2009. Proceedings of the Indiana Academy of Science 118(1):76–80

MONITORING GYPSY MOTH PHEROMONE FLAKE CANOPY THROUGH-FALL

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ABSTRACT. Indiana Department of Natural Resources and USDA Forest Service applied pheromone flakes, disparlure, to a very low-level gypsy moth (*Lymantria dispar*) population in south-central Indiana in June 2008 to eradicate the infestation. One aerial application of Disrupt II, a disparlure-based mating disruptor, was applied over the forest canopy. The fall of the flakes through the forest canopy to the forest floor was monitored using 50.8 × 76.2 cm white foam core boards. Percent canopy cover and distance from the plane's flight lines had no effect on canopy through-fall. Only 0.73 flakes per m^2 were recorded, compared to 22 flakes per m^2 on average that would have been deposited on areas without tree canopy. These figures indicated that in this study 96.7% of the applied flakes were retained in the canopy and only 3.3% constituted canopy through-fall. There was only a minimal chance that pheromone flakes would land in streams or cave openings within the area studied.

Keywords: Gypsy moth, pheromone flakes, mating disruption

European gypsy moth (*Lymantria dispar*) is not native to the United States and lacks effective natural controls. The caterpillars feed on the foliage of many host plants. Although oaks are the preferred host species, the caterpillars defoliate many species of trees and shrubs when oaks are not available (Liebhold et al. 1995). When high numbers of gypsy moth caterpillars are present, forests may suffer severe and repeated defoliation that can result in reduced tree growth, branch dieback, and tree mortality. High numbers of caterpillars also create a public nuisance and can affect human health (Sharov et al. 2002). The national strategy for managing gypsy moth includes eradication in areas not yet generally infested and strategically applied suppression in generally infested areas (Sharov et al. 2002).

Indiana Department of Natural Resources detected gypsy moth on the Hoosier National Forest in 2006. Additional trapping in 2007 indicated that there was a very low level incipient population in the treatment area. Although individual gypsy moths were present in the area, they had not yet become established. The optimum time to treat this potential infestation was before gypsy moths became established and spread. Without intervention, this population was expected to grow and contribute to a faster rate of spread into other non-infested areas. Mating disruption relies on the use of the gypsy moth sex pheromone, disparlure. Female European gypsy moths are flightless and naturally release this pheromone to attract males. The objective of the application was to disrupt mating by saturating the treatment area with enough pheromone sources to confuse male moths and thus prevent them from finding and mating with female moths. Mating disruption using the pheromone disparlure is considered specific to gypsy moth and is not known to cause impacts on non-target organism populations, water quality, microclimate, or soil productivity and fertility (USDA 2008, Vol. III, Appendix H). The product Disrupt II, which incorporates disparlure, has proven effective at eliminating gypsy moths at very low population levels.

The purpose of this cooperative project between the USDA Forest Service and Indiana Department of Natural Resources was to eradicate the gypsy moth by preventing moths in the treatment area from reproducing.

Although final flake location, whether in the forest canopy or forest floor, does not affect the

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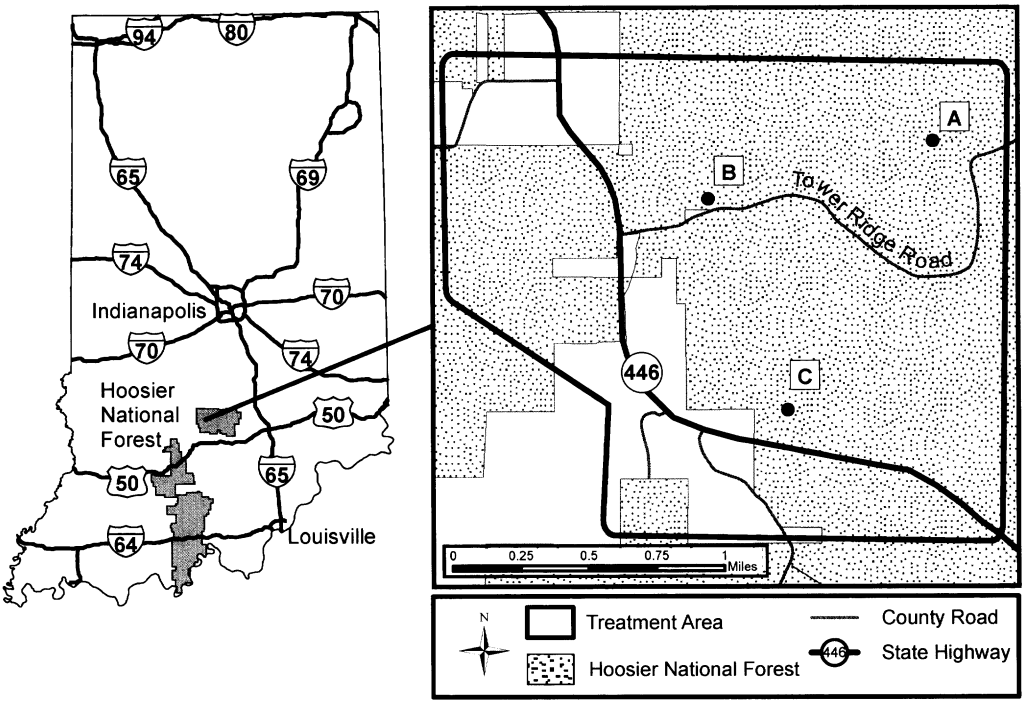


Figure 1.—Location map of treatment area and sampling Transects A, B, and C on the Hoosier National Forest in south-central Indiana.

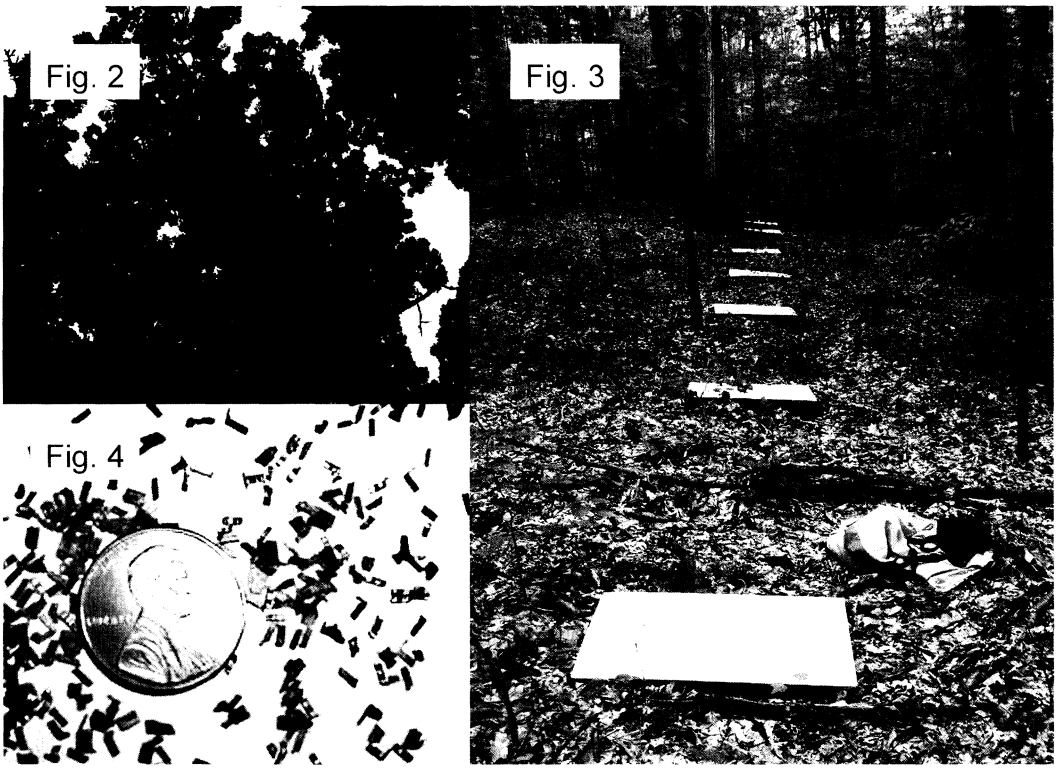
effectiveness of Disrupt II, some persons had expressed interest in the possible deposition of flakes into streams or cave openings. They were concerned the flakes would be eaten by cave fauna causing undo stress in an already nutrient-poor environment. The objective of this study was to estimate the amount of pheromone flakes reaching the forest floor or potentially entering streams or cave openings.

METHODS

Study area.—The treatment area (748 ha.) covered both private land (17%) and Hoosier National Forest System land (83%) in southeastern Monroe County, Indiana (Fig. 1) and was in the Brown County Hills Ecological Subsection (Zhalnin & Parker 2007). A 91 m buffer surrounded the treatment area. Fifty-seven percent (425 ha) of the treatment area was in the Charles C. Deam Wilderness on the Hoosier National Forest. The Ecological Land Types were: Transect A, a broad flat ridge; Transect B, a north-facing slope; and Transect C, the south side of a narrow ridge (Zhalnin 2004).

The area around Transect A, an old field in 1939 (Jenkins & Parker 2000), had an overstory of poletimber-small sawtimber trees with yellow-poplar (*Liriodendron tulipifera* L.), white oak (*Quercus alba* L.), American beech (*Fagus grandifolia* Ehrh.), and bigtooth aspen (*Populus grandidentata* Michx.). The understory consisted of pawpaw (*Asimina triloba* L.), sugar maple (*Acer saccharum* Marsh.), and American beech. The area around both Transects B and C was forested in 1939. Sawtimber-size white oak, black oak, (*Quercus velutina* Lam.), sugar maple, and yellow-poplar comprised the overstory at Transect B, and the understory consisted of sugar maple and American beech. At Transect C the overstory was dominated by large sawtimber white oak with a few large sawtimber black oak. The understory was dominated by American beech, flowering dogwood (*Cornus florida* L.) and sugar maple.

Data sampling.—Before treatment application, three transect locations were generated randomly using ArcGIS. All of the transects were in the Charles C. Deam Wilderness. The western point of each east-west transect was located using a Garmin GPS unit and the generated UTM coordinates. Twenty points, 3.048 m apart, were located along each transect



Figures 2–4.—Photos showing aspects of this study. 2. Canopy photo after classification; 3. Foam boards placed at Transect C; 4. Pheromone flakes, actual size is 1 mm × 3 mm.

due east of the generated coordinates. Transects were perpendicular to the flight lines.

To estimate overstory canopy above each point, digital images were taken at approximately 66 cm above ground level (66 cm was as low as the camera could be placed using a tripod). A tripod-mounted Sony Cybershot DSC-S85 digital camera with the lens at wide angle was used. To position the camera lens axis horizontally, we used bubble levels on the tripod and one placed over the lens. The camera was oriented so that the long dimension of the image ran north and south. Images were taken the mornings of June 6 and 9, 2008. ERDAS Imagine software was used to classify the images by percent as either sky or canopy (Fig. 2). Some images were edited, using Microsoft Photo Editor, by changing colors to those matching leaves when portions of boles or leaves were initially classified as sky due to bright sunshine.

To monitor pheromone flake through-fall, we placed 50.8 × 76.2 cm white foam core boards at the 20 points along each of the three transects. The points marked in the initial layout were used as the southwest corner of the boards. The long dimension was oriented north and south. The foam boards were placed 5–13 cm above the ground the day before application (Fig. 3) as level as possible. Hours after aerial application of the flakes, the boards were inspected and each flake location was marked on the board with a permanent marker. Flakes were counted after the boards were returned to the office.

Treatment application.—The treatment consisted of one aerial application of a mating disruptor called Disrupt II (Hercon Environmental, Emigsville, Pennsylvania) on 23 June 2008—prior to the emergence of male moths. Disrupt II is typically referred to as pheromone flakes because it consists of 1 mm × 3 mm plastic-laminated flakes with a layer of pheromone sandwiched between the outer layers of plastic (Fig. 4). The flakes are coated with glue so they will adhere to tree parts in the canopy.

GPS equipment recorded the plane's flight paths while applying the pheromone flakes.

The data was then exported to ArcGIS. GPS locations were recorded for one end of each transect. A Trimble XT GPS unit was used to locate more accurately the eastern point at Transect A and the western point at Transects B and C. The UTM easting coordinate for each point along the transect was developed by adding or subtracting 3.048 m to or from the previous point. We then determined the distance from each point to the nearest flight line.

Statistical analysis.—Data were analyzed with analysis of variance (ANOVA) and linear regression using SAS (SAS 2004). Duncan's multiple-range test was used for means separation in the ANOVA.

RESULTS AND DISCUSSION

Transect B had a significantly higher percent canopy cover (90.7%) ($P < 0.05$) than Transect A (89.3%) and Transect C (89.2%). Though Transect B had significantly higher percent canopy cover, this difference may not be important. Transect B percent canopy cover ranged from 87.6–93.5%, Transect A ranged from 83.8–92.6%, and Transect C ranged from 87.2–94.4%. There was only one point on Transect A with 83.8% canopy cover. The next lowest percent canopy cover on that transect was 86.4, very similar to Transects B and C. The fact that Transect A was an old reverting field, compared to the continuously forested Transects B and C, would explain the lower canopy coverage on some points for Transect A.

Transect B recorded eight flakes on seven boards, the highest count of the three transects. Transect C had six flakes on five boards and Transect A had three flakes on three boards. Although percent canopy cover had no significant influence on flakes falling on the boards ($R^2 = 0.003$), Transect A, a reverting old-field, may have had a more compact and compressed canopy structure and that may have prevented the flakes from falling to the forest floor. Also, because Transect B was on a slope, there might have been gaps in the canopy caused by a stair-stepping of the overstory canopy. This could have permitted more flakes to filter through the canopy.

According to a study in Virginia, flakes tend to be distributed in a non-uniform pattern (Thorpe et al. 2006). They tend to peak beneath the pods or distribution points of the plane and bottom out under the fuselage and wing tips of the plane. However, in our study on the Hoosier National Forest, the distance from a flight line had no significant influence on flakes falling on the boards ($R^2 = 0.01$). There were also insufficient flakes to determine a distribution pattern comparable to the Virginia study.

At the dose used in this treatment (37.5 grams active ingredient per hectare), an average of 22 flakes per m^2 would have been deposited on areas without tree canopy (Thorpe et al. 2006). This corresponds to an expected density just over 8 flakes per board for a total of approximately 500 flakes for all 60 boards. However, only 17 flakes were actually recorded on the 60 boards. This corresponds to 0.73 flakes per m^2 or one flake for every 1.4 m^2. These figures indicate that in this study 96.7% of the applied flakes were retained in the canopy and only 3.3% constituted canopy through-fall. Thus the canopy intercepts the vast majority of flakes, keeping them from reaching the forest floor.

The glue remained tacky; therefore, the chances were high that pheromone flakes would stick to the first object encountered on the forest floor. This greatly reduced the probability that a pheromone flake would wash into a stream or enter a cave opening.

Though there was only a 3.3% through-fall of flakes at the time of application, nearly 100% of the flakes would fall to the forest floor in autumn with leaf fall. These flakes would become part of the forest litter layer and not move off site into streams or caves. During application it was possible to halt the application of flakes when flying over streams or other non-target areas, thus preventing flakes from falling into streams not covered by tree canopy. Therefore, with the small number of flakes falling through the canopy to the forest floor, the glue remaining tacky, and the ability to halt application of pheromone flakes over streams, there was only a minimal chance that pheromone flakes would land in streams or cave openings within the area studied.

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Manuscript received 23 September 2008, revised 19 December 2008.