Mobile Phones, Citizen Scientists, and the Cloud

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collaborative work with many co-PIs and students
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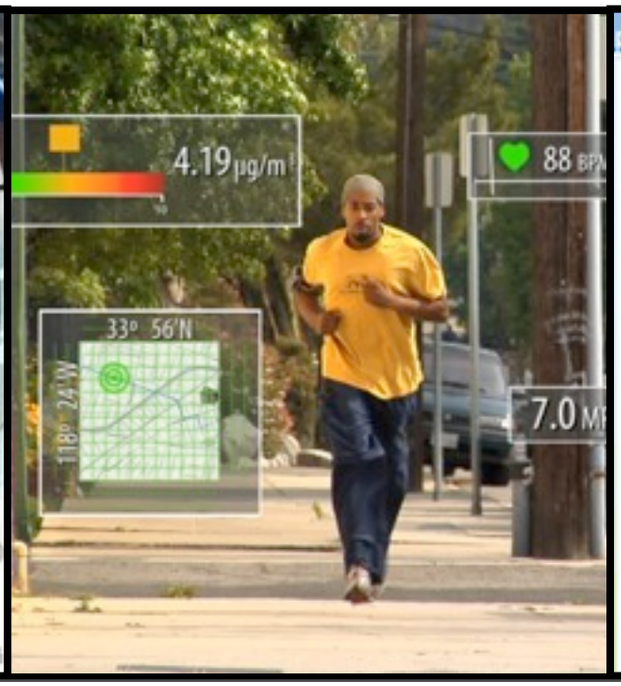
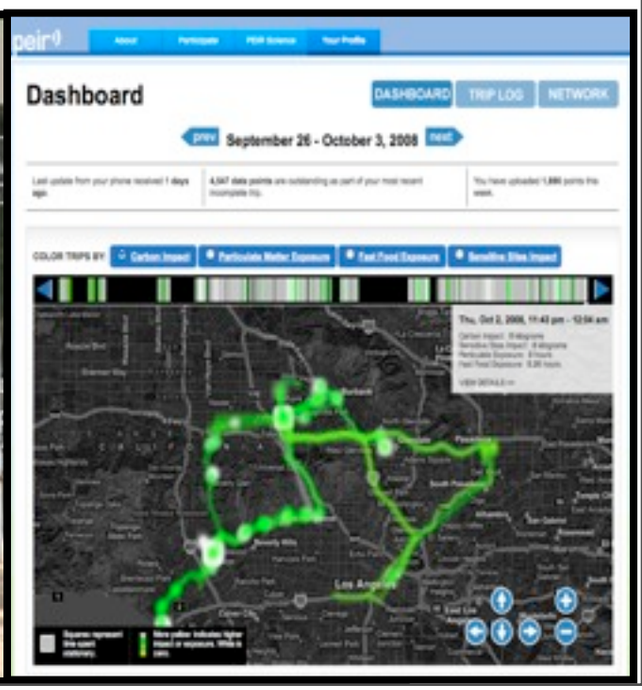
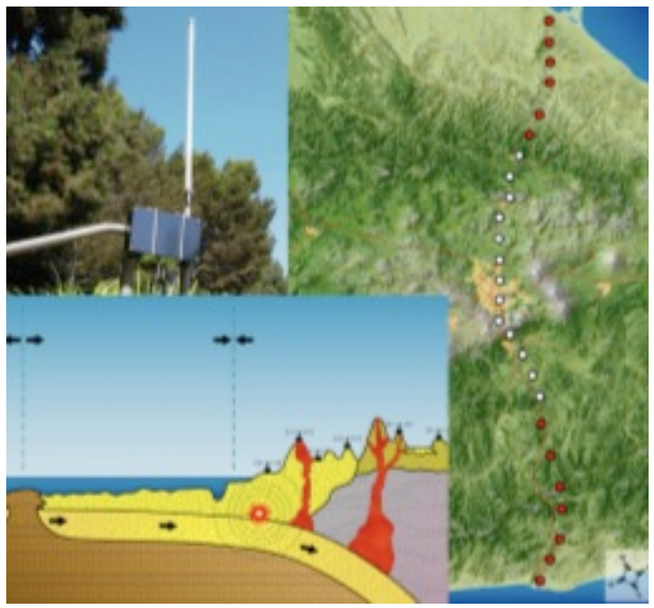
http://participatorysensing.org

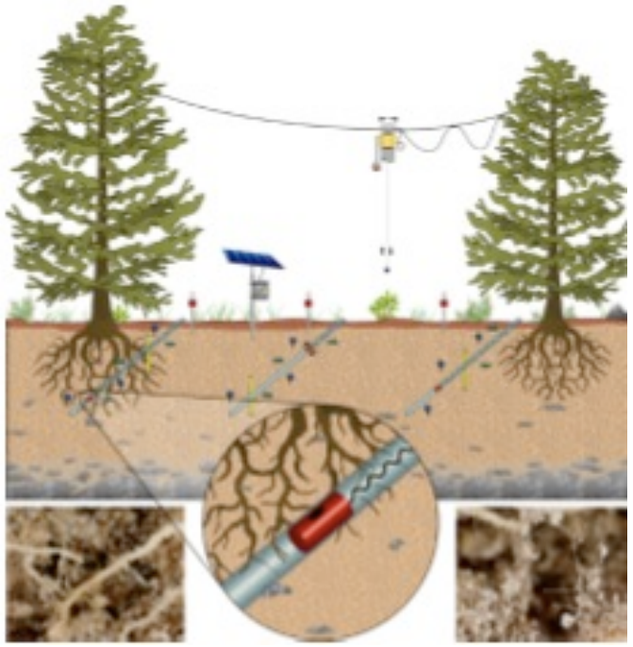


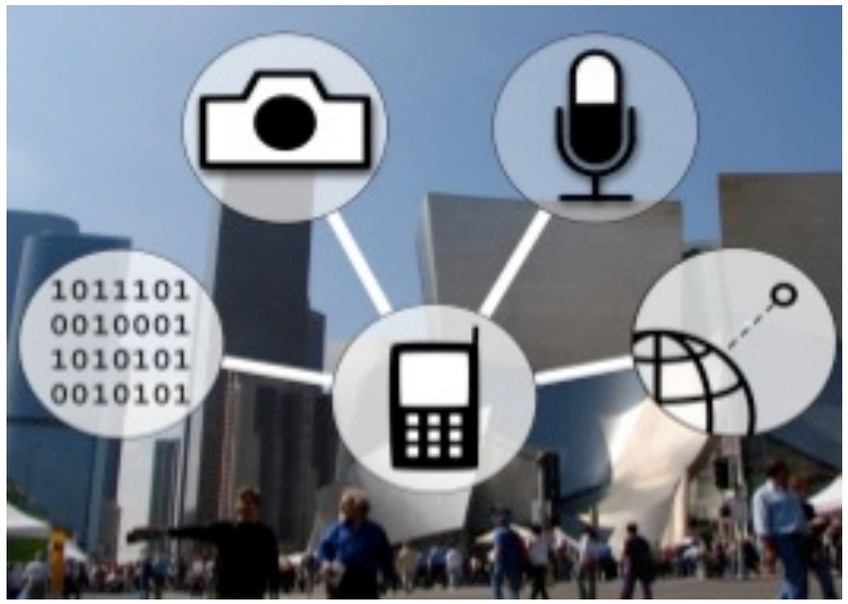


CENS Focus: Embedded Networked Sensing

Our center-wide focus is to create programmable, distributed, multi-modal, multi-scale, multi-use observatories to address compelling sciences and engineering issues.
From the natural to the built environment. From ecosystems to human systems.







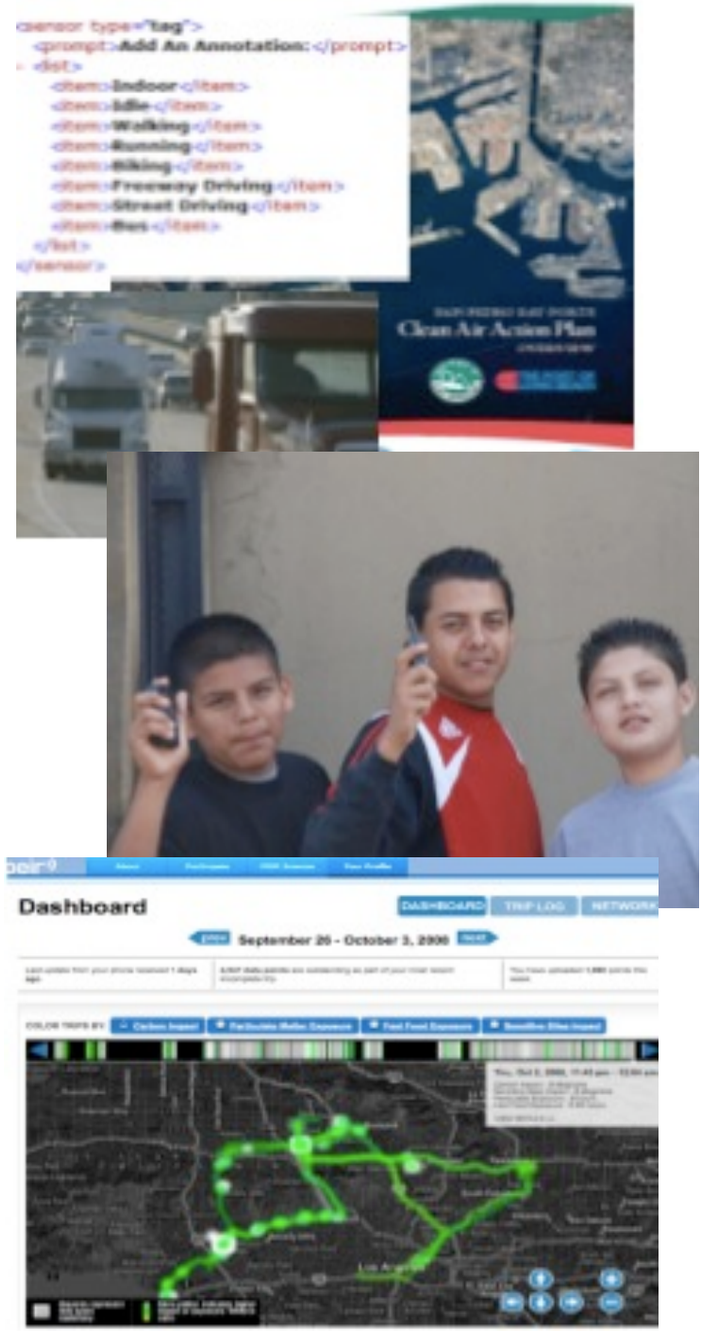
Mobile Personal Sensing

Enabled by > 3 x 10^9 mobile phone users, increasingly with ...

- Imagers, location, bluetooth-connected sensors
- Automatic-geocoding of data
- Programmed, user, and sensor initiated capture
- Server-side processing and presentation of data

Motivated by 6 x 10^9 people on planet earth and their concerns ...

- Individual health and wellness
- Public health, urban planning, epidemiology
- Civic concerns (transportation, safety, culture ...)
- Resource management



Participatory Sensing: Campaign Model

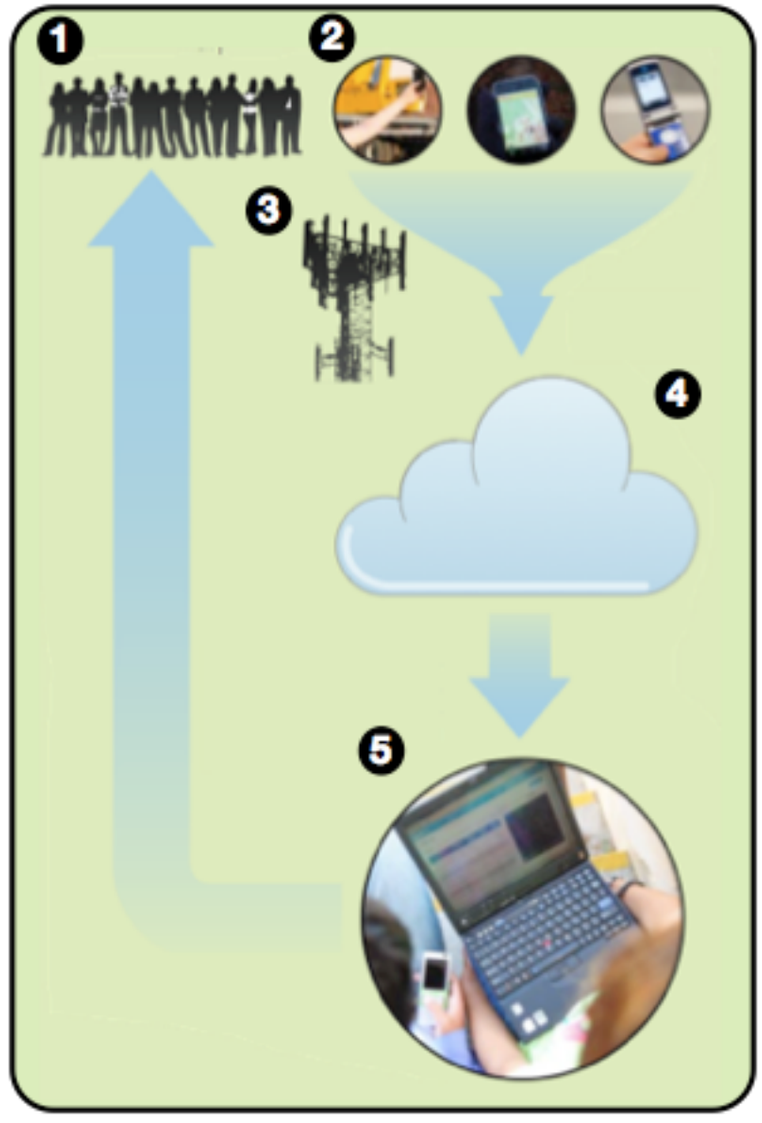
Distributed data gathering challenges as "campaigns"

Spatially and temporally constrained systematic data collection operations

Exploring a single hypothesis, phenomena, or theme

Using human-in-the loop sensing to gather data

With automatic and manual classification, auditing, and analysis



Precedent: Community-Based Participatory Research

Technical Challenge: the Human Factor

Diverse population of participants with mobile phones

- different availability, mobility patterns, diligence, skills, timeliness, phone capability

Opportunistically leverage mobility for sensing coverage

- humans are self-willed; feedback with incentives for improved participation

Privacy for participants

- selective sharing, control over resolution, visualization for privacy screening

Quality assurance for data consumers

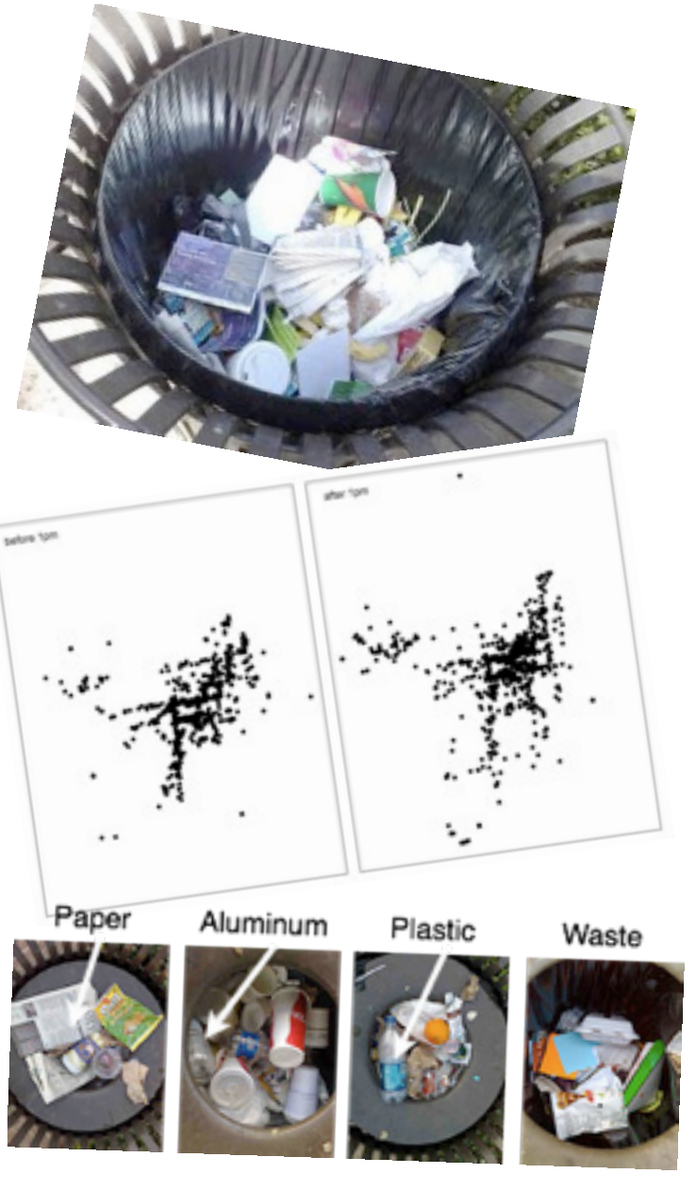
- verification, attestation, audit trails of measurements

- rate contributions to assign reputation to participants

We are developing algorithms, software, and network services to address these challenges.

Initial Pilot Campaigns

GarbageWatch
Recycling Practices on Campus



HabWatch
Harmful Algal Blooms

What's Bloomin
Blooming Flora on Campus

Invasive Plants Campaign - “What’s Invasive!”

The Santa Monica Mountains National Recreation Area is the nation’s largest urban national park, featuring over 500 miles of recreation trails and 47 miles of beaches, all within easy access to a metropolitan region of more than 17 million people.

In May, we handed out 10 Nokia phones to NPS staff to see if they could record the locations of the six top invasive plants:

Harding grass

Perennial pepperwood

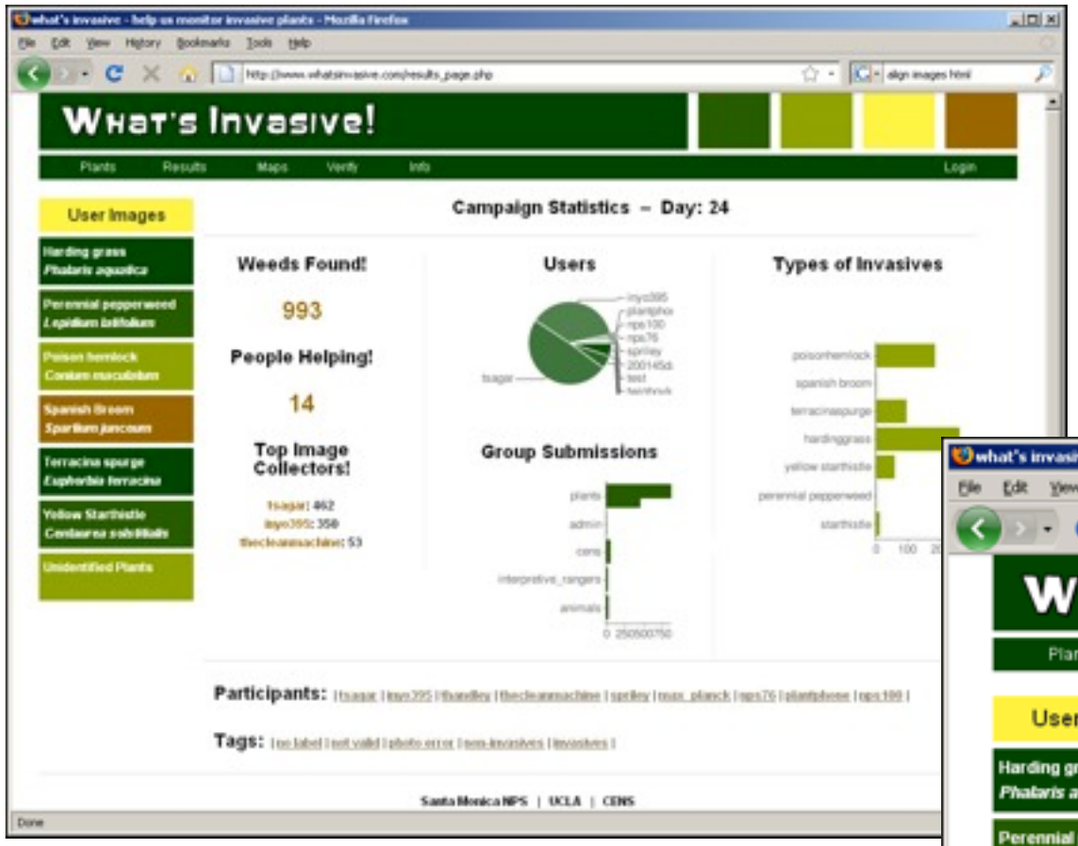
Poison hemlock

Spanish broom

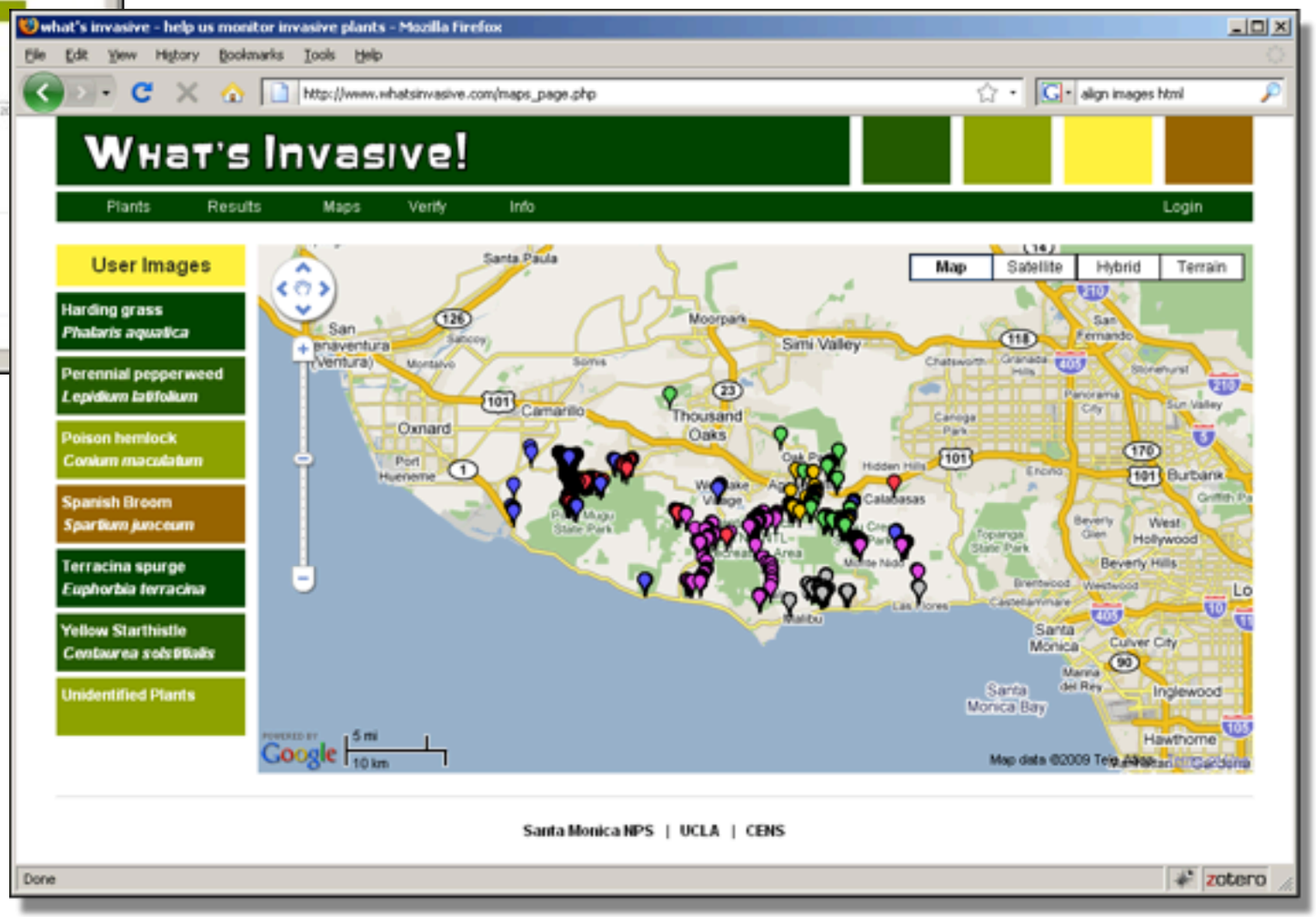
Terracina spurge

Yellow starthistle

Invasive Plants Campaign - “What’s Invasive!”

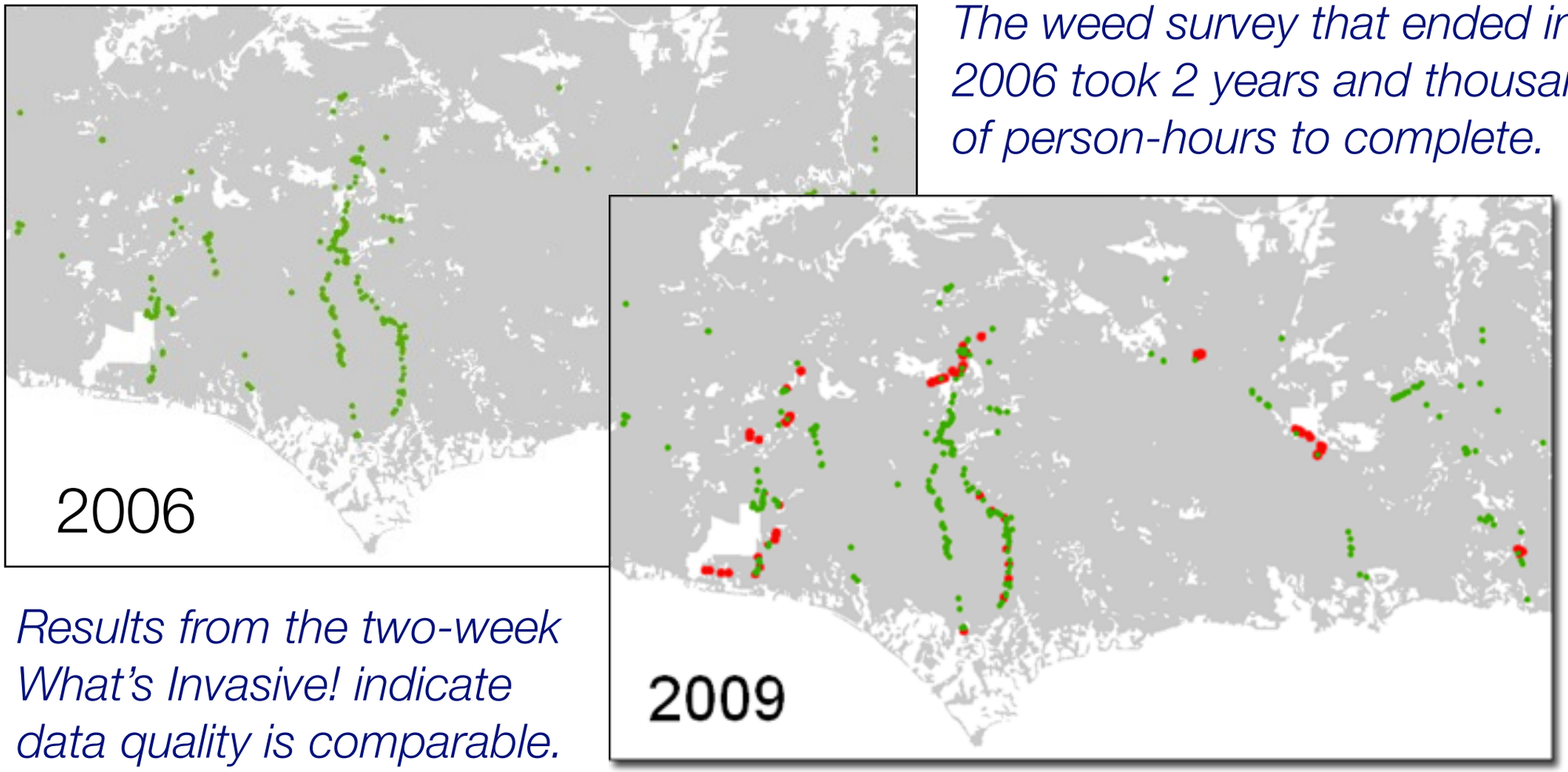


Mobile data collection included image capture and species tagging on the phone. Feedback was primarily through the website, with summary statistics and maps of newly found invasive plants, updated in real-time.



With extensive help and feedback from the NPS participants, we were able to establish motivation for data collection and the desired feedback to the mobile device.

Invasive Plants Campaign - “What’s Invasive!”



The weed survey that ended in 2006 took 2 years and thousands of person-hours to complete.

Results from the two-week What’s Invasive! indicate data quality is comparable.

New distributions and significant advancement of some invasive species have occurred within that last 3 years since the original survey.

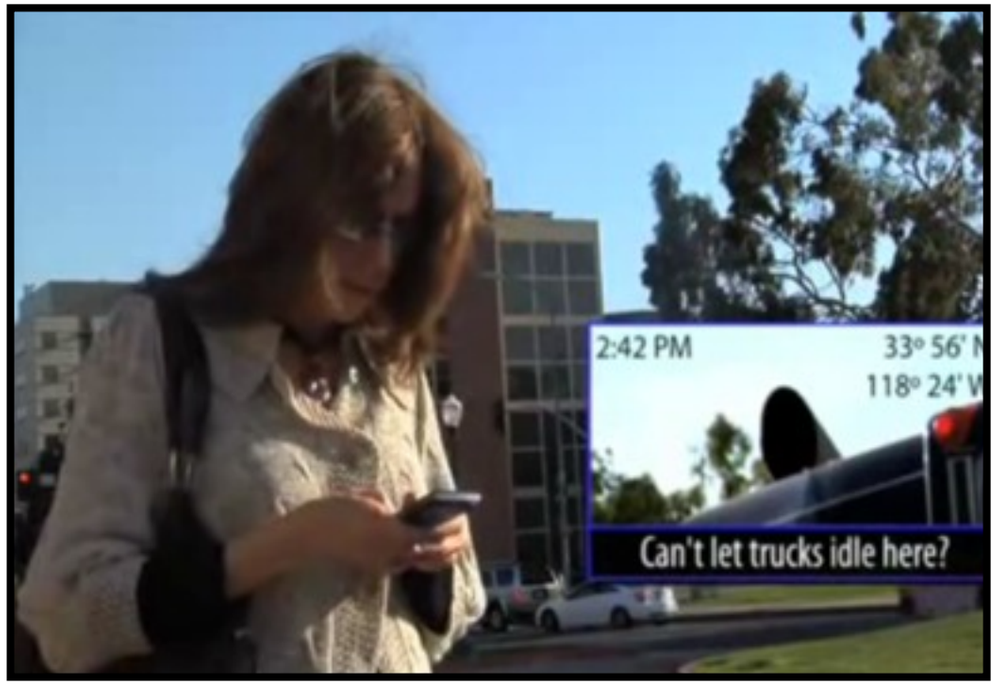
Conservation specialists at the NPS, armed with this new data, can focus attention on managing areas that are newly invaded.

Wasteful Idling of Trucks - “What’s Polluting!”

The reduction of truck idling is becoming a significant target in efforts to reduce fuel consumption and emissions from heavy-duty trucks.

Fuel consumption by idling trucks by as much as 20 million barrels annually, there has been a growing amount of anti-idling legislation pending or being considered.

Idling buses and other vehicles at or near schools or hospitals are particularly detrimental to health and well-being.



Wasteful Idling of Trucks - "What's Polluting!"

Public participation in identifying wasteful idling trucks and busses has been limited to recording information for later submission to websites or by reporting telephone.

- Vehicle Type
- School Location and District
- License Plate Number
- Vehicle Company Name and Number
- Date, Time, and Location of the Incident
- Approximate Year of the Vehicle
- Make and Model of the Vehicle
- Date, Time, and Location of the Incident

Mobile phones, with image capture, geocoding, and date-time stamping allow concerned citizens to more easily capture such data at the time of occurrence.

Wasteful Idling of Trucks - “What’s Polluting!”

- **Buses, Commercial, Municipal**
- **Diesel or Gas?**
- **Near a hospital, school, elder care home?**
- **Attendant?**
- **Repeat Offender or Location?**
- **Severity of Exhaust: 1 – 5**

Images of offending vehicles will be placed in a public archive and displayed on the What’s Polluting website as incentive for responsible companies and institutions to correct bad behavior.

Rapid Campaign Platform (RCP)

Objective

- Enable individuals to easily build their own campaigns

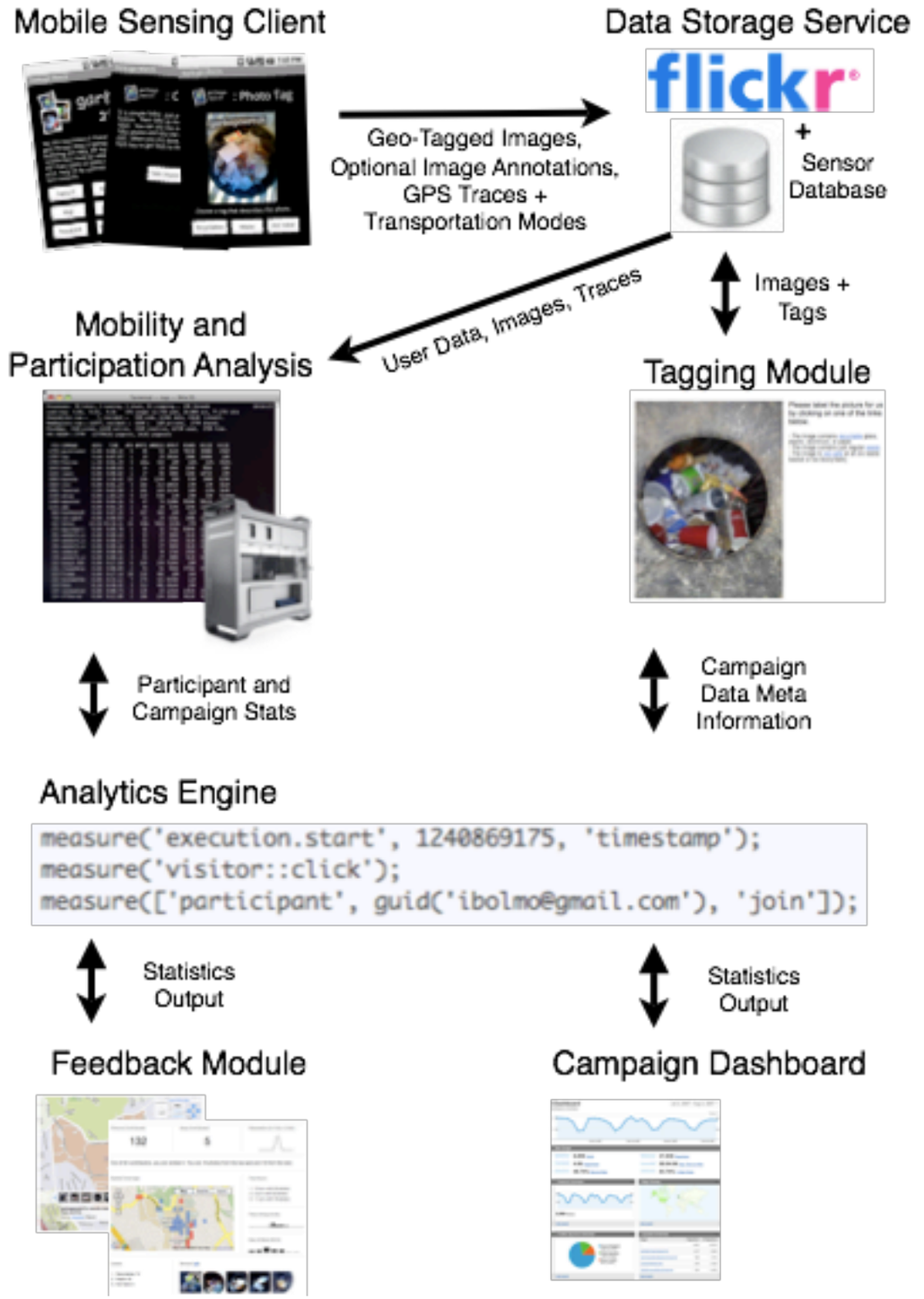
- Use cloud services so that hosting can be done offsite and scaling can occur

Enabling Modules

- Extendable Android client for media capture, upload, and feedback

- "Template" website and "data mux" to quickly get a campaign up and running

- Aggregation and visualization service for campaign and participant analytics



RCP: Android Client

Features:

- Geo-tagged photo capture and tagging.

- Provide statistics about your contributions.

- View a map of recently submitted photos.

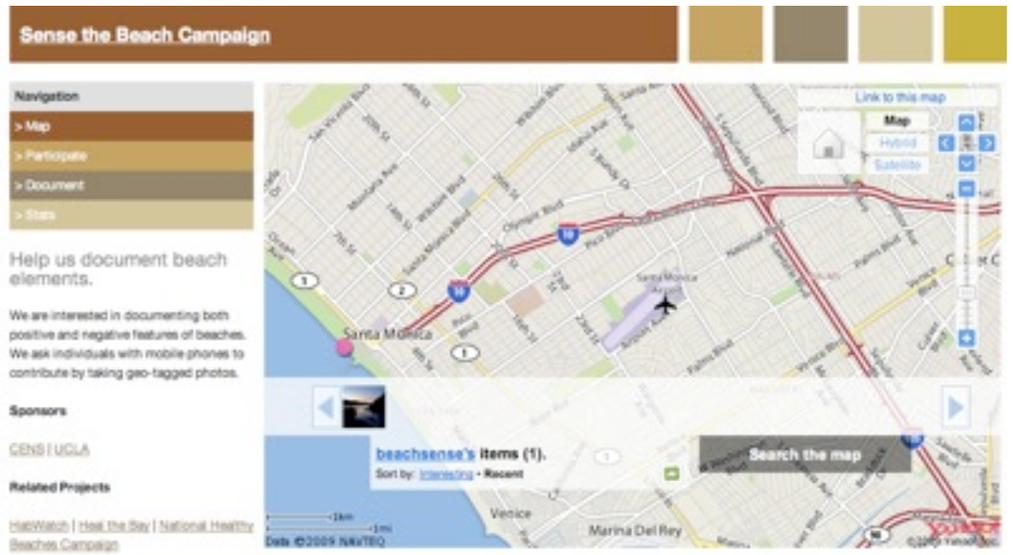
- Get feedback through notifications in areas where participation is needed.

- Services for automatically uploading your location and photos.

RCP: Template Website and Data Mux

AppEngine Based Website

- Contains information about the campaign including what the campaign is about, how to participate, and some visualizations for feedback in regards to participation



AppEngine DataMux

- Processes incoming data so that it can be piped to different storage services

- Flickr to store images
- AppEngine Datastore or SensorBase for other data
- Cametrics for campaign and participant statistics

RCP: Data Storage

Flickr

- For storing images and meta information such as tags

- Chosen due to familiarity, API functionality, and 24.95 flat rate for unlimited uploads / storage

AppEngine Datastore or SensorBase

- For storing other content not related to images directly or location trace data

RCP: Cametrics

Logging, summarization, and visualization solution for campaign related analytics

- Can “measure” different aspects of a campaign and generate simple
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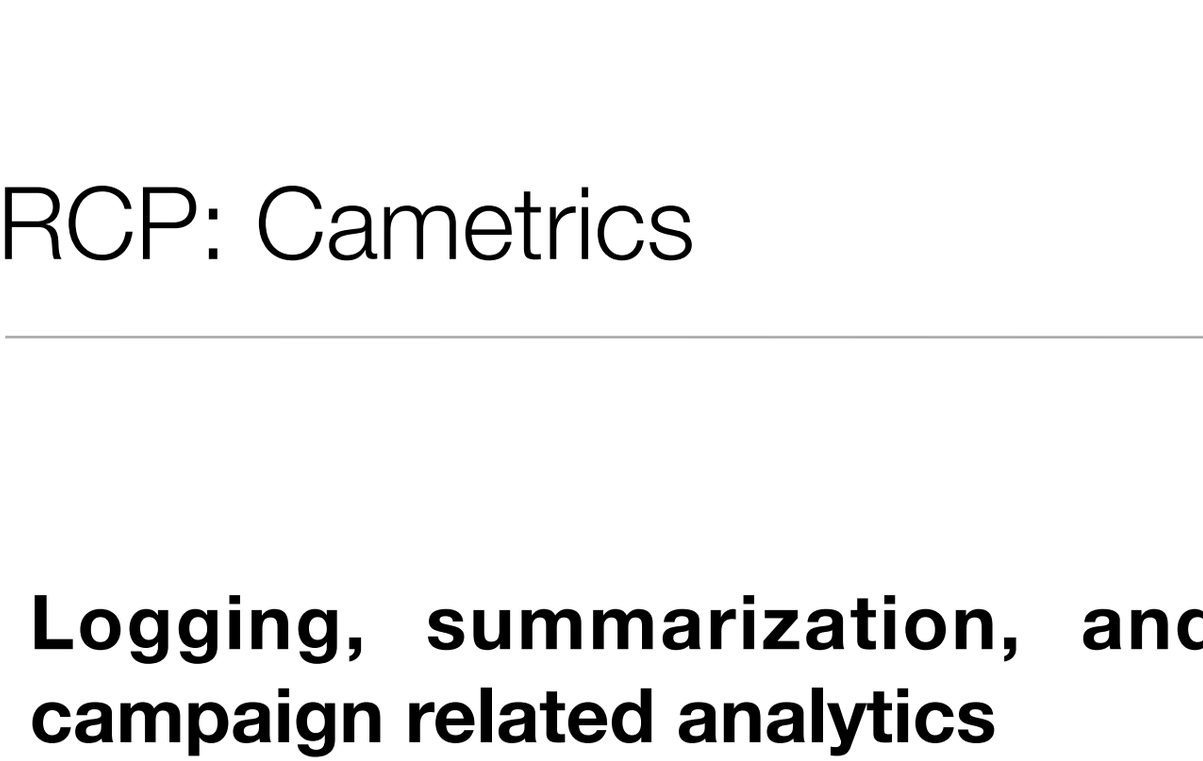

Cametrics::measure(‘contributions’, 1, ‘number’)Cametrics::measure(‘users’, $username, ‘string’)
Cametrics::measure(‘group’, $groupname, ‘string’)Cametrics::measure(‘invasives’, $type, ‘string’)
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Call for Participation and RCP Download

We would really like to get you involved in our campaigns that we are running in Santa Monica and New York City. Please sign up to become beta testers at:

http://participatorysensing.org

You can also download the code for RCP at that same location so that you can start your own campaign and help us extending the framework.