

Testbeds for microbial source tracking using microfluidic paper-based analytical devices



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Summary

The team has developed a molecular method to detect fecal contamination around animal operations using *Bacteroidales* DNA as a biomarker. The team integrated this molecular method with data collected from weather stations to provide a risk heatmap for fresh produce operations in proximity to animal operations. The team has collected data on levels of *Bacteroidales* from >1,800 data points in testbeds (animal operations, stonefruit operations, and leafy greens operations). The data highlights that direction and activity are important factors in determining the levels of *Bacteroidales* around animal operations. In addition, the team has integrated visualization of weather data on top of the *Bacteroidales* concentration to highlight these trends.

Objectives

1. Characterize testbeds for distribution of aerosolized fecal contamination and generate a risk heatmap that incorporates bioaerosol distribution and environmental metadata.
2. Test the ability of microfluidic paper-based analytical devices (μ PADs) to rapidly characterize bioaerosol distribution.

Methods

The research involved three distinct testbeds at (1) Purdue University Animal Unit (ASREC), IN, (2) stonefruit operations, CA, and (3) leafy greens operation, AZ. A total of 1,890 collection flags were strategically placed across these locations, accompanied by weather stations and air quality monitors. The flags were swabbed, and *Bacteroidales* were detected using qPCR assays. The resulting data were used to generate risk heatmaps based on *Bacteroidales* levels.

Results to Date

Within testbed 1, we illustrated that we can integrate the data obtained from molecular assays and that obtained from weather stations (Figure 1). For example, wind direction and magnitude are indicated with arrows while PM2.5 and PM10 levels are indicated as symbols. We highlight that a gradient of *Bacteroidales* exists in testbeds 2 (Figure 2) and 3 (Figure 3). In these results, it is clear that direction of the sampling site matters in addition to distance from the source of hazard.

Benefits to the Industry

This study develops and validates a method for quantifying the risk of fecal contamination around animal operations. The team has noticed that each testbed provides a different distribution of bioaerosols and thus, a site-dependent risk analysis is important. Based on these results, we advocate for site-specific analysis to complement existing general guidelines.

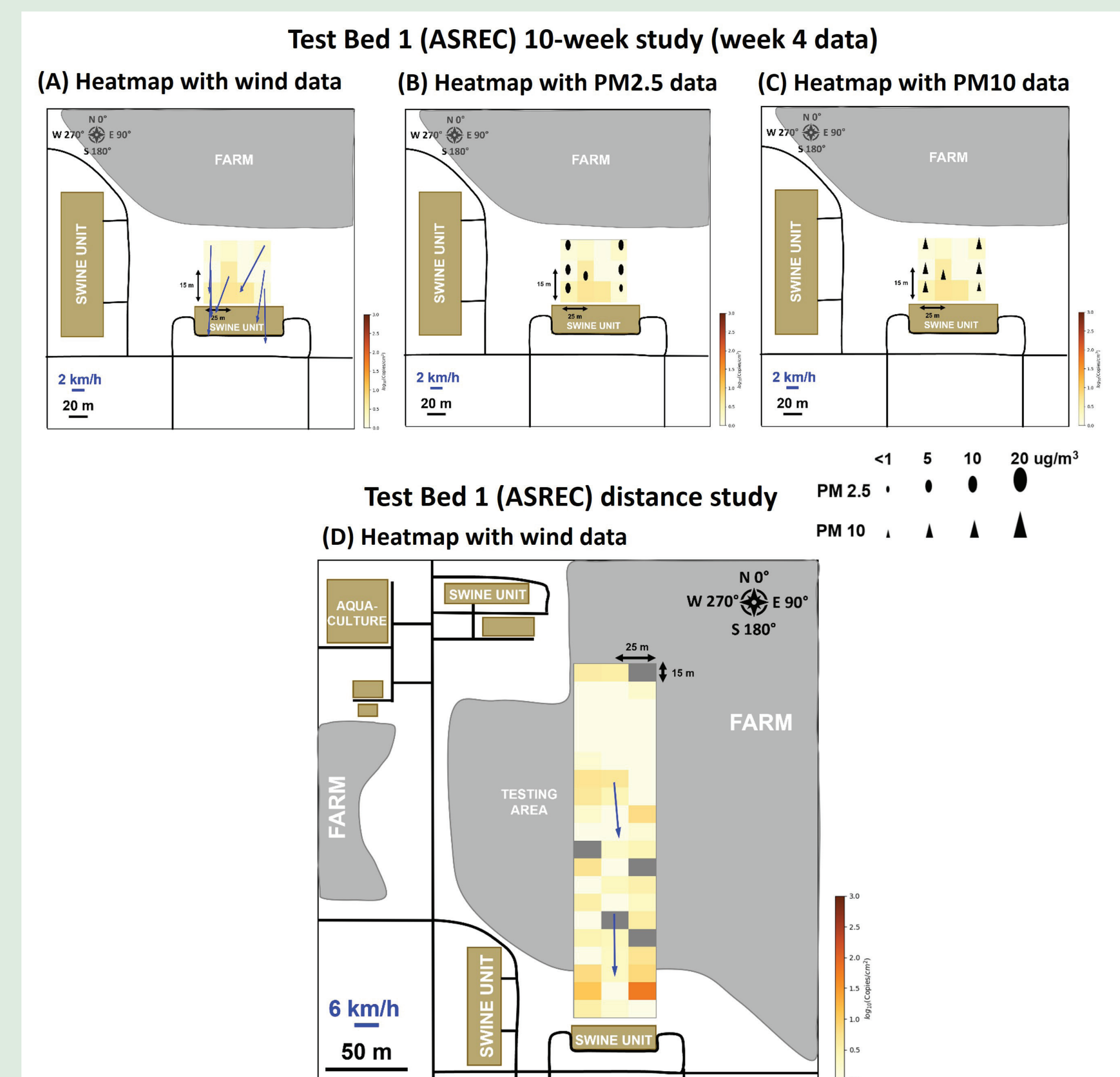


Figure 1. Testbed 1 (ASREC, Purdue): Heatmaps of *Bacteroidales* concentration with wind data for 10-week study (panel A), with PM2.5 data (panel B), and with PM10 data (panel C). Size of oval shape represents PM2.5 concentration, and triangle represents PM10 concentration. Length of arrow and direction of point denote wind speed and direction, respectively. Panel D shows the data collected over a longer distance from animal operation. Grey boxes denote missing collection flags.

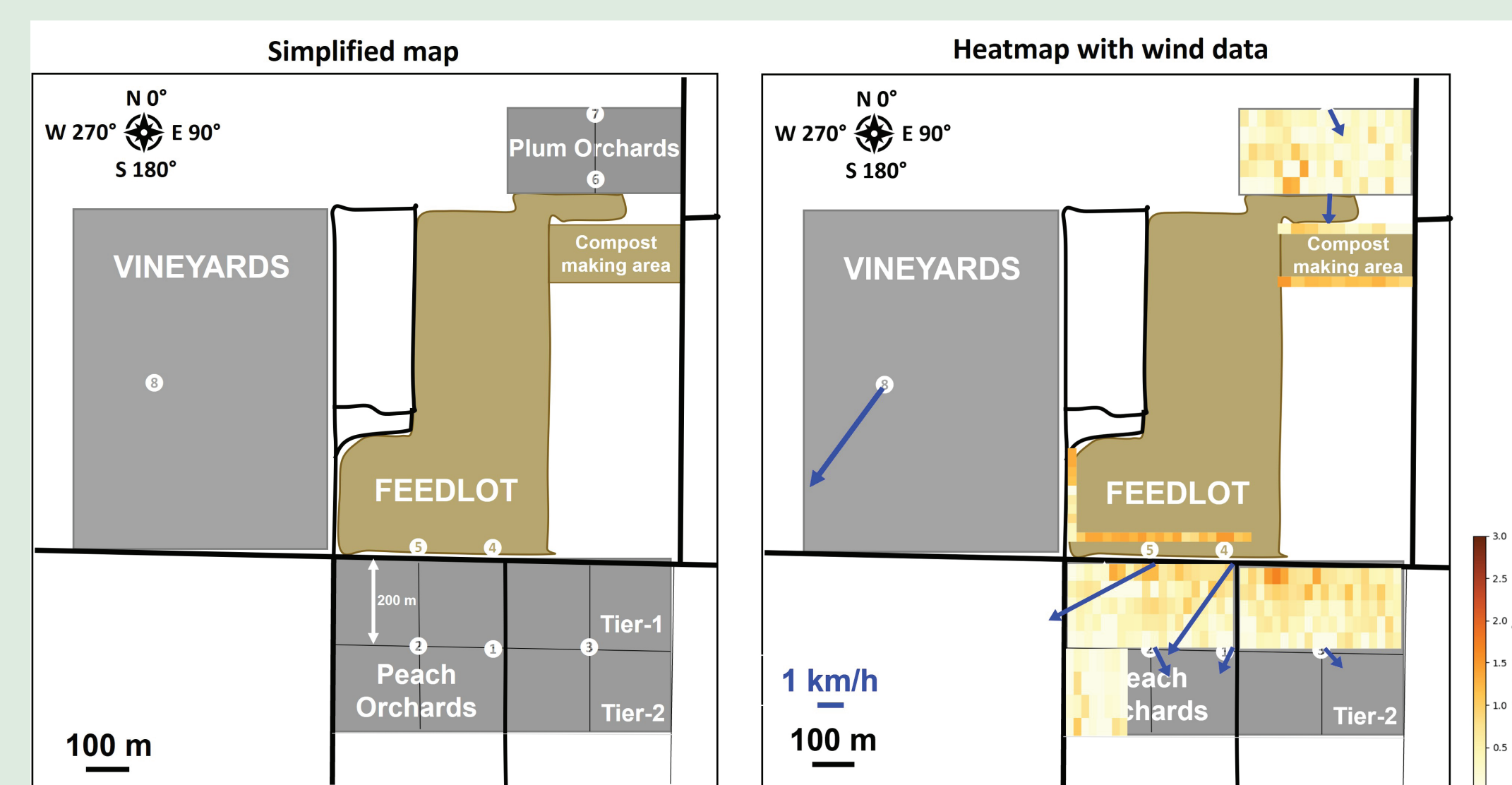


Figure 2. Testbed 2 (Stone fruit operations, CA): **Simplified map** - Numbers in circles show weather station location; plum orchards had 100 collection flags/orchards placed 50 m apart from N to S and 20 m apart from E to W; peach orchards had 200 collection flags at 50 m (N to S) and 20 m (E to W) apart in Tier-1, and 40 collection flags in Tier-2; feedlot had 30 collection flags and compost area had 20 flags. **Integrated heatmap** with wind data - heatmap of *Bacteroidales* concentration shows bioaerosol distribution in different directions. Length of arrow and direction of point denote wind speed and direction, respectively.

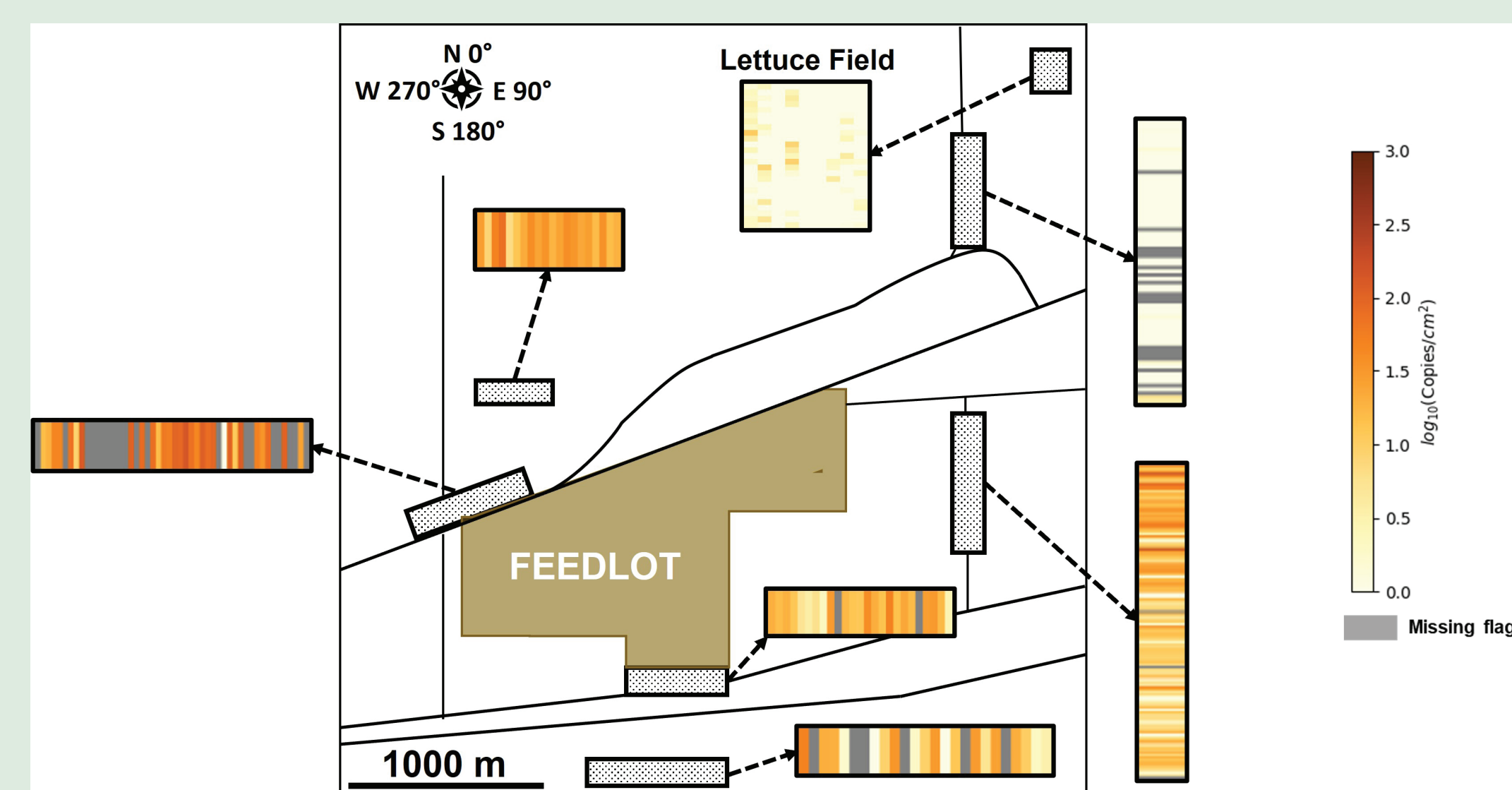


Figure 3. Testbed 3 (Leafy greens operations, AZ): Distribution of levels of *Bacteroidales* around a feedlot shows a dependence of risk on direction.