USDA United States Department of Agriculture

Drought Impacts in the Southern Region

A synopsis of presentations and ideas from the

Drought Adaptation Workshop in Region 8

January 2017 *Atlanta, GA*

Forest Service Washington Office February 2018 Office of Sustainability and Climate

Drought Impacts

in the Southern Region

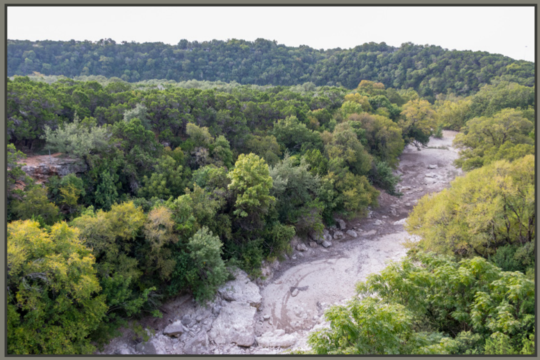
Background

In January 2017, the USDA Forest Service hosted a two-day drought adaptation workshop in Atlanta, Georgia to share state-of-science information on drought and climate effects in the region and to develop management response strategies. The workshop was attended by regional experts from the ***Forest Service Southern Region***, ***Southern Research Station***, and ***Office of Sustainability and Climate***; the ***USDA Southeast Regional Climate Hub***; and state and federal climate offices. They met to address challenges, cultivate opportunities, and develop and expand the collective understanding of the most effective management strategies to adapt to and mitigate the effects of drought in the region. The workshop focused on the effects of, and management responses to, drought in forest, riparian, and aquatic ecosystems.

Drought in the Southern Region

Although the southeastern United States is frequently impacted by hurricanes and floods, drought conditions are also relatively common. Droughts are relatively short in duration when compared to those of the southwestern and central United States, generally lasting 1-3 years (Seager, Tzanova, & Nakamura, 2009). Drought conditions can rapidly develop across the region as a function of reduced tropical cyclone activity, warm season rainfall variability, high evapotranspiration rates, and high water usage (Kunkel et al., 2013).

Precipitation patterns in the Southeast are strongly influenced by the position of the Bermuda High, a semi-permanent high pressure zone on the eastern U.S. coast, and by the two phases of the El Niño-Southern Oscillation: El Niño and La Niña (Misra & DiNapoli, 2013). When the Bermuda High is located nearer to the southeast United States, the region is more susceptible to drought conditions (Figure 1) (Ortegren, Knapp, Maxwell, Tyminski, & Soulé, 2011).



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According to the National Drought Mitigation Center, drought originates from an insufficiency of precipitation over an extended time period—usually more than a season—producing a water shortage for some activity, group, or environmental sector. Types of drought include:

- *Meteorological* – degree of dryness in weather over a defined period of time;
- *Agricultural* – links meteorological drought with agricultural impacts;
- *Hydrological* – precipitation deficits, with emphasis on effects on the hydrological system (e.g., water storage and flux); and
- *Socio-economic* – demand for economic goods exceeds supply as a result of weather/climate-related shortfall in water supply (Wilhite & Glantz, 1985).

In terms of forest and rangeland ecosystems, *ecological drought* is an episodic deficiency in water availability that drives ecosystems beyond thresholds of vulnerability, affects ecosystem services, and triggers feedbacks in natural and human systems (Crausbay et al., 2017).

Humans also contribute to or alleviate drought by modifying hydrological processes (e.g., through land use, irrigation, and dam building) (Van Loon et al., 2016).

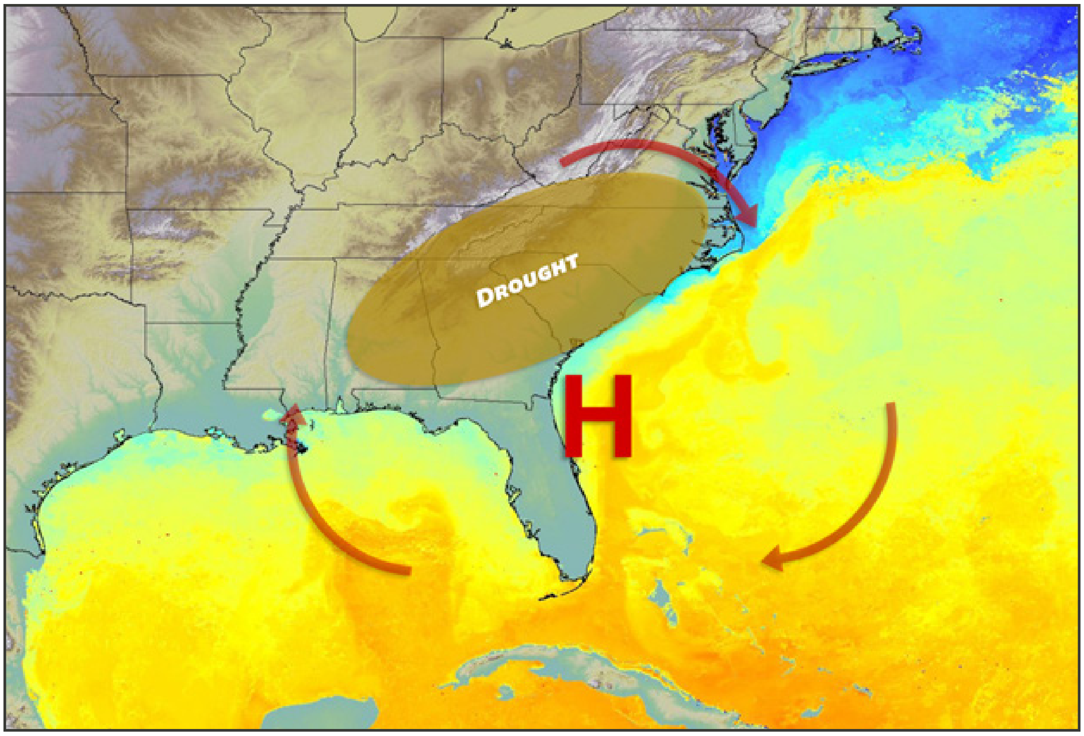
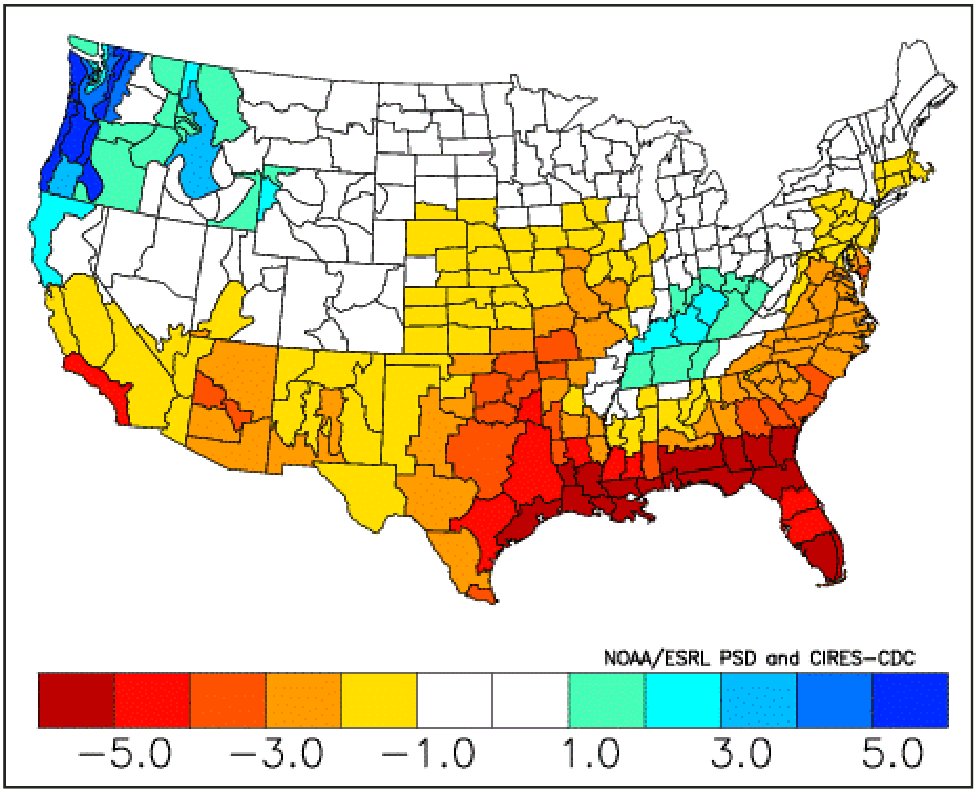


Figure 1 - The position of the Bermuda High is often associated with drought conditions, as hot air rotates clockwise around the high-pressure system. When this position is located closer to the coast of the southeast United States, it contributes to droughts in the region ([North Carolina Climate Office](#)).



El Niño typically causes above-average precipitation and reduces the probability of winter temperature extremes across the southern United States (Higgins, Leetmaa, & Kousky, 2002). In contrast, La Niña generally results in increased risk of drought and warmer than normal temperatures across the region (Higgins et al., 2002; Mo, Schemm, & Yoo, 2009) (Figure 2).

Figure 2 - Composite precipitation anomalies in inches for years influenced by La Niña from November through March: 1954–1955, 1955–1956, 1970–1971, 1973–1974, 1975–1976, 1988–1989, 1964–1965, 1999–2000, versus the 1971–2000 long term average, aggregated by climate division ([NOAA: Earth System Research Laboratory](#)).

Drought conditions are a common occurrence across the Southeast, but there was no clear long term trend for drought during the 20th century (Easterling et al., 2000). Although small scale droughts occur across the region each year, widespread droughts have occurred twice in the last 20 years (1998–2002 and 2007–2008). The late 20th century and early 21st century droughts broke many meteorological and hydrological records, causing billions of dollars in agricultural losses (NOAA: National Center for Environmental Information (NCEI), 2017). Figure 3 contrasts the moisture deficits between the 2007 drought year and the 2009 non-drought year (Koch, Coulston, & Smith, 2012).

Although annual precipitation amounts have not changed statistically in most of the region between 1948 and 2012, the intensity of extreme rain events increased in all but a few areas (Powell & Keim, 2015). As a result, the region experiences more high-intensity rainfall events, resulting in precipitation lost as runoff and in increased soil erosion. In addition, the seasonality of precipitation has changed, with summers becoming drier (Kunkel et al., 2013). In the southeastern United States, droughts are more likely to form as a result of rainfall deficits from the prior seasons, rather than just from the summer (Wang, Fu, Kumar, & Li, 2010).

Future Drought in the Southern Region

Summer rainfall variability is projected to increase in future decades, resulting in exceptionally wet or dry summers compared to current conditions (Li, Li, & Deng, 2013; Li, Li, & Kushnir, 2012; Wuebbles et al., 2014). Average temperature will also likely increase throughout the remainder of the 21st century, resulting in higher evapotranspiration and increased drought risk (Kunkel et al., 2013; Sobolowski & Pavelsky, 2012).

Throughout the 21st century, global climate models (using both high and low greenhouse gas emission scenarios) project that Texas and Oklahoma may experience a decrease in precipitation, whereas the states to the east may experience an increase, with the largest changes occurring in the late 21st century (Kunkel et al., 2013; Sobolowski & Pavelsky, 2012).

Although global climate models project that precipitation will increase overall throughout the region over the next century, they also project that drought frequency and intensity will increase as a result of rising temperatures (Strzepek, Yohe, Neumann, & Boehlert, 2010; Zhao & Dai, 2015). Altered seasonality of precipitation is expected to continue along current trends, with wetter autumns, winters, and springs, but drier summers

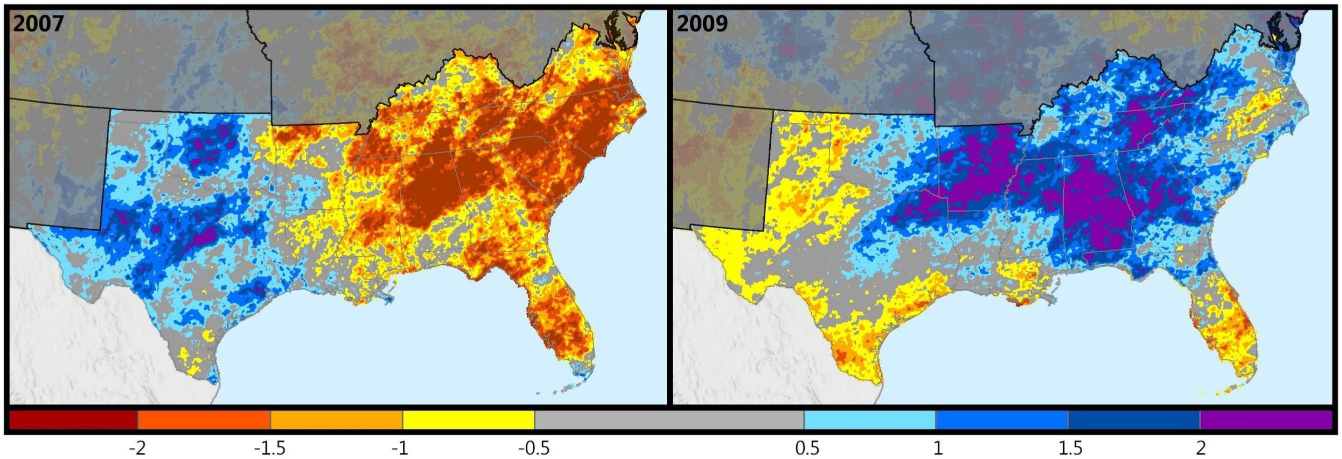


Figure 3 - Relative moisture deficit and surplus (z-scores) for the 2007 drought year and the 2009 non-drought year, in standard deviations from the mean over the last century (Koch et al. 2012). Click map for an interactive version depicting z-scores between 2000 and 2016 in 3-year windows.

(Sobolowski & Pavelsky, 2012) with more pronounced summer droughts (Ahmadalipour, Moradkhani, & Svoboda, 2017; Sheffield & Wood 2008).

Moderate and severe droughts are projected to increase 5 percent and 30 percent respectively across the region by the end of the century (Strzepek et al., 2010) (Zhao & Dai, 2015). Moderate agricultural drought may increase by as much as 50 to 100 percent, and severe agricultural drought may increase by 100 to 200 percent (Zhao & Dai, 2015). Based on model projections, researchers expect that soil moisture will decrease (Dai 2013, Sheffield & Wood, 2008) and that both short (4–6 months) and long term (12 months or longer) droughts will increase throughout the 21st century (Sheffield & Wood, 2008).

Drought Impacts to Forest Ecosystems

Droughts affect forest ecosystems by contributing to reduced growth and increased mortality (Allen et al., 2010; Breshears et al., 2005; Klos, Wang, Bauerle, & Rieck, 2009), increased risk of large scale insect outbreaks (Weed, Ayres, & Hicke, 2013), and increased wildfire risk and area burned (Littell, McKenzie, Peterson, & Westerling, 2009; Westerling, Gershunov, & Cayan, 2003). Moreover, because drought reduces tree vigor, it exacerbates the effects of other stressors, in some cases making forests more susceptible to insects, diseases, and fire (Weed et al., 2013). Insects such as the southern pine beetle, Ips beetle, and gypsy moth can cause large scale environmental and economic damage during large outbreaks (Figure 4).

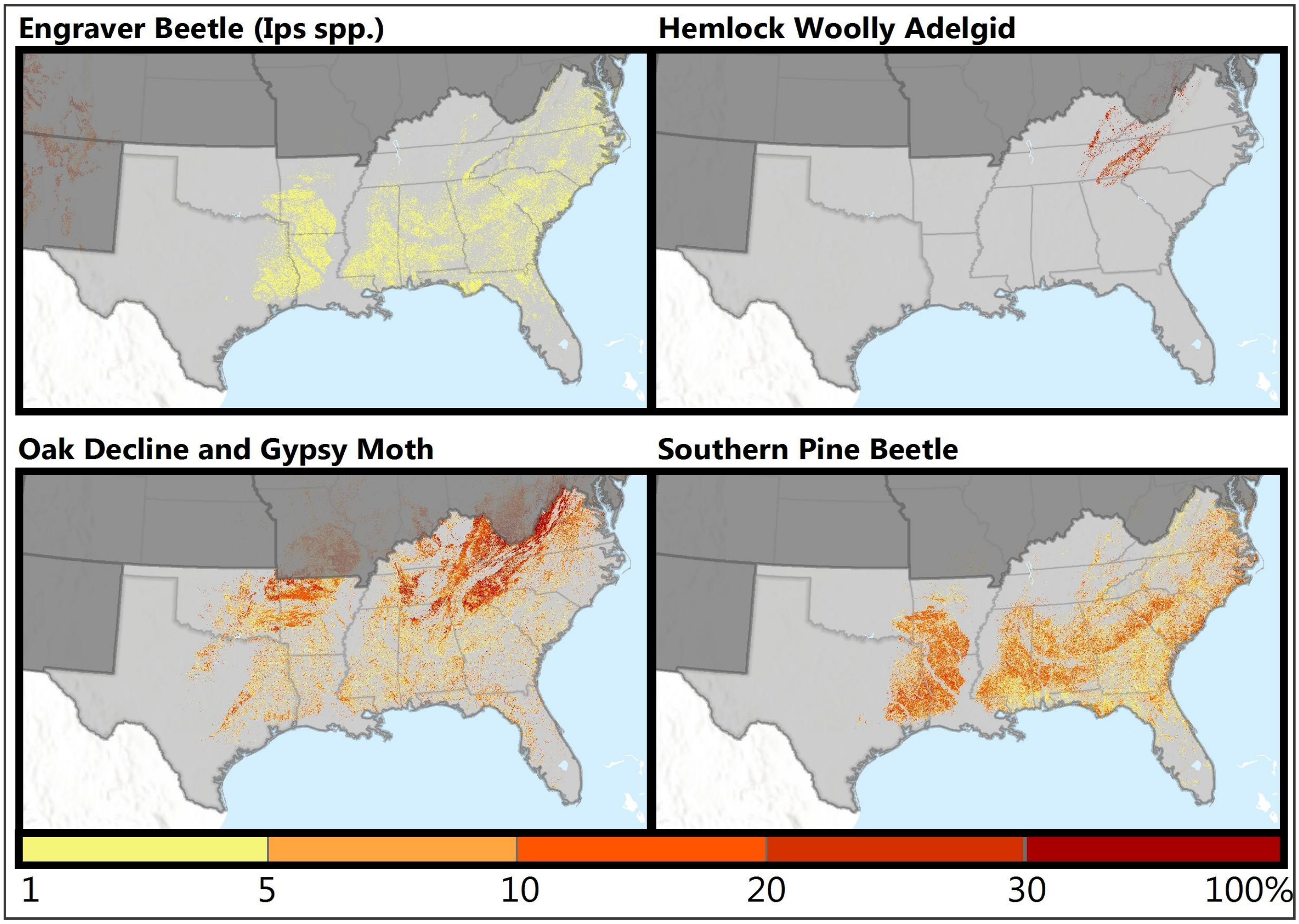


Figure 4 - Proportion of basal area projected to be lost between 2013 and 2027, for the host species of four examples of different types of disturbance agents (USDA Forest Service Forest Health Technology Enterprise Team, 2014). Click here for interactive maps on forest disturbances and drought.

Although wildfires in the Southern region do not generally attain the sizes of those in the western U.S., frequent large fires are relatively common in Texas and Oklahoma grasslands and in Florida (MTBS Project, 2017) (Figure 5). Warmer, drier conditions associated with more frequent drought may lead to increased wildfires (Liu, Stanturf, & Goodrick, 2010). The link between drought and fire frequency and size in Mississippi has been documented for counties dominated by pine forests and in the southern part of the state (Grala & Cooke, 2010).

Wetland sites, such as those found in the coastal plains, are more sensitive to drought conditions than drier sites (Conner, Song, Williams, & Vernon, 2011). Freshwater swamp forests in Louisiana are particularly threatened by a combination of drought and intrusions of saltwater triggered by drought conditions (Hoeppner, Shaffer, & Perkins, 2008).

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Climate change is expected to have major impacts on the longleaf pine savannas of the Southeast, which have already lost large portions of their range (Beckage, Gross, & Platt, 2006; Frost, 1993). Increased growth rates due to more carbon dioxide in the atmosphere could lead to a transition from open savannas to closed

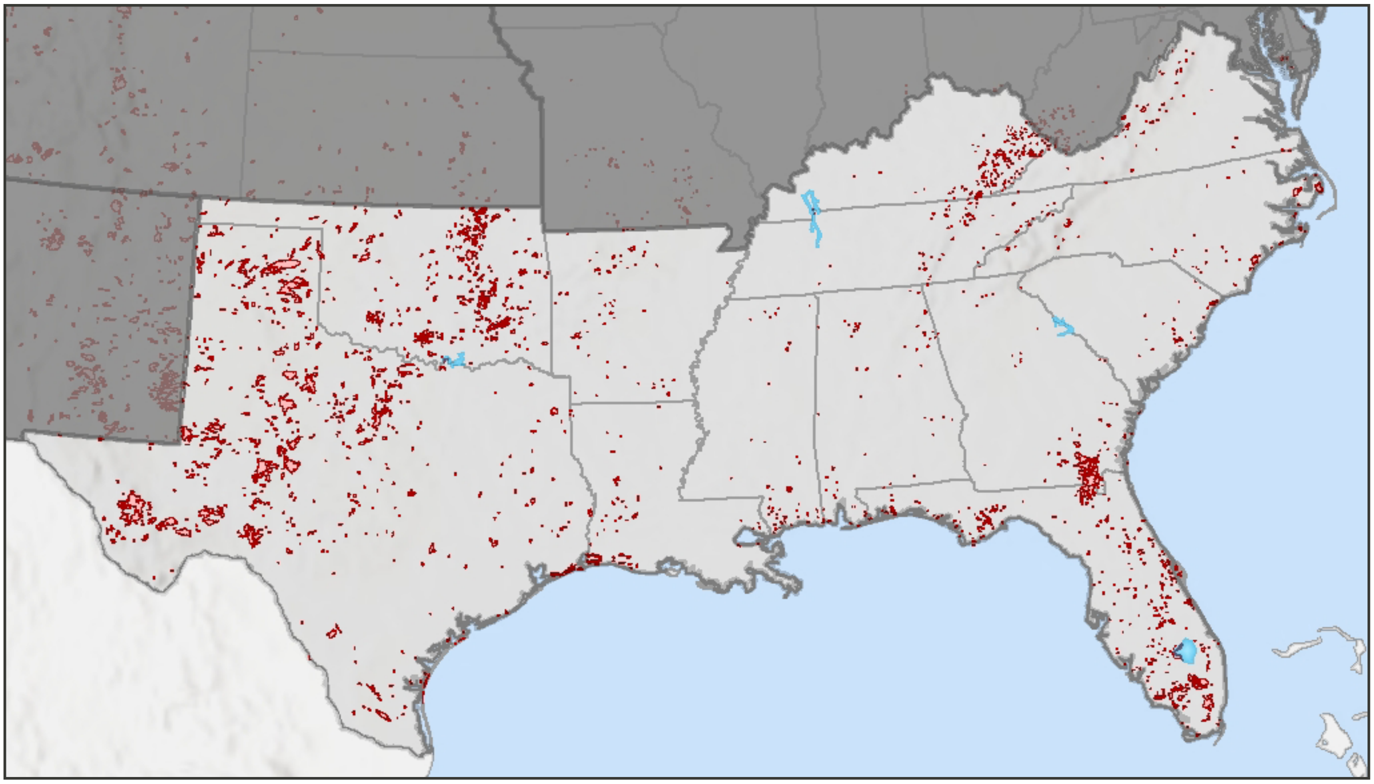

Figure 5 - Fires 500 acres and larger from 2000 to 2015, based on the USGS Monitoring Trends in Burn Severity Program (MTBS Project, 2017). Click here for an interactive map.

pine forests (Beckage et al., 2006). Summer droughts could stress these systems, although this is difficult to predict because in some drier sites these forests have developed increased drought resilience (Whelan, Starr, Staudhammer, Loescher, & Mitchell, 2015).

Forest Ecosystem Management Strategies

Several management options are available for responding to the effects of drought and climate change on forests in the southeastern United States:

- Restore longleaf and shortleaf pine ecosystems across their historic range (Kabrick, Dey, & Gwaze, 2007; Van Lear, Carroll, Kapeluck, & Johnson, 2005). Both longleaf and shortleaf pine provide numerous benefits in the context of responding to climate change (Kabrick et al., 2007; Van Lear et al., 2005), including resilience to drought (Whelan et al., 2015).
- Improve forest health across national forests and private lands. For example, the ***Southern Pine Beetle Program*** was developed following major outbreaks in 1999–2003 that caused over $1 billion of damage (Nowak, Asaro, Klepzig, & Billings, 2008). The program has since completed more than one million acres in treatments across private and public ownerships (USDA Forest Service, 2017). The program demonstrates how managers can apply forest health strategies across large geographic areas to produce multiple benefits.
- Avoid a one-size-fits-all approach. Site-specific management is needed for practices that maintain forest cover, protect forest vegetation and soils, and reduce erosion (Vose, Clark, Luce, & Patel-Weynand, 2015).
- Promote native drought- and heat-tolerant species that use water more efficiently in areas most vulnerable to drought or projected to experience more drought in the future.
- Assess drought vulnerabilities and landscape changes, and employ aggressive adaptive management strategies that include thinning and prescribed fire. Monitor effectiveness and adapt future strategies based on what is learned.
- Use prescribed fire to reduce stand densities, increase landscape heterogeneity, and increase resilience to drought.
- Conduct thinning in high density forests to increase individual tree health and make trees more resilient to drought, and more resistant to insect outbreaks (D’Amato, Bradford, Fraver, & Palik, 2013).
- Increase resources to implement treatments across large landscapes. Seek cost-sharing opportunities with other agencies and organizations.
- Develop management plans that recognize future uncertainty and projects that maximize adaptive management opportunities.
- Promote education and share information within and across agencies and with the public to improve understanding of drought and climate change effects.
- Promote tree size and age diversity in stands and across large landscapes to increase resilience to drought, insect outbreaks, and wildfire.

Drought Effects in Riparian and Aquatic Ecosystems

The potential for more frequent and severe droughts in some parts of the region will continue to alter ecosystems and will stress a wide range of freshwater species (Dai, 2011; Elsner & Jagger, 2006; Emanuel, 2005; Gibson, Meyer, Poff, Hay, & Georgakakos, 2005; Kaushal et al., 2010; Parisi & Lund, 2008; Shepherd, Grundstein, & Mote, 2007). Past severe droughts caused increased mortality rates of fish in lakes and reservoirs from decreases in dissolved oxygen (Ingram, Dow, Carter, Anderson, & Sommer, 2013). As a result, droughts will likely alter the distribution and abundance of freshwater algae, zooplankton, benthic invertebrates, and fish (Ingram et al., 2013).

More frequent and intense droughts, coupled with increasing water demands from greater evapotranspiration and human consumption, may cause increased drying of streams (Foster, Bearup, Molotch, Brooks, & Maxwell, 2016; Perkin et al., 2017). This in turn may reduce biodiversity and increase the frequency of local species extirpation, when the species most capable of re-colonizing or surviving in such conditions dominate the community (McCargo & Peterson, 2010; Peterson, Wisniewski, Shea, & Jackson, 2011).

Loss of species diversity is currently seen in the spread of the invasive red shiner (D. M. Walters et al., 2008), loss of highland endemic fishes from southern Appalachian streams (Scott, 2006; Scott & Helfman, 2001; D. Walters, Leigh, & Bearden, 2003), and reduced diversity in fragmented and flow-altered systems.

Riparian and Aquatic Ecosystem Management Strategies

» Maintain and restore drought-tolerant riparian vegetation that will prevent erosion. Increasing genetic diversity and population size of fish and other aquatic fauna, and increasing in-channel physical habitat heterogeneity can help increase resilience (Palmer et al., 2009).

» Promote awareness of El Niño-Southern Oscillation phases, emphasizing wetland restoration during the wet phase and avoiding the dry phase to improve project success and minimize risk (Erwin, 2009).

» Prevent rapid changes in water levels where feasible, to delay onset of water stress during dry periods (Malone, Starr, Staudhammer, & Ryan, 2013).

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