A MODEL FOR THE OPTIMIZATION OF THE DETECTION AND ERADICATION OF ISOLATED GYPSY MOTH COLONIES

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ABSTRACT

Biological invasions of pest species pose a threat to the stability of ecosystems, both natural and managed (Liebhold et al. 1995, Shogren and Tschirhart 2005). Considerable effort is expended by national and local governments on excluding alien species via detection and eradication of invading populations, but these efforts are not necessarily designed in the most economically or biologically efficient manner. In places where an invasive species has not yet established, we need to know how managers can optimize detection methods in order to minimize both detection and eradication costs.

Practical limitations that constrain the detection and management of small, newly founded alien populations are common problems for managers (Welk 2004). Early detection is one of the most cost-effective ways to reduce the impact of invasive species worldwide (Myers et al. 2000, Byers et al. 2002, U.S. National Invasive Species Council 2005). Therefore, there is an urgent need to design and test monitoring strategies in order to achieve early detection and, in turn, provide more effective control (Ruckelshaus et al. 2002).

Using the North American gypsy moth (*Lymantria dispar*) as a case study, we develop a mathematical model to consider the trade-offs between increased detection costs associated with high detection efforts (i.e. high trap densities) and decreased eradication costs due to the ability to detect populations when they are smaller and less expensive to control. We develop a mathematical model to aid in the trapping design both for detection and eradication efforts in the western and midwestern U.S. and for Slow-the-Spread management activities along the northeastern edge of the U.S.

We chose the ongoing invasion of the gypsy moth in North America because of the availability of extensive life history survey data describing its spread and because of prior research to examine various methods to slow that spread. The gypsy moth continues to slowly expand its range across North America from the site of its initial introduction in Massachusetts; it is considered a significant threat to both natural and managed systems. Gypsy moth outbreaks often result in defoliation of vast expanses of forests. Over 300 million acres of forested land and urban and rural treed areas in the United States were identified as at risk for gypsy moth invasion in 1995 (U.S. Department of Agriculture).

We use mathematical models to determine the optimal trapping densities with respect to minimizing management costs and maximizing the ability to detect new gypsy moth infestations. The implicitly spatial

model considers a generally infested area in which variable densities of traps are randomly distributed in a finite area, in order to detect colonies that are also randomly distributed. We examine the effect of several parameters including arrival rate, colony growth rate, total area, and cost on the optimal trap density.

Because the rate of new colony arrival and establishment is highly variable in nature and depends on several ecological and social factors (including forest type, human population density, transportation infrastructure, and climate,), we specifically examine the case of low and high colony arrival and establishment rates. Initial results indicate that as arrival and establishment rates increase, the optimal density of traps needed to minimize cost and maximize detection abilities increases also, but much less rapidly than expected.

In the future, we plan to further investigate the impact of trapping design on minimizing cost and maximizing the ability to detect new colonies through the use of spatially explicit models and Monte Carlo simulation techniques. Additionally, all of these models will be useful in designing monitoring strategies, not only for the gypsy moth, but also for other invasive forest pests.

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