P1.6 PHEROMONE FATE AND TRANSPORT IN FOREST CANOPIES

Tara Strand*, Brian Lamb, Gene Allwine
Laboratory for Atmospheric Research
Washington State University, Pullman, Washington

Holly Peterson
Montana Institute of Technology, Butte, Montana

Harold Thistle, Ed Holsten, and Pat Shea
United States Forest Service

1. INTRODUCTION

The artificial release of insect pheromones is currently being used as a control strategy to protect forest and agricultural stands against insects. However, pheromone diffusion and transport, composition, and insect response are not clearly understood. Additionally, no robust method exists to measure instantaneous pheromone plume concentrations. To improve our understanding of pheromone fate within a forest a tracer test program was developed.

In order to measure pheromone dispersion, sulfur hexafluoride (SF_6) is used as a surrogate. During the past three years, tracer releases were conducted in oak hickory, lodgepole pine, and ponderosa pine forests; this paper focuses on the ponderosa pine study.

The objective of this study is to increase our understanding of plume fate and transport within a forest and to develop tools that can assist land managers with placement of artificial pheromone sources in timber stands and agricultural groves.

2. DATA

Data were collected, over nine days, in a ponderosa pine forest near LaPine, Oregon during July 2001. The canopy height was approximately 20 m. On each test day, SF_6 was released continuously over a 9 hr period. Test periods were scheduled to begin as early as 4:30 and as late as 14:30. Thirty-min average tracer samples were taken at every 15 to 30 degrees along three circles, with radii of 5m, 10m, and 30m extending from the SF_6 source. Instantaneous tracer concentrations (1Hz) were measured at various points along the 10m circle and turbulence measurements were obtained with a sonic anemometer positioned at the source (1 m height). Further details of the release and sampling methods are available elsewhere (Peterson and Lamb, 1995; Peterson and Lamb, 1992; Peterson et al., 1990).

Corresponding author address: Tara Strand, Washington State Univ., Dept. of Civil and Environmental Eng., Pullman, WA 99164-2910; email: strand@mail.wsu.edu.

3. RESULTS

The instantaneous tracer data show that SF_6 plumes have steep spatial concentration gradients and meander in narrow filaments. Additionally, during a thirty minute release period, these filaments can be found in all 360 degrees of the wind direction, resulting in an intermittent instantaneous concentration time series at any specific receptor.

Time averaged tracer data have been used to determine dilution rates as a function of downwind distance. As illustrated in Figure 1, regression curves through the observations can be obtained and used with pheromone release properties to estimate pheromone concentration levels as function of distance from the source. This can be directly applied as a tool to guide deployment of artificial pheromone sources for insect disruption. Similar information can also be obtained using a simple Gaussian dilution model (Wilson and Lamb, 1994) where the dilution is calculated from measured turbulence levels or estimated using empirical dilution coefficients: $D = BuX^2/Q_e$ where $B = \pi\sigma_\theta\sigma_\phi$, u is the wind speed, X is downwind distance, and Q is the gas release rate. Results from the application of this simple model are also shown in Figure 1. For these data, the model appears to be in good agreement with the observations. These results are for all nine test days and show that dilution levels change as function of time of day due to changes in stability or turbulence levels within the canopy. These changes are illustrated in Figure 2.

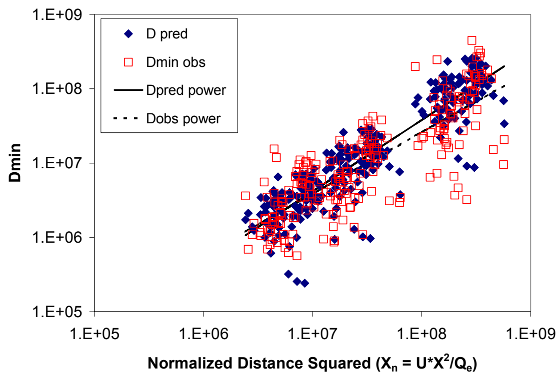

Figure 1. Minimum dilution rates as a function of normalized distance squared in comparison to minimum dilution predicted with a simple Gaussian dilution model.

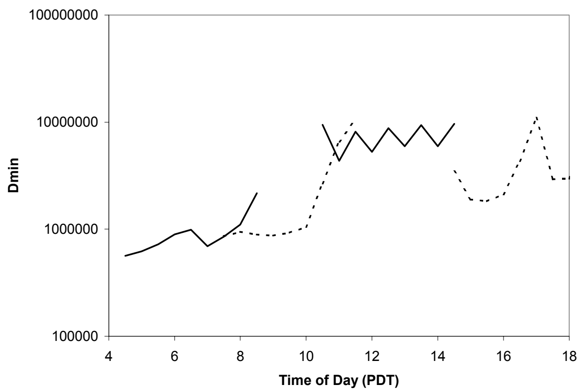

Figure 2. Minimum dilution from four separate tests as a function of time of day.

Insects respond to an instantaneous plume as opposed to mean concentrations, therefore, it is worthwhile to develop methods for simulating instantaneous plume behavior within a canopy. As a starting place, a Lagrangian puff model has been developed to simulate instantaneous plume behavior. A puff is emitted and moved forward every second and a basic Gaussian puff formula is used to calculate dispersion. The model is driven by the sonic anemometer velocities collected in the field. For a 30 min period, this yields a concentration field shown in Figure 3. The model also produces instantaneous time series of concentrations at given receptors, shown in Figure 4. Further work is underway to evaluate the accuracy of this model and to use the model to investigate plume properties related to insect response models.

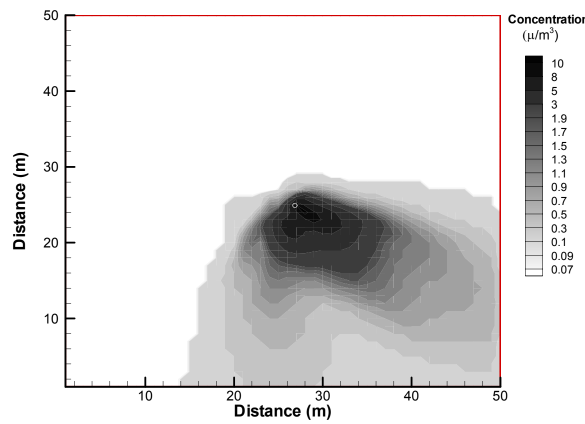

Figure 3. Predicted concentration field ($\mu g/m^3$), from the Lagrangian puff model, for June 23, 2001 from 6:00 a.m. to 6:30 a.m. A point source at 1m was used (white circle in plot).

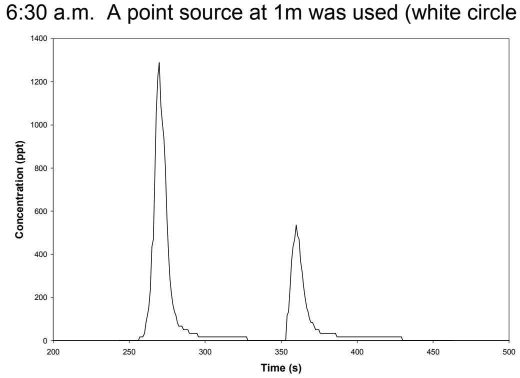

Figure 4. Predicted instantaneous concentrations (ppt) at a receptor located 10 m from the source.

4. ACKNOWLEDGMENTS

This research was supported by the USDA Forest Service FHP/FHTET, award No.: 01-CA-11244225-025.

5. REFERENCES

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