THE INFLUENCE OF STAND THINNING ON SURROGATE PHEROMONE PLUMES

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Abstract

The objective of this study is to determine how stand density affects the behavior of pheromone plumes in a southern pine stand. Thinning is known to reduce southern pine beetle (SPB, *Dendroctonus frontalis* Zimmermann) mortality in southern pine stands (Lorio, 1980). The mechanisms by which this occurs are not yet clear but probably consist of multiple, perhaps even synergistic, factors. It is possible that changes in the dispersion and physical movement of pheromone plumes in these stands as they are thinned impacts the risk of infestation. Also, the effectiveness of pheromone management strategies may be improved by determining the spacing and location of pheromone dispensers in the trunk space of a forest stand so that plume dispersal and shape can be optimized. In more generic terms, this data set will compliment previous work (Thistle et al. 2004) in an effort to develop in-stand dispersion models and analytical techniques that will allow pest managers to optimize placement and location in the development of in-stand pest control strategies. In the past few decades, outbreaks of North American bark beetles have brought about renewed interest in these often devastating forest pests. The impact of these outbreaks and the anticipated impact of future outbreaks have stimulated the continuation of basic and applied research on the use of semiochemicals to manipulate bark beetle populations (Werner and Holsten 1995). In the southern U. S., losses to SPB are often dramatic and have reached unprecedented proportions in recent years (USDA Forest Service 2003). To mitigate forest losses and improve forest health, initiatives emphasizing thinning pine stands have recently been funded.

The method used here is a tracer experiment utilizing SF_6 and 30 min mean samplers described in Krasnec et al. (1984) combined with high frequency sampling described in Benner and Lamb (1985). The basic configuration (Thistle et al. 1995, Thistle et al. 2004) is to surround a point source of SF_6 with a dense array of mean samplers. A high frequency sampler is deployed at one point on the mean array so the structure of the plume at high frequency can be compared to the mean plume. SF_6 is chosen because it can be detected at concentrations as low as 10 ppt (even at 1 Hz), is conservative (fairly non-reactive in the environment) and a large body of scientific literature exists utilizing it as a gaseous tracer.

These tests were run on the Winn Ranger District of the Kisatchie National Forest outside of Winnfield, LA. The basic array consisted of 50, 30-minute mean SF_6 samplers, a 7 port sampler collecting 5 minute mean SF_6 samples and one high frequency sampler collecting 1 Hz data. Fourteen trial days were run. Each trial consisted of 4.5 hours of data or nine, 30-minute samples collected sequentially. When all the samplers are considered, this renders around 450 30-minute samples per test along with the 5-minute and 1 Hz records. The samplers are arrayed in concentric circles around the source. The canopy on the site was a loblolly pine canopy with a dense understory. Four trials were run in the unthinned canopy, then the understory was removed and three trials were run in the canopy with a basal area of about 140 ft^2, three trials were then run with the canopy thinned to a basal area of 100 ft^2 and finally four trials were run with the basal area reduced to 70 ft^2.

Data analysis has only begun but the two graphs below are enlightening. In the first time series (Figure 1), the plume passages past the single, 1 Hz sampling point show a large degree of coherence and multiple peaks in each plume passage. This is a low wind speed, low dispersion, atmospherically stable environment. The plume moves laterally slowly so that the time series shows extended periods of SF_6 at the sampler port. The plume is meandering back and forth over a small range giving multiple peaks at the port as the plume

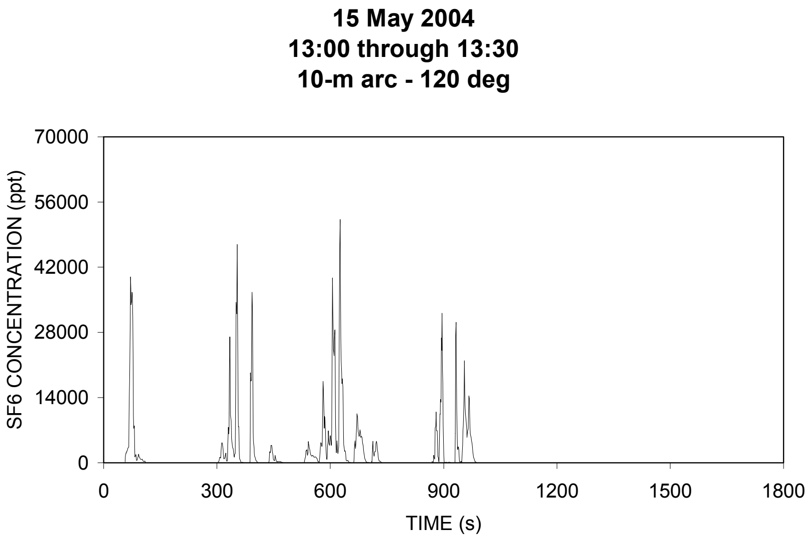

Figure 1.—Time series of SF_6 collected on the 10 m arc in the unthinned loblolly pine canopy.

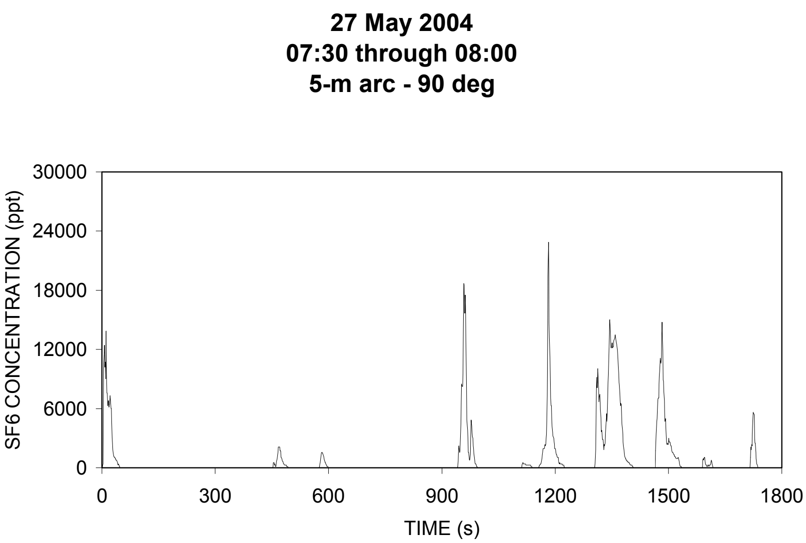

Figure 2.—Time series of SF_6 collected on the 5 m arc in the loblolly pine canopy thinned to 70 ft^2 basal area.

centerline meanders back and forth across it. This then contrasts with Figure 2 measured in the canopy with basal area of 70 ft^2 allowing a much more energetic flow regime to penetrate into the canopy. The floor of the canopy receives direct solar radiation so the canopy is atmospherically unstable. The larger turbulent scales associated with this flow regime are expressed in the time series which consists of more discrete peaks as the plume meanders across a wider range and crosses the single point less often leaving a larger number of zeroes in the series between plume crossings. (For discussion of similar plume structures measured or inferred in pheromone research the reader is referred to Aylor et al. 1976, Murlis and Jones 1981, Elkinton et al. 1984 and Mafra-Neto and Carde 1994.)

The implications of these data are not presently clear but thinning does have a dramatic influence on ventilation, incident solar radiation and the dispersive characteristics of the in-canopy environment. Plumes in the less dense canopy will have a larger meander range which may increase the probability of encounter by an insect but the higher velocity flows and increased wander of the plumes probably causes them to be ripped apart by the trees thus rendering them less coherent and difficult to associate with the point source where they originated. The plumes in the thicker canopies exist in a low dispersion environment and may be easier to track though they are not moving away from the point source as quickly. It is expected, however, that they will remain more concentrated for a longer distance in the stable trunk space atmosphere although they will move more slowly due to the very low velocity ambient flows.

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