



Why have southern pine beetle outbreaks declined in the southeastern U.S. with the expansion of intensive pine silviculture? A brief review of hypotheses



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ABSTRACT

The southern pine beetle has shown a dramatic decline in outbreak activity over much of the southeastern United States since the turn of the 21st century compared to previous decades. Concurrently, from the 1950s through the present day, a twenty-fold increase in pine plantation area has occurred across the region while trends in genetic tree improvement and pine silvicultural advances have seen a marked increase in application towards the end of the 20th century. We examine southern pine beetle outbreaks in the Piedmont and Coastal Plain physiographic provinces of the southeastern U.S. relative to this increase in pine plantation area and intensive management. While climate and natural enemy hypotheses are discussed, the substantial changes to the management and condition of the southern pine resource in the form of plantations that are genetically improved, younger, faster growing, less overstocked or more fragmented may provide a more robust explanation for regional declines in SPB outbreak activity.

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1. Introduction: Southern pine beetle in the 21st century

As a native forest insect pest, the southern pine beetle (SPB), *Dendroctonus frontalis* Zimmermann, has long been considered

the most economically important and destructive in the Southeastern United States. This is due primarily to the prevalence of its major pine hosts, the economic importance of pine plantation culture across the region, as well as the ability of SPB to mass attack and overwhelm healthy host trees when their populations grow exponentially following invasion of weakened hosts. Thus, aggregations of SPB-infested and killed trees, known as ‘spots’ (Fig. 1), once initiated, often will multiply and expand rapidly into regional

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Fig. 1. Southern pine beetle 'spot' from above and within.

'outbreaks' that can envelope forest landscapes and encompass multiple counties and states, often over successive years (Birt, 2011b; Hain et al., 2011). Such expansive outbreaks in southern pine forests every 5–7 years used to be the norm for the better part of the 1960s through the 1990s, according to the best available records on outbreak activity (Clarke et al., 2016). Several major works, including hundreds of scientific papers on SPB population dynamics were published based on this approximately 40-year period of outbreak activity (Coulson and Klepzig, 2011).

Most SPB outbreaks during the latter half of the 20th century impacted southern pine plantations, particularly loblolly (*Pinus taeda* Linnaeus), shortleaf (*Pinus echinata* Miller) and Virginia pine (*Pinus virginiana* Miller), as well as natural pine stands. These outbreaks often enveloped hundreds of counties across multiple states during any given year. By the late 1980s, 15% of the gross annual growth of southern pine was lost to mortality, much of which was attributed to pine bark beetles (USDA, 1988). Over the last 15–20 years (1996–2016), however, major SPB outbreaks spanning more than a county or two and persisting for longer than a year have largely failed to materialize across most of the Piedmont and Coastal Plain regions of the Southeast where intensive pine plantation culture is most common. With each passing year, it becomes more apparent that something is different about SPB outbreak dynamics. While still a significant threat to the resource, SPB is not currently the widespread and regularly cyclical pest that it used to be in the southeastern U.S. Although 20 years is not a long time within an ecological context, it is a notable gap given the continuing expansion of intensively managed, even-aged, single-species (monoculture) pine plantations across the region.

Although notable multi-year outbreaks of SPB have occurred since the turn of the 21st century and continue to this day, examples are less common in southern pine stands that are managed intensively in the Piedmont and Coastal Plain physiographic provinces of the Southeast. Indeed, the vast majority of SPB activity in the last two decades has been in forests that are largely unmanaged, overstocked, on less than ideal sites, or are approaching natural senescence (Nowak et al., 2016, 2015). In more northern areas, many afflicted stands are natural and consist of species such as shortleaf, Virginia, white (*Pinus strobus* Linnaeus), Table Mountain (*Pinus pungens* Lambert) or pitch (*Pinus rigida* Miller) pine (Nowak et al., 2016). Intensively managed pine stands, on the other hand, typically involve genetically improved loblolly pine or, less commonly, slash pine (*Pinus elliottii* Engelman) and some combination of wider seedling spacing, herbicide site preparation and/or release from hardwood competition, mechanical site preparation, fertilizer application, pre-commercial and commercial thinning,

and other methods (Allen et al., 2005). Genetic tree improvement programs have been transformative to southern pine plantation culture, resulting in high quality loblolly and slash pine seedlings bred for superior growth rate, stem form, adaptability and disease resistance (Byram et al., 2005). The use of some of the above intensive practices in combination with the rapid growth and yield potential of genetically improved trees have additive effects on tree growth and therefore, when used in tandem, greatly improve productivity and profit margins for growers (Cumbie et al., 2012; Fox et al., 2007a; Jokela et al., 2010).

The last widespread SPB outbreak in the Southeast (1999–2002) occurred primarily in the Southern Appalachians and Cumberland Plateau physiographic regions and impacted multiple pine species (loblolly, shortleaf, Virginia, white, pitch, Table Mountain) that were generally growing as natural stands, unmanaged plantations or in mixed pine/hardwood stands (Nowak et al., 2016). While this outbreak did impact some intensively managed loblolly plantations, these were primarily areas outside of the natural range of loblolly pine and which now have mostly reverted back to hardwood stands. Other more recent and notable areas of SPB outbreak include Atlantic coastal areas from Virginia Beach north through Chincoteague/Assateague Islands off the Delmarva Peninsula (Asaro, 2013–14; Chamberlin, 2015), the New Jersey Pine Barrens (http://www.state.nj.us/dep/parksandforests/forest/njfs_spb.html), and Long Island, New York (<http://www.dec.ny.gov/animals/99331.html>). Many of these areas contain older (50+ years), unmanaged pines growing on poor soils and exposed to occasional high winds, saltwater intrusion and salt spray from major storms like Hurricanes Irene (2011) and Sandy (2012). While southern pine beetle is relatively new to some of the more northern locations due to milder winters, it is none-the-less no surprise that, with these stand conditions, SPB has reached outbreak levels. In the South, several recent outbreaks were mostly limited to National Forests such as the Oconee in Georgia (2007) and the Homochitto (2012), Tombigbee (2014) and Bienville (2015) in Mississippi in higher-risk stands. These outbreaks spread very little beyond the National Forest boundaries and were short-lived. In the last 10 years, there have been far fewer reported hectares of beetle-killed pine across 13 states in the Southeastern U.S. (<2025 ha) compared to the Pine Barrens of southern New Jersey alone (>12,000 ha) (Schlossberg, 2016).

To date, the widespread expansion of genetically improved trees and associated silvicultural practices across the southern pine growing region have received little mention as a potential explanation for SPBs decreased abundance at the regional level (Clarke et al., 2016). This is surprising given the importance of

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