Piloting Short-Term Messaging and Results of a $PM_{2.5}$ Sensor Study

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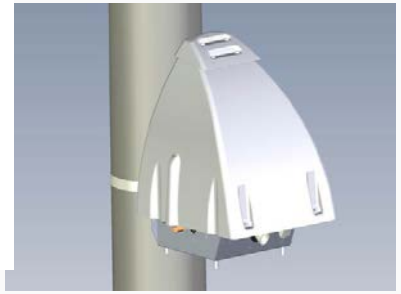
Agenda

- Introduction
  - E-Enterprise Advanced Monitoring Recommendations
- Sensor Data Messaging
- $PM_{2.5}$ Sensor Field Study
- Questions

Introduction - Proliferation of Sensors

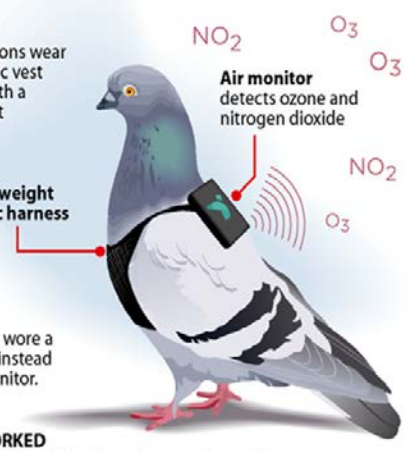


21st Century 'Canary in a Coal Mine'

The Pigeon Air Patrol — a joint project by tech companies Plume Labs and DigitasLBi — released pigeons outfitted with air-monitoring packs to record and report real-time air pollution levels in London. This three-day venture was used to spread awareness on London's smog problem.

WHAT IT IS

Racing pigeons wear a small fabric vest outfitted with a feather-light backpack.



One pigeon wore a GPS device instead of an air monitor.

HOW IT WORKED

Londoners Tweeted their location to a Pigeon Air team member and received real-time results (via Twitter) of air quality in their area.

SOURCE: DigitasLBi

PAUL HORN / InsideClimate News

Introduction

E-Enterprise Advanced Monitoring Team (EEAMT) Recommendations

- E-Enterprise Leadership endorsed five recommendations in April 2016
- Members: States (organized by ECOS), OAR, ORD, OECA, OW, OEI, and EPA Regions 1 & 2

Recommendations:

#1: Feasibility study for a voluntary 3rd party certification program

#2: Technology screening and support network

- Recommendations 1 & 2 will build on lessons learned from sensor evaluations and pilot projects https://www.epa.gov/air-research/air-sensor-toolbox-citizen-scientists

#3: Interpretation of data from advanced monitoring approaches

- Finalize & expand pollutant list for prototype website that messages short term, real-time measurements http://bit.ly/VillageGreenPilot

#4: Data standards & data quality tiers

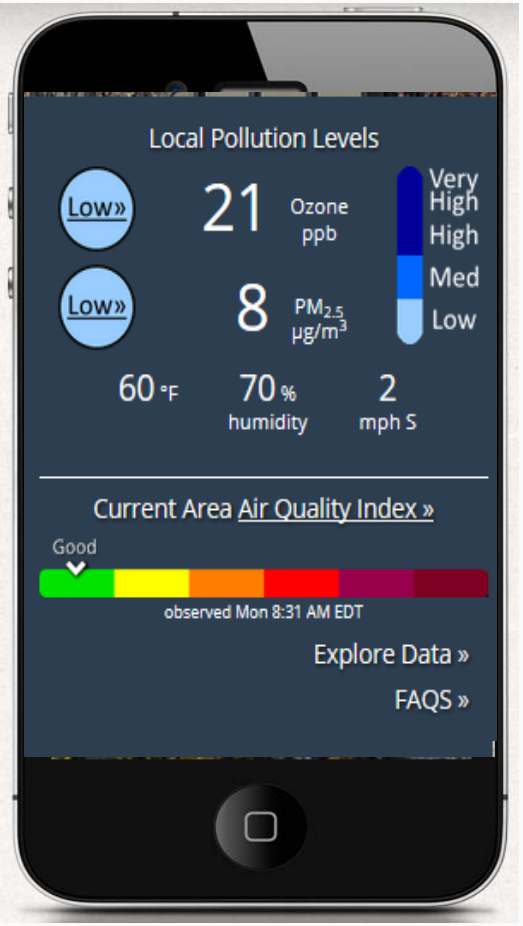
#5: Lean technology evaluation parameters

Introduction

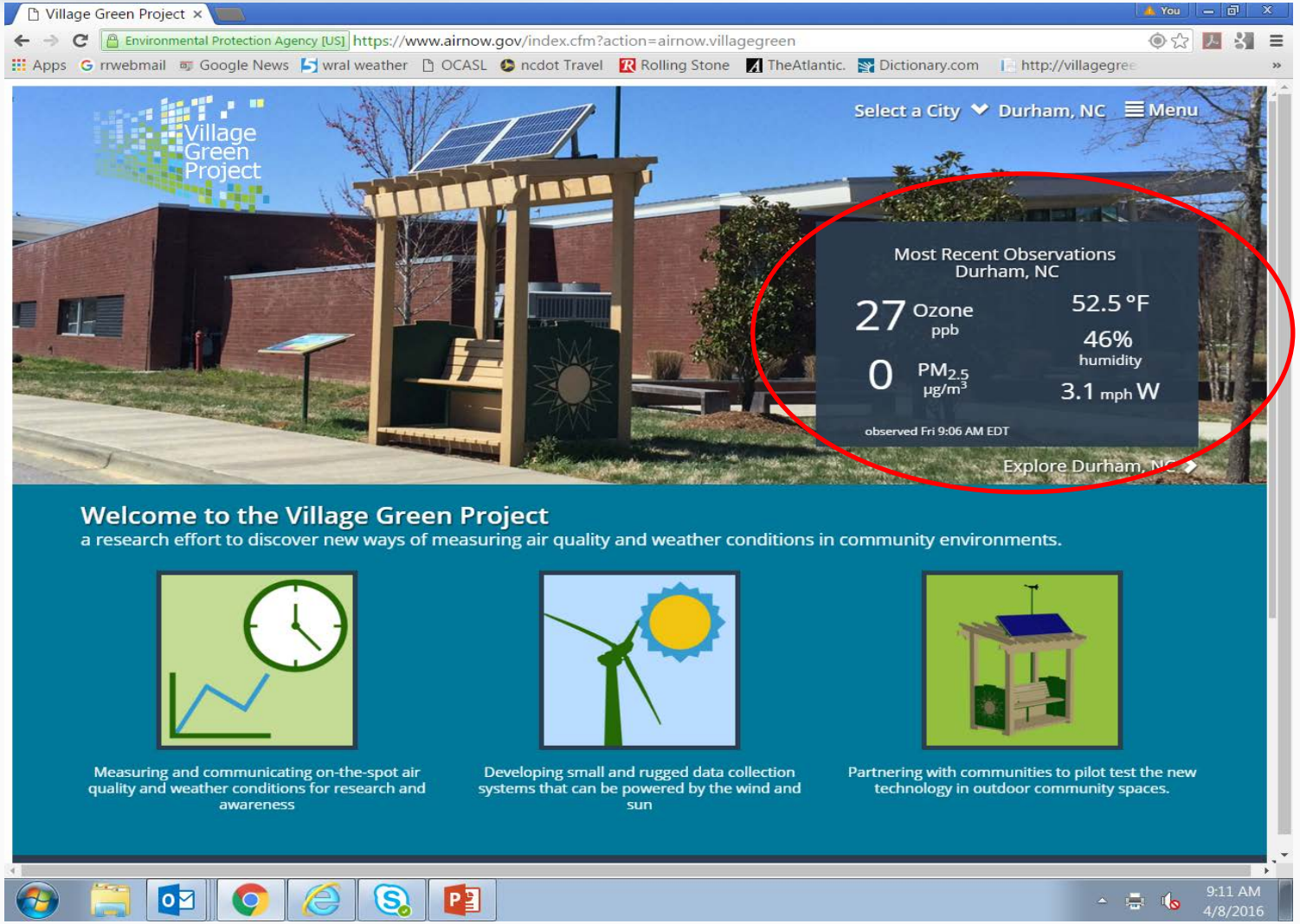
- There is a great deal of growth in the availability, use, and quality of air quality sensors
- Sensor technology has great potential to empower people to understand local air quality but communicating real-time data is complicated
- Health studies do not support linking short term (e.g. 1-minute O_3 or $PM_{2.5}$) exposures to adverse health effects
- Many developers are incorrectly using whatever information is currently available, e.g., AQI

Sensor Scale Pilot Project

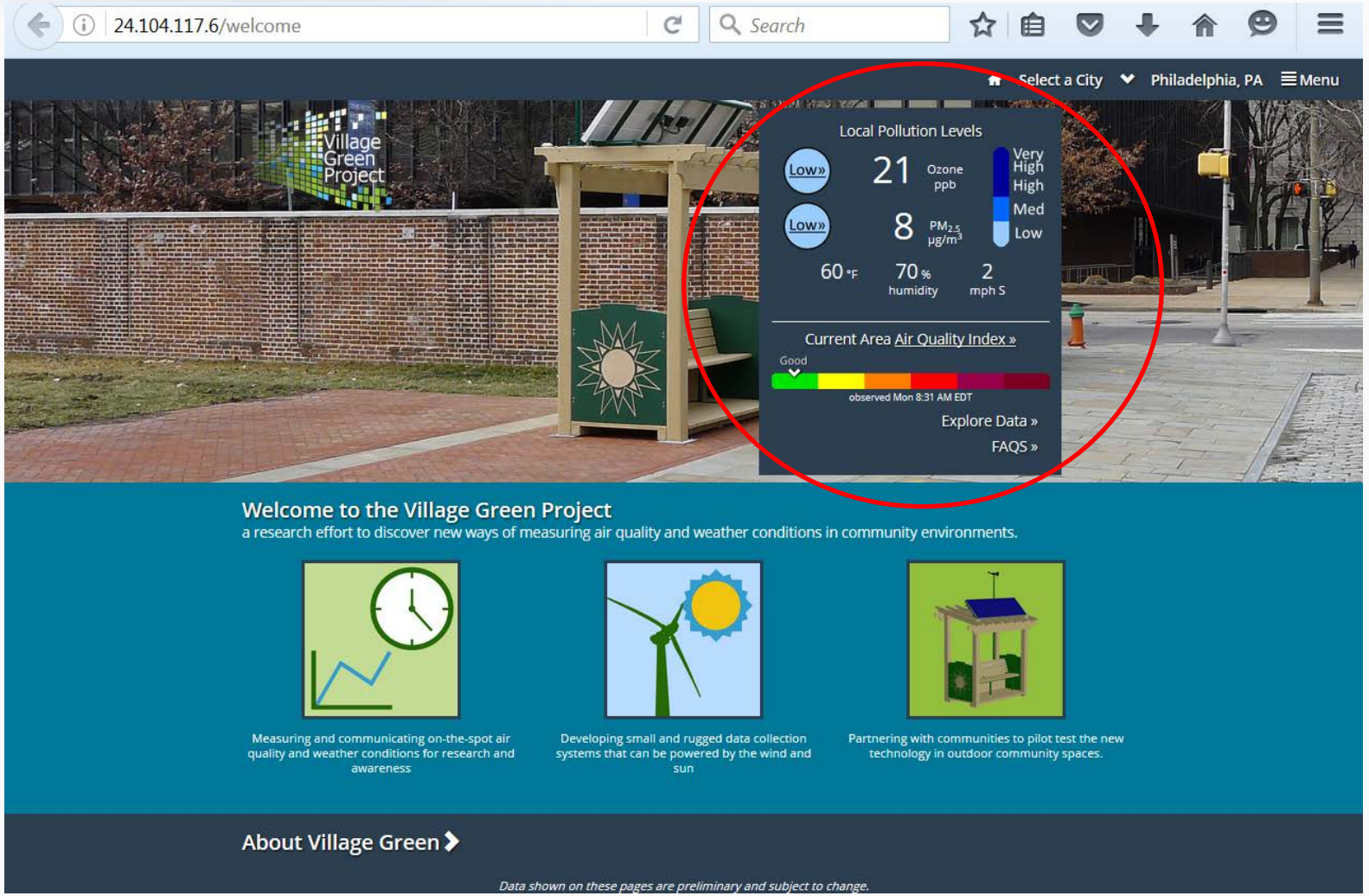
- On May 6th, EPA launched a new “sensor scale”
  - EPA developed the scale to help the public understand 1-minute data from Village Green stations
- Pilot appears on existing Village Green data webpage
  - http://bit.ly/VillageGreenPilot
- A fact sheet, FAQs, and other information available on the Air Sensors Toolbox
  - https://www.epa.gov/air-research/air-sensor-toolbox-citizen-scientists
- EPA is testing the effectiveness of the scale and messages during a spring-summer 2016 pilot project



Previous Village Green Website



Enhanced Village Green Website



Ozone Breakpoints and Messages

Pilot version **1-Minute Ozone Readings** ***Not for regulatory purposes***	
Low **0-59 ppb**	Enjoy your outdoor activities.
Medium **60-89 ppb**	If medium readings continue, use the Air Quality Index to plan outdoor activities.
High **90-149 ppb**	If high readings continue, consider adjusting outdoor activities, especially if you are sensitive to ozone. Check the Air Quality Index to find out.
Very High **≥150 ppb**	If high readings continue, consider adjusting outdoor activities. Check the Air Quality Index to find out. Very high readings may mean the sensor is not working properly.
	Sensor may be offline. Check the Air Quality Index.

$PM_{2.5}$ Breakpoints and Messages

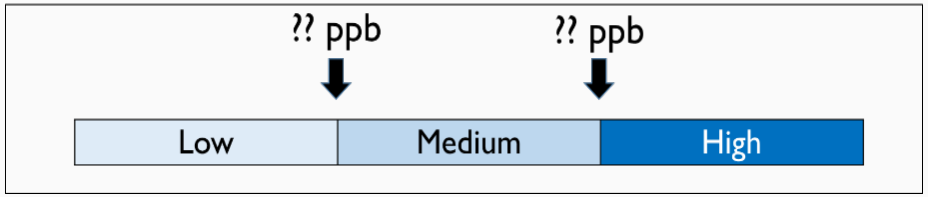
Pilot version **1-minute particle pollution ($PM_{2.5}$) readings** ***Not for regulatory purposes***	
Low **0-29 ug/m3**	Enjoy your outdoor activities.
Medium **30-69 ug/m3**	If medium readings continue (for an hour or more), use the Air Quality Index to plan outdoor activities.
High **70 - 499 ug/m3**	You may be near a source of particle pollution like dust, smoke or exhaust. Check the Air Quality Index to plan outdoor activities.
Very High **≥500 ug/m3**	You may be near a source of particle pollution like dust, smoke or exhaust. Check the Air Quality Index to find out if you should adjust outdoor activities. Very high readings may mean the sensor is not working properly.
	Sensor may be offline. Check the Air Quality Index.

Ozone Sensor Breakpoints

- Used available air quality data, together with judgments about the objectives for each sensor category
- Air quality analyses link 1-minute to 8-hour O_3 concentrations to inform sensor breakpoints without reinterpreting the health evidence
- ~7.6 million one minute ozone values from 18 sites (4 Village Green locations and 14 FRM)

AQI Categories (8-hr)

Potential Sensor Categories (1-min)



$PM_{2.5}$ Sensor Breakpoints

- For $PM_{2.5}$, the available 1-minute data is more limited than for O_3
  - **5 monitors provide 1-minute $PM_{2.5}$ data (DC, PA, KS, NC, NY)**
- $PM_{2.5}$ concentrations can exhibit sharp spatial and temporal gradients, with the potential for extremely high concentrations near sources
- $PM_{2.5}$ AQI categories are based on 24-hour concentrations; 24-hour $PM_{2.5}$ NAAQS is 35 $\mu g/m^3$

Near-Source Concentrations

1. Designated smoking areas:
   ~ 70 to > 500 $\mu g/m^3$
2. Near/on diesel buses:
   ~ 75 to > 1,000 $\mu g/m^3$
3. Near street paving operation:
   ~ 80 $\mu g/m^3$
4. Near candles/cooking
   ~ 100 to > 1,000 $\mu g/m^3$

Analytical Approach for $PM_{2.5}$

Low breakpoint (30 µg/m³):

- Considered relationship between 1-hour and 24-hour $PM_{2.5}$ concentrations
- Much more data available to identify relationships with 1-hour concentrations – almost 400 monitors covering most states
- One-hour $PM_{2.5}$ concentrations are better predictors of 24-hour concentrations

Upper breakpoint (70 µg/m³):

- Identification of $PM_{2.5}$ concentration ranges that have been measured near sources like bus terminals, smokers, cooking – high sensor readings should warn people that they may be near a PM source
- In response to high readings, people may be able to move away from sources and reduce their exposures

Next Steps

- EPA is piloting “sensor scale” messaging
- Village Green website has a “contact us” link
- Based on feedback, EPA will update the scale and messages as appropriate. Our goal is make them available to sensor developers later this year.
  - Note: Earlier versions of the information shown in the tables and the mobile website have been focus tested, and we have solicited previously from other stakeholders – EPA plans to continue soliciting feedback

$PM_{2.5}$ Sensor Field Study - Overview

Main Objective: Examine the use of low-cost particulate matter (PM) sensors for answering questions about Tribal air quality

Monitoring is being conducted in two phases:

Phase 1: Collocation of the sensors with existing $PM_{2.5}$ Federal Reference Method (FRM) monitor

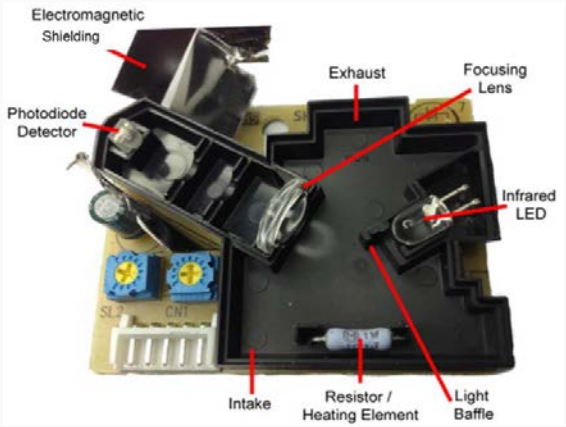
Phase 2: Monitoring near a local source to examine impacts on local air quality and nearby PM concentration gradients

Study Design

- One MicroPEM and two AirBeam sensors were evaluated
- Sensor selection was based on past performance during EPA testing, cost, durability, mobility, and ease of use

AirBeam

RTI MicroPEM



Internal components of the AirBeam sensor

Project Status

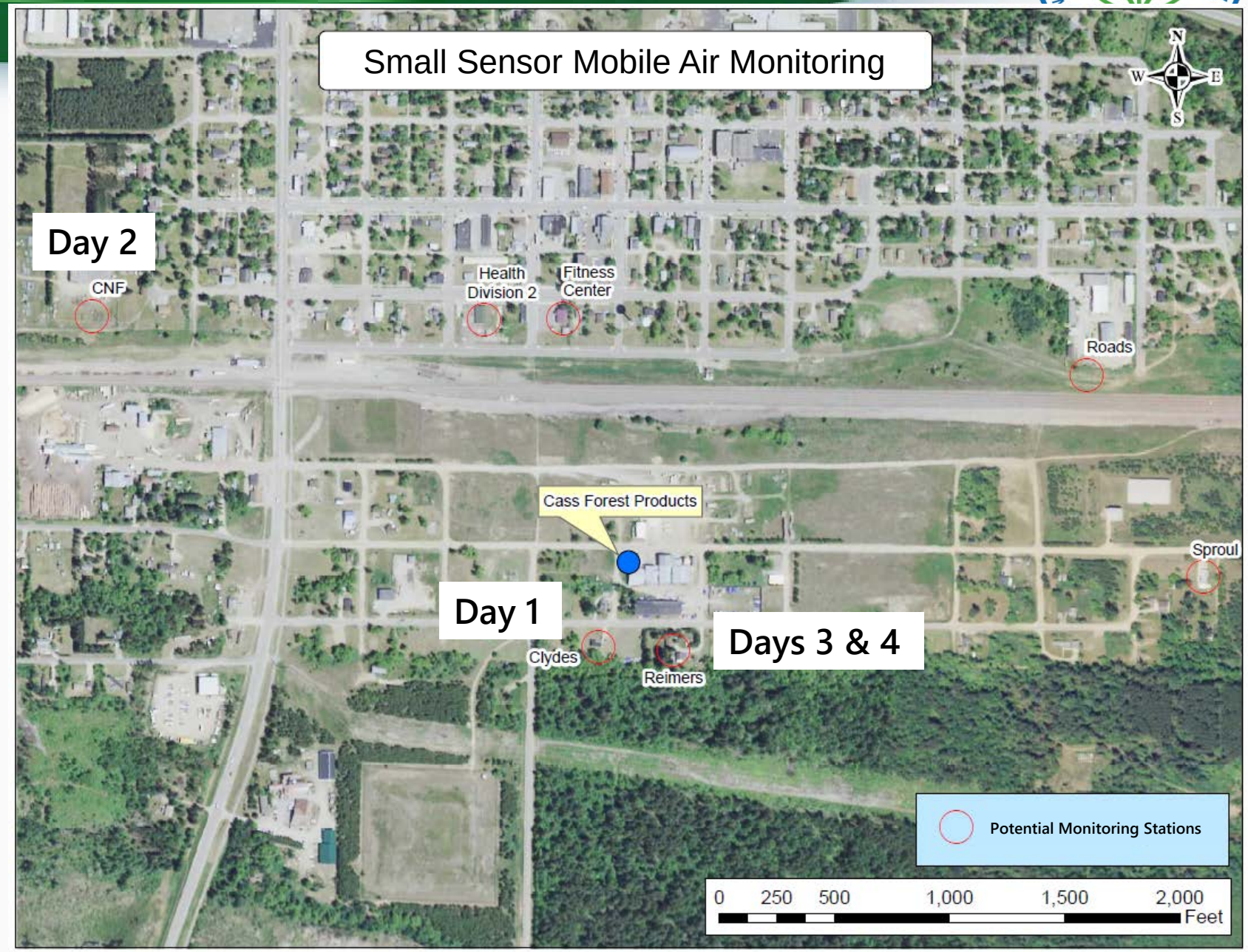
- Phase 1 - Collocation monitoring
  - Data were collected October 22, 2015 – June 13, 2016
  - Data analysis performed on data collected October 22, 2015 – February 28, 2016
- Phase 2 - Near-source monitoring
  - Data were collected June 13, 2016 - present*

*As of August 2016, sensor data are still being collected at a near-source site.

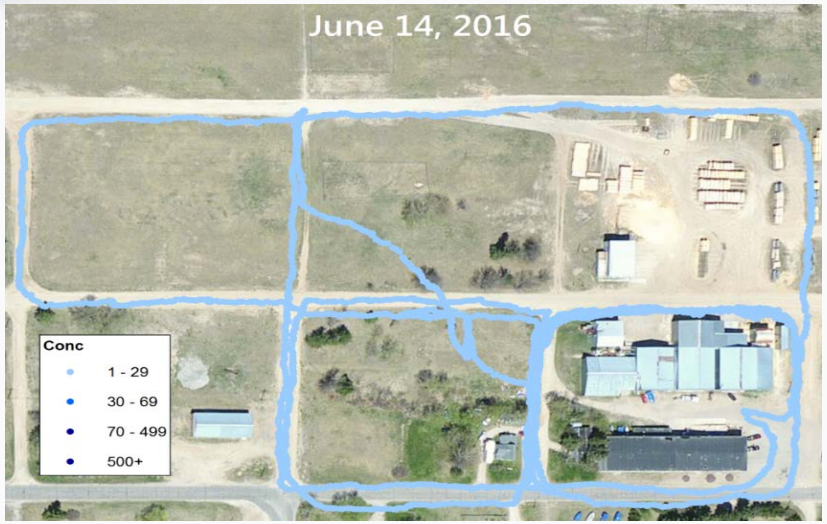
Phase 2: Near-Source Monitoring

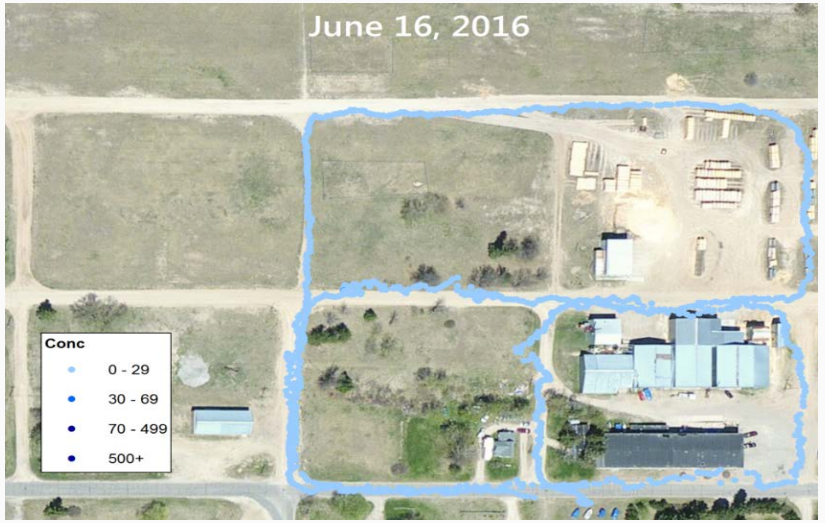
- Collected data near a 1940's boiler/kiln on June 13-17, 2016
  - MicroPEM and both AirBeams (AirBeam A is working under more moderate, summertime conditions)
- Performed meteorological forecasts 1-day ahead to determine which site to monitor at each day given forecasted prevailing winds
- Set up a small meteorological tripod to monitor wind speed and direction
- Performed mobile monitoring with one AirBeam to examine spatial gradients near the source

Phase 2: Study Design



Phase 2: Preliminary Results





<u>Next Step:</u>
Analyze data and determine comparability of sensor readings under ambient vs. near- source conditions

Preliminary Results – Do Not Cite or Quote

Sensor Study - Observations & Next Steps

- Observations
  - AirBeams performed inconsistently (one performed well despite harsh conditions, other did not perform)
  - MicroPEM required frequent in-field calibration and substantial post-processing using data from a second sensor
  - Multiple off-the-shelf sensors should be used to collect sensor data
- Next Steps
  - Analyze collocation and near-source sensor data
  - Consider effect of particle size/shape in reading of sensor

Questions