Cool weather can amplify attacks of tree-killing bark beetle

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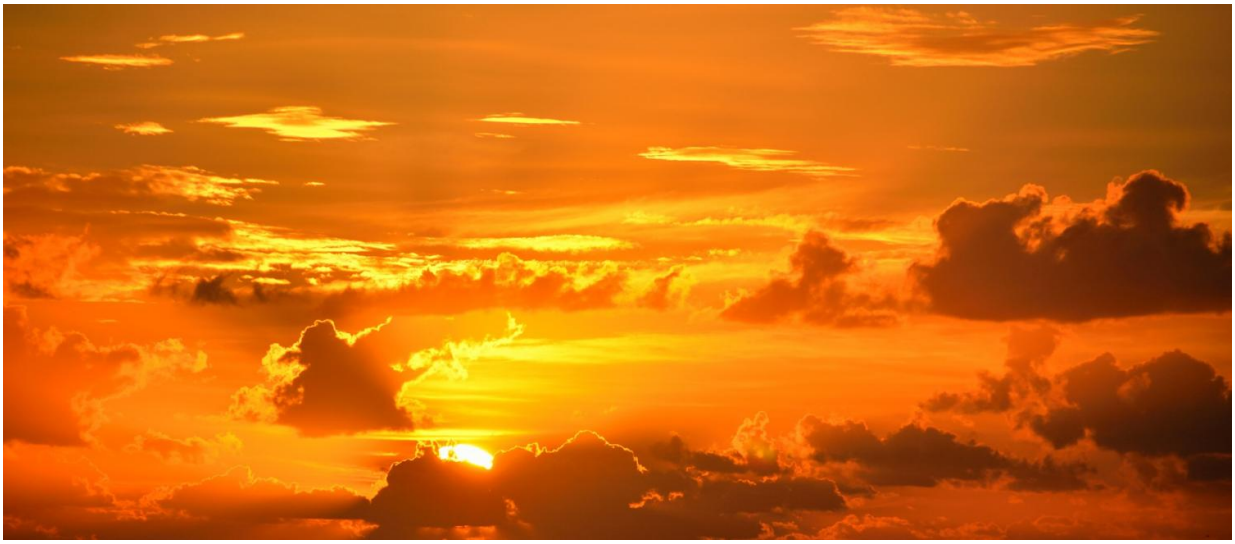

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As a warming climate invites the destructive southern pine beetle to expand its northern range, the cooler weather in this new habitat can potentially increase the lethality of the insect's assault on trees, according to a new study from Dartmouth College.

The research demonstrates how climate change can create a destructive, one-two punch for forests that are already under attack, and another mechanism by which weather can influence the abundance of insect pests.

In the study, the Dartmouth research team shows how the colder fall and winter temperatures encountered in northern latitudes influences the growth and development of immature southern pine beetles, leading to a more synchronized emergence of adults once the weather warms.

The behavior detailed in the research raises the risk for pine forests because the emerging beetles kill trees by attacking in large numbers. The more beetles that are active at the same time, the better the chance they will overwhelm tree defenses and produce even more beetles for the next generation of attacks.

"Climate change is not only giving this destructive species new territory to prey on, it's creating a more lethal pest that can wreak havoc on forests," said Jeffrey Lombardo, who conducted the research as a Ph.D. candidate at Dartmouth.

While native to the southeastern United States, the southern pine beetle is thriving as the climate warms. The pest is an icon of range expansions that are being permitted by climate change. In 15 years, the insect has steadily increased its range from the southeastern U.S. into New Jersey, New York's Long Island, Connecticut, Massachusetts, and now as far north as upstate New York.

In seeking to understand the mechanisms that reinforce the insect's success in response to climate change, the Dartmouth research focuses on how beetle development from larva to adult is impacted by varying weather patterns.

"This research gives us a more sophisticated understanding of how temperature differences impact a species that has moved beyond its traditional range," said Matthew Ayres, a professor of biology at Dartmouth, and a coauthor of the study. "We've come a long way from 2007 when we got our first hint of how the cooler winters were

producing different seasonal patterns in beetle populations."

To conduct the study, the team used a combination of approaches including in situ laboratory experiments, a theoretical development rate model, and field trapping of wild beetles in newly-occupied pine forests of New Jersey as well as in the beetle's historic habitat in the southeastern states.

The research demonstrates that cooler fall and winter temperatures in their expanding northern range significantly increase the population of beetles at the end stage of larval development and also causes them to emerge en masse when the weather becomes warmer. This concentrated pooling of developing individuals—a phenomenon known as phenological synchrony—results in larger populations of mature beetles emerging at one time.

Conversely, researchers found that when left in warmer temperatures, life stage convergence was absent; the beetles continued developing unabated and do not demonstrate a similar pooling of population in one stage of development.

While not all species benefit from a large number of individuals in the same territory, the southern pine beetle relies on high population density to more effectively "bleed-out" pine trees. Coordinated mass-attacks on pine trees by beetles opens up additional resources, which can then support more beetles. This positive feedback can push the population into outbreak.

"The power of numbers from synchronously emerging beetles can spell disaster for pine trees," said Lombardo, who is joining the faculty of St. Mary's College in Maryland.

The study, published in the journal *Oecologia*, indicates that

temperatures around 50 degrees Fahrenheit permit larvae to feed and grow, but do not allow them to advance beyond the pupal stage. Thus, the larvae all become ready to pupate, but pupation and emergence of the tree-hunting adults do not happen until temperatures warm to about 60 degrees or higher.

According to the study, the physiological mechanism is relevant to any insects that have variable thermal responses among life stages, lack diapause and experience cool winters. The authors note that their work was inspired by studies of mountain pine beetles, a related species that occurs in western regions of North America.

The study is a warning of how changing climate can bring new risks to forests, but is also an example of how science can help. The knowledge from this study is being built into the southern pine beetle prediction system, which is a tool for forest managers to anticipate seasons of high risk and ramp up detection and suppression efforts.

"Forests all over the world are being challenged by changes in the distribution and abundance of potential pests and this makes good science more important than ever," said Ayres.

More information: J. A. Lombardo et al, Temperature affects phenological synchrony in a tree-killing bark beetle, *Oecologia* (2018). DOI: 10.1007/s00442-018-4164-9

Provided by Dartmouth College