, as noted previously, is unlikely to translate to long-term land use change—the North Region also lost 577,000 acres of forest to development (10.2 percent of the gross forest cover loss), while the South Region lost 1.3 million acres of forest to development (6.8 percent of the gross loss). Conversion of developed land cover to forest cover was negligible in all regions.

From the MTBS data (fig. 16-4), it is evident that regions in the West (Pacific Coast Region, Rocky Mountain Region, and Alaska) drive the national wildfire statistics. By contrast, the North Region had very little wildfire activity on forested lands between 1984 and 2017. While the South Region showed a fairly large burned extent in some years, the fires were usually low-severity; high-severity fires were essentially nonexistent.

Regarding drought, the regional trends in the MDZ percentages (fig. 16-5) are broadly similar to the U.S. aggregate trend, although recently, larger percentages of the forests in the Pacific Coast and Rocky Mountain Regions have experienced intense moisture deficits than observed nationally. In 2016 and 2017, more than 43 percent of the forest area in each of these regions had moderate or worse moisture deficits, while nationally these percentages were less than 19 percent. Five-year MDZ maps of the conterminous United States for the 2008–2012 and 2013–2017 periods (fig. 16-8) provide geographic context regarding variations in moisture conditions through time, and can be connected to observed forest health impacts. For example, during the 2008–2012 period, a

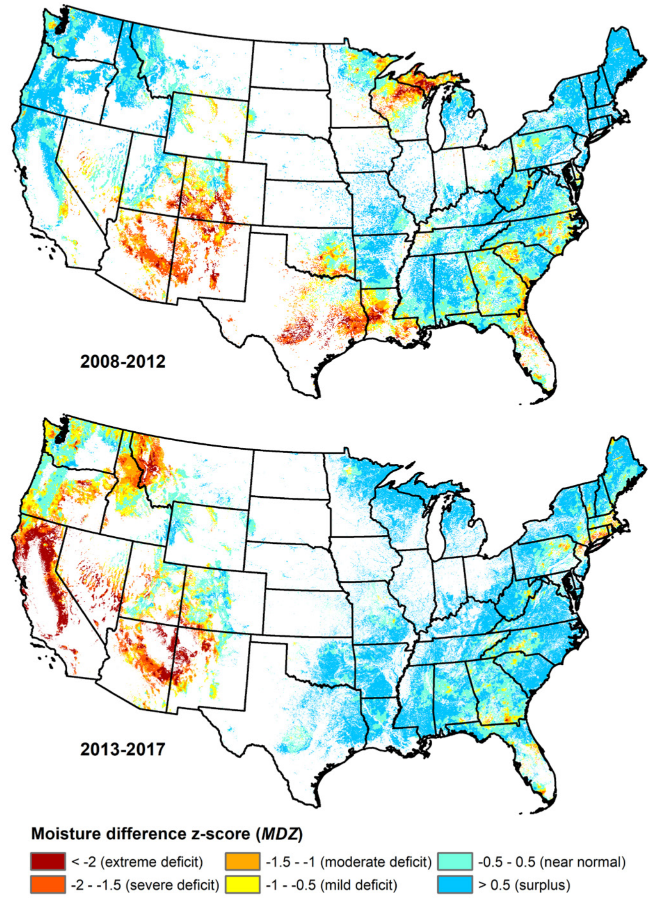

Figure 16-8—Five-year moisture difference z-score (MDZ) maps for the conterminous United States, 2008–2012 and 2013–2017. In each map, the MDZ values depict the degree of departure during that 5-year period from long-term (100-year) average moisture conditions. Nonforest areas have been masked from both maps. Data source: PRISM Climate Group, Oregon State University.

large area of severe to extreme moisture deficit stretched across much of Texas and Louisiana. Although there were other geographic “hotspots” of drought during this period, this hotspot has been associated with considerable forest mortality, some of which is captured in a county-level map developed from IDS data (fig. 16-9, top). Likewise, a prominent feature of the 2013–2017 MDZ map (fig. 16-8, bottom) is the presence of extreme moisture deficits across nearly all forested areas of California. These historically exceptional drought conditions—as with yellow-cedar decline in Alaska, believed to have been exacerbated by climate change—have been linked to widespread forest mortality in the State. The corresponding map of forest mortality due to abiotic causes during this period (fig. 16-9, bottom) indicates drought as the predominant mortality agent in 48 of California’s 58 counties.

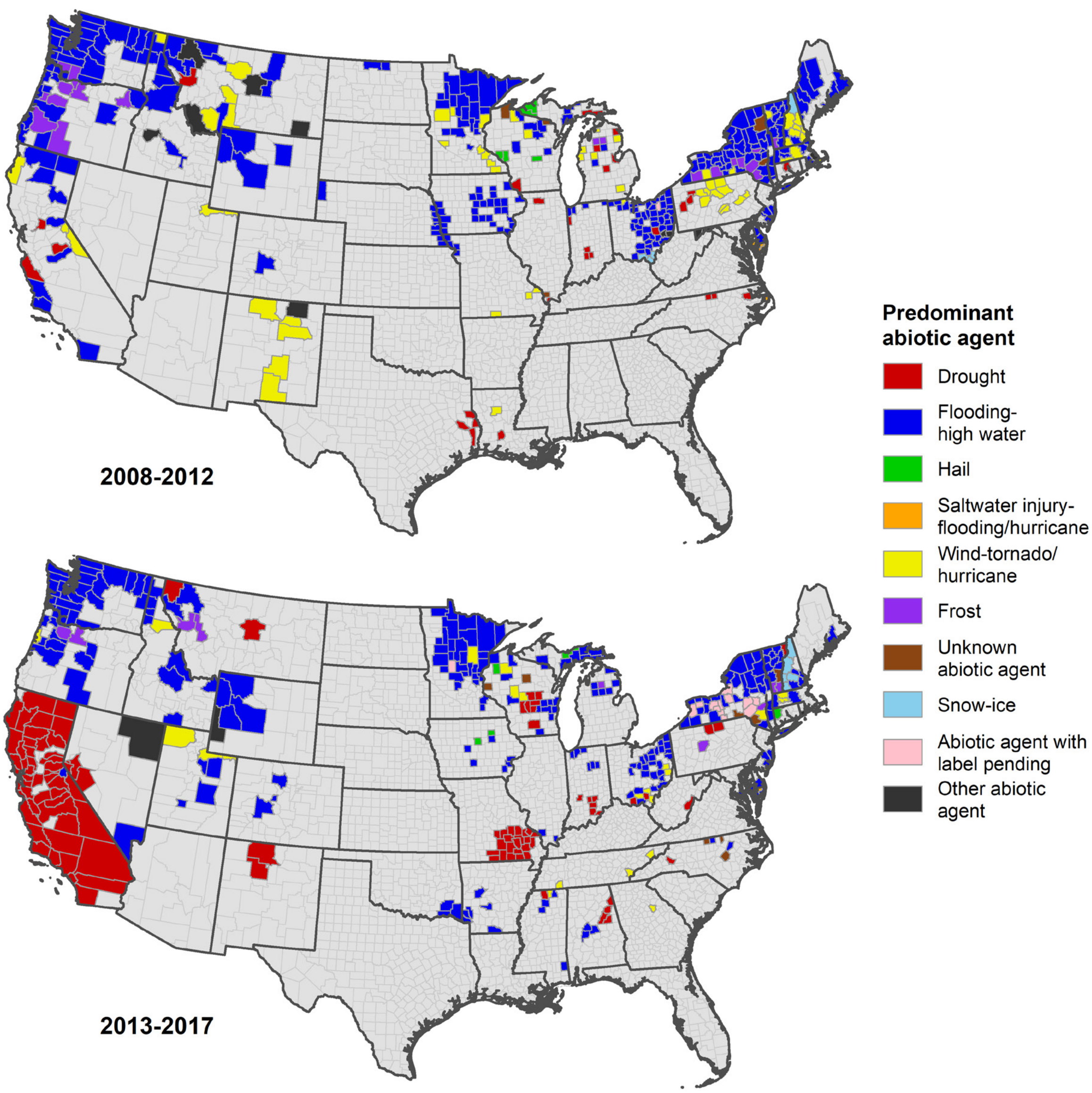

Figure 16-9—Maps showing counties in the conterminous United States that had forest mortality caused by abiotic agents during the 2008–2012 and 2013–2017 periods. Affected counties are categorized by the predominant causal agent. The “Other abiotic agents” category includes agents that accounted for less than 1,000 combined acres with mortality during the period of interest. For 2008–2012 (in order of impact): avalanche, mud-land slide, chemical, abiotic agent with label pending, air pollutants, lightning, nutrient imbalances, and winter injury. For 2013–2017: mud-land slide, salt damage, and avalanche. Fire, harvest, and human activities (e.g., land clearing, herbicide application) are excluded. Data source: Forest Health Protection, National Insect and Disease Survey Database.

Why can’t the entire indicator be reported at this time?

Assessment of trends in mortality due to non-fire abiotic agents is difficult due to inconsistencies in data collection. The IDS data are collected primarily via aerial surveys, which are not conducted systematically but when requested by affected stakeholders. In addition, winter storm damage may be assessed after green-up, making recent damage difficult to see. Intensive assessments of other wind storm damage may be conducted locally, but there are no requirements for centralized reporting nor mechanisms for recording observed events.