RESEARCH IN PROCESS

Modeling tools for design of science-based *Listeria* environmental monitoring programs and corrective action strategies

SUMMARY

Well-designed environmental monitoring programs for *Listeria* as a strategy to identify and eliminate *Listeria monocytogenes* risks are essential for the produce industry, and are increasingly mandated by both regulatory agencies and buyers. The industry also needs science-based tools to evaluate responses to *Listeria* detection that are both appropriate for a specific facility and its unique processes and effective in reducing risk of contaminated products. As it is not practical to test out different corrective actions and sampling strategies in a given facility, our objective is to use computer modeling to identify the optimal approaches for a particular setting. Specifically, a model we have previously developed is being adapted to fresh produce processing facilities and will be validated with sampling data collected through an on-going project. This project will provide industry with science-based resources for selecting appropriate corrective action approaches and demonstrating the equivalency of different sampling strategies in their unique facilities.

OBJECTIVES

1. Develop a series of computer models, representing different produce processing facilities, to be validated with industry data collected through an on-going complementary USDA Specialty Crop Research Initiative (SCRI)–funded project at Cornell University, as well as historical industry data where applicable.
2. Evaluate differential corrective actions in response to *Listeria* spp. and environmental monitoring plans in the modeled fresh produce processing facilities.

METHODS

Four produce operations were selected for this project: two packinghouses and two fresh-cut facilities.

The production schedule and routine events in each operation are being mechanistically modeled using NetLogo 6.0 to simulate *Listeria* transmission and cross-contamination over time.

The model prioritizes the observed features of a food production environment that are relevant to the behavior and persistence of *Listeria* contamination. Initial visits to produce processing facilities involved detailed measurement/observation of structures (floor, walls, and ceiling), equipment, personnel, and conditions (water, temperature, traffic, and workflow) that have been previously identified as important predictors of risk by many published studies.

For this project, major emphasis is placed on discretizing the floor and equipment in Zones 2 and 3, and potential sources and niches in Zone 4, and identifying contamination routes to Zone 1 surfaces.

Once the models for the four facilities are parametrized to reflect the facility-specific features, they will be validated with historical and prospectively collected *Listeria* contamination data. Facility relevant corrective actions will be coded in the model to test their effectiveness for the given facility.

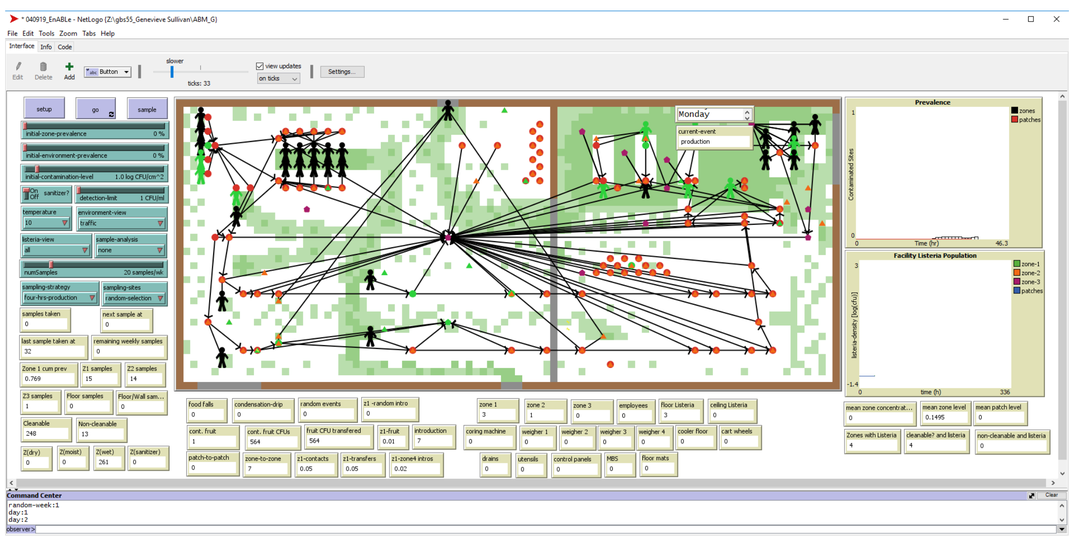

Figure 1. Model interface for a facility as viewed in NetLogo, displaying topography, agents (e.g., employees, equipment), and features of the preliminary agent-based model developed.

RESULTS TO DATE

As this project involves the development of computer models, main results are expected towards the project end. So far, a preliminary version of the first model has been constructed. **Figure 1** shows the screenshot of the model interface. **Figures 2–4** show equipment, traffic, and water maps underlying the model. Also, several activities are being pursued and accomplished that have led to interesting case studies. For example, observations at Facility 1 revealed that there was standing water nearly covering the entire floor of the production area, which may have a significant effect on model predictions for this facility as this was not the case in the facility modeled in our previously developed agent-based model (EnABLe). It was also observed that at certain times during production there are extra employees present, and therefore it will be of interest to evaluate the effect of additional employees on the model's prediction of *Listeria* dynamics.

BENEFITS TO THE INDUSTRY

Currently, there are few studies reporting surveillance of *Listeria* spp. in U.S. fresh produce processing facilities and no studies on optimal environmental monitoring strategies. Similarly, there are no computer modeling tools available to industry or researchers for microbial dynamics in fresh produce processing facilities that we are aware of. The goal of this project is to provide data and tools that will help fresh produce processing facilities (i) optimize corrective actions in response to presence/absence test results in various product handling areas, and (ii) identify alternative routine environmental monitoring programs that provide equivalent risk reduction.

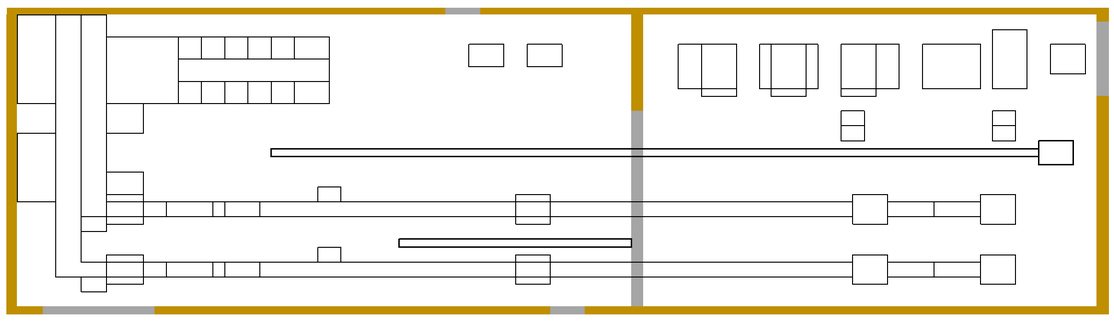

Figure 2. Floor map of Facility 1, with outline of equipment, walls, drains, and doors. Locations and dimensions based on measurements taken during initial observation visit.

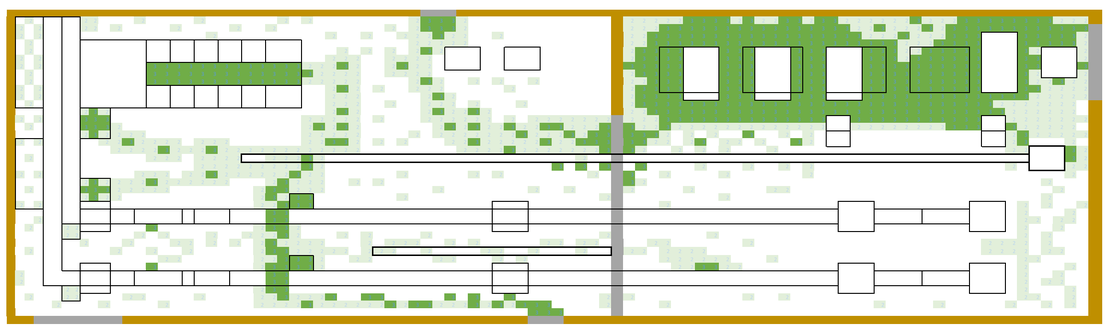

Figure 3. Traffic map of Facility 1, with darker green representing high-traffic areas and white representing low-traffic areas.

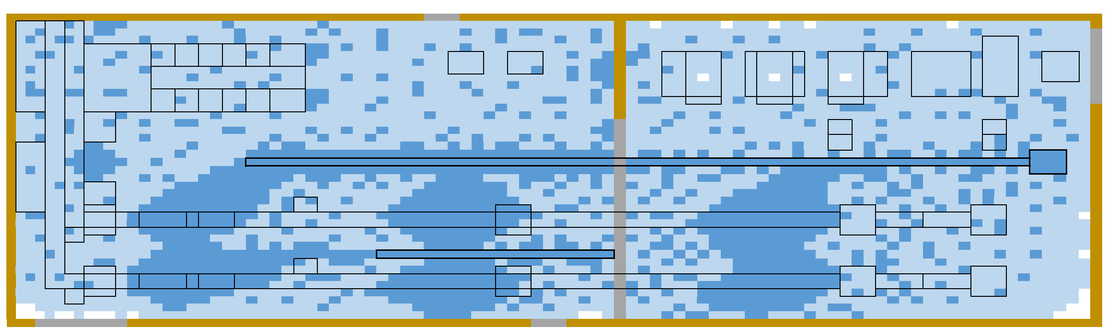

Figure 4. Water map of Facility 1, with darker blue representing areas with standing water, light blue representing areas where moisture was observed, and white representing dry areas.

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