Evidence of criticality in North American gypsy moth invasion found

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The European gypsy moth, introduced to North America in 1869 near Boston, Mass., has steadily spread from there, devastating forests from eastern Canada to Wisconsin to North Carolina and thwarting all attempts at control. In a paper just published in the journal *Ecology Letters*, ecologists at the University of Georgia Odum School of Ecology and other researchers studying invasive insects report that the success of new gypsy moth populations is partly dependent upon the size of the patch they occupy—information that could eventually help control the spread of the moths and other invasive pests.

It has long been known that for some species, populations will not persist unless a certain critical density exists—a minimum number below which a population cannot thrive. Near that threshold, there is positive density dependence: the population's growth rate increases along with its density. Scientists have predicted there also is a minimum area required for a small population to survive, but had not been able to confirm it in nature.

Now, using data from the gypsy moth invasion, the researchers have shown there is indeed a critical area necessary for species that are subject to positive density dependence.

"Critical points have been known in physics for decades," said study co-author John M. Drake, an associate professor in the Odum School. "Now, with new methods and more sophisticated theories, we are discovering critical phenomena in many areas of science. What's especially interesting about this one is the role played by space. It's a deeply geometric aspect of ecology, one that until now had been only an idea. This paper shows it to be true in nature as well."

"Populations that cover too small an area are likely to fail even if they exceed a previously recognized critical density for establishment," said Andrew M. Kramer, a postdoctoral associate in the Odum School and another of the study's co-authors. "This is, to our knowledge, the first empirical demonstration that the persistence of small populations can be determined by the size of the area they occupy."

A successful invasive species, such as the gypsy moth, may seem an unlikely choice to inform the study of small populations. At the edge of their current range, however, where they are expanding into new territory, numerous small populations exist in a transition zone. Because of the economic damage they cause, an enormous amount of data about gypsy moths has long been collected through the U.S. Forest Service "Slow-the-Spread" program.

Each spring, gypsy moth eggs hatch and caterpillars emerge to consume the foliage of trees; adult moths appear briefly in late summer to breed. The females are flightless and emit pheromones to attract mates, a strategy that only works well at short distances—making the gypsy moth one of those species that requires a critical density to persist in small populations.

"If there aren't enough individuals in the area, they are likely to be too far away from potential mates, and the population won't grow," said Kramer.

Using Forest Service data, Kramer and his colleagues determined the density and area of each patch occupied by small populations of gypsy moths over a 12-year period. That allowed them to calculate the critical area needed to sustain a small population.

“We found that small populations can be more successful if they’re spread over a larger area,” Kramer said.

Although previously predicted by theory, the findings are not intuitive. “It’s a complicated interaction,” Kramer said. “The population has to be dense enough to persist, but not too dense. If a population is compressed into a very small area, it will fail because of the way the male moths disperse. They won’t encounter potential mates as they spread out away from their point of origin—they’ll move out into unoccupied areas.But when a population with the same number of individuals occupies a larger area, the males are much more likely to encounter females as they disperse.”

The study’s results have implications for the control of invasive species, potentially helping managers more accurately target their efforts, and for conservation of threatened or endangered species.

“Knowing that there is a critical area threshold for certain species could inform decisions about habitat protection or re-introduction,” Kramer said. “For restoration programs, considering not just the minimum number of individuals needed for the population to thrive, but also the optimal area they need, could increase the chances of success.”

Provided by University of Georgia

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