Species spread in spurts—and here's why

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Credit: University of Minnesota

When plants and animals move into new spaces they often do so by fits and starts, with lots of progress one year and less—or even a loss of ground—the next. Conventional wisdom attributes this pattern to variations in the environment in which they're immersed—changes in terrain or weather or the presence of other species that aid or inhibit them.

Now, researchers led by University of Minnesota postdoctoral fellow Lauren Sullivan and assistant professor Allison Shaw have shown that such external variables aren't needed to explain the irregular spread of species. Rather, such an irregular pattern can arise simply from characteristics of the population itself—a combination of the impact of reduced growth rate that occurs when population density is low and relationships between the rate at which a population grows or spreads and how dense that population is.

The study, published today in the *Proceedings of the National Academy of Sciences*, is part of a larger body of work aimed at understanding how plant and animal species expand their ranges. The findings not only are fascinating from a theoretical perspective but also are valuable for predicting the rate of spread of—and so combating —nonnative invasive species such as emerald ash borers, kudzu and pine bark beetles.

To explore what might be causing invasion rates to vary over time, the researchers developed and tested mathematical models of species spread that incorporate the principle that populations tend to grow more slowly when density is low (known as the Allee effect) as well as two other density-dependent effects: overcompensatory population growth, in which a burst in reproduction moves population density past its equilibrium state, and density-dependent dispersal, which links the speed at which populations spread to how dense they are. The researchers found that models combining an Allee effect with either overcompensatory population growth or density-dependent dispersal produced the type of patterns that have been observed in real life.

"Most theory predicts invasions occur at a constant speed, or that more complex factors like predator-prey dynamics or environmental heterogeneity cause the speed of invasions to fluctuate," Sullivan said.

"Our work finds that simple, intrinsic density dependence can induce complex invasion behavior."

In addition to answering questions, the research also raises new ones. "Many actual populations spread at varying rates," Shaw said. "I'll be curious to see how much of this variation is due to the mechanisms we identified versus due to other ecological complexities."

Improving our understanding of the mechanisms behind uneven spread, the researchers say, will make it possible to predict more accurately how species will expand their ranges. That, in turn, will help theoretical biologists better understand how systems change over time, and could help resource managers better anticipate and respond to invasions of harmful non-native species.

More information: Density dependence in demography and dispersal generates fluctuating invasion speeds, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1618744114

Provided by University of Minnesota

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