The Public Laboratory
for Open Technology and Science

PublicLaboratory.org | *an open-source civic science initiative*

Introduction

Citizens lack the basic tools to independently assess information that is handed down to them by perceived experts, especially with regard to environmental issues. Climate change skepticism is just one manifestation of the increasing gap in trust between the science establishment and its audience – a gap which counts among its causes the inability of scientists and technologists to engage in a participatory way with everyday people. PLOTS bridges this gap through collaboration to solve communities' real world problems. The affordable DIY tools which our open community develops has enabled hundreds of people to independently collect and interpret data, thereby bolstering their evaluative capacity and improving local access to critical information on environmental issues. Our model represents a shift in how citizens interact with data: they may engage at any level of Bloom's taxonomy, including framing questions and interpreting results. This stands in contrast to other citizen science projects, whose participants are often limited to performing a narrow set of tasks such as categorizing data or logging observations. Through the process of first-hand data creation and analysis, PLOTS community researchers build expertise in critical thinking and technologies with broader application to their role as civic participants.

Mission statement

The Public Laboratory for Open Technology and Science (PLOTS) is a community which develops and applies open-source tools to environmental exploration and investigation. By democratizing inexpensive and accessible "Do-It-Yourself" techniques, Public Laboratory creates a collaborative network of practitioners who actively re-imagine the human relationship with the environment.

The core PLOTS program is focused on "civic science" in which we research open source hardware and software tools and methods to generate knowledge and share data about community environmental health. Our goal is to increase the ability of underserved communities to identify, redress, remediate, and create awareness and accountability around environmental concerns. PLOTS achieves this by providing online and offline training, education and support, and by focusing on locally-relevant outcomes that emphasize human capacity and understanding.

Infrastructure

Our web presence and seven brick-and-mortar "community research centers" form the backbone of a unique group of open source community researchers who share their expertise in science, technology, community organizing, activism, and anthropology publicly on the web and in person. To launch this initiative, we have had generous support from the *Knight Foundation*, the *MIT Center for Civic Media*, the *National Affordable Housing Network*, *UNICEF*, the *Shpilman Institute*, *DevelopmentSeed*, and various other gifts and awards. The resulting infrastructure has enabled regional communities of researchers to solve problems and share information with

each other through offline meet-ups and workshops. The resulting collaborative efforts yield open source how-to guides for making and customizing tools for inquiry, and methods for conducting rigorous investigations which are in turn documented on our site and in hard copy at research centers. The data produced is designed to function as civic information: visually accessible and distributable in standard formats.

Program areas

Public Laboratory has three primary program tracks: Sustainable Futures, Civic Environmental Science and Healthy Homes. Tool development and and regional research projects falls into these categories (at times spanning two or three), creating linkages across disparate geographic regions that share environmental and social challenges and conditions. Examples of Healthy Homes include robotic air pollution trackers; examples of Civic Environmental Science include urban watershed and green infrastructure mapping, as well as wastewater monitoring; examples of Sustainable Futures include over a year and a half of wetlands monitoring along the Gulf Coast after the BP oil spill and researching affordable hydrogen sulfide sensing in gas patch communities dealing with the effects of hydraulic fracturing.

Across all program areas, tools and research sites, we promote community engagement, affordable, do-it-yourself techniques, ethical practices, and transparent, accessible, advocacy-based outcomes:

Community engagement around civic and environmental issues: We prefer to use the terms *colleague*, *collaborator*, or *partner* instead of *user* or *participant,* as each of our projects in done in cooperation with communities. In our work to date, we have seen diverse interest from NGOs, technologists, governments, students, artists, activists, and hobbyists; however, many are residents of the communities facing environmental issues, and we consider these residents -- especially in under-served communities -- to be our primary focus. Underserved communities facing environmental issues are often the subjects of scientific research by outsiders who fail to understand the needs and interests of the community. With PLOTS tools, communities can become investigators of the subjects of concern to them, and through the process, come to understand and own the results. Once data is collected and interpreted, community researchers can leverage it to influence and convince journalists, scientists and policymakers.

This sense of ownership and leverage resonates strongly with the PLOTS community. Reflecting on a recent PLOTS event, one student commented, *"... it gives our communities a chance to fight back. We were basically able to make our own Google Earth. It made us realize that we don't always have to rely on companies or what they say. This process gave us the confidence to do things that we might have thought were too complicated or troublesome - you can really do so much with relatively little."*

DIY research: The PLOTS community leverages Do-It-Yourself R&D as an open and shared methodology to support critical inquiry. A central impulse of DIY is to understand and own technology through self-production with available materials, and PLOTS is an outgrowth of this ideal -- we make tools by rapid prototyping with opportunistically repurposed materials. To make something oneself is to have a sense of ownership of it, and we extend this sense to scientific tools and data. PLOTS provides technical support and how-to guides much like other DIY movements, but our focus is on high-veracity data methodologies and reproducible results from experiments conducted by well-supported (yet non-professional) investigators. DIY aims to make technology something anyone can develop; PLOTS aims to make scientific research something anyone can do well.

Ethics of tool use: As both individuals and as a community, we stand to benefit from the legal protections of open source licensing, but more importantly, we are attempting to create a culture of critical inquiry and discourse to link technologies with their social context. By exploring and debating topics like the ethics of data production, the importance of high-level participation in research projects, and the socioeconomic and political dimensions of our work, we hope to equip ourselves as a community with the necessary frameworks to assess political, social, and ethical questions in the diverse applications of our tools in the field.

Outcomes and Formats: One advantage of a central PLOTS staff is that we have been able to support our broader research community with the infrastructure to publish and disseminate PLOTS data and methodologies. To provide a space for the sharing of consistent and well-structured data, while also connecting such data to the stories and cultures which give it context, we have launched two distinct initiatives:

> The **Public Laboratory Archive** fulfills several goals; one is to support the legitimacy of locally-sourced data by presenting it in formats which are legible to the traditional scientific establishment, and ensuring that the data can be correlated with more traditionally-collected data, such as that of the United States Geological Survey. To improve accessibility to the PLOTS digital collections in areas beyond the reach of the internet, we are creating archived collections of images and maps on USB sticks and DVDs, and contributing them to local libraries in places like Belle Chasse and Buras, Louisiana.
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> PLOTS published the first **Grassroots Mapping Forum** in June 2011 -- a large, fold-out publication that featured a July 2010 map from Wilkinson Bay, Louisiana. On the reverse we featured an interview with local resident Barbara Marcotte, an editorial, a balloon mapping guide, and means of recording and submitting ground observations to be added to the Archive. The goal of the Forum is to create a compelling picture of the cultural context and landscape that situates the aerial photographs, and which invites continued critical discussion in the PLOTS community. The Forum leveraged the printed format to open our digital Archive to a broader audience which might more naturally pick up a map left at a library, a seafood market, or a marina.

Local chapters

PLOTS communities are mostly organized by regional "chapters" -- some of which are jump-started by staff members, and others of which developed organically in response to local issues or goals.

> **Butte, Montana:** A PLOTS Butte Site Coordinator position has been funded by the National Affordable Housing Network. PLOTS and NAHN have been working with Butte residents since June on mapping and fulfilling community development outcomes in the Centerville neighborhood. Currently the Butte Coordinator is working on the distribution of a local paper newsletter and with a dedicated team of 5-7 volunteers who map regularly with kites and balloons.
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> In addition to the mapping events, grassroots mappers attended Centerville's neighborhood meetings, inviting residents to participate in oral history interviews to discuss what about Centerville should be documented. Through both mapping and community discussion, the Centerville PLOTS chapter has several long-term goals -- including organizing a neighborhood association and beginning to fundraise for small improvement grants.
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> **Asheville, North Carolina:** Asheville was the site of the October "barnraising", during which remote sensing experts, community organizers, agriculture specialists and an extended community of makers joined to collectively develop affordable infrared photography techniques for vegetation analysis, brainstorm research directions and goals and make infrared analysis accessible to a broader public. After this meeting, the Asheville site has continued a partnership with RiverLink and with the local small-scale farming community.
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> **Gulf Coast:** PLOTS began an effort to map the BP Oil Spill in the Gulf of Mexico on May 5, 2010, only two weeks after the Deepwater Horizon sank into the Gulf. Since then, staff and volunteers have completed over 70 mapping trips, worked with 130 local Gulf Coast residents, trained 15 trip leaders, collected approximately 100,000 images and have created over 50 maps from these images -- work which continues today, as wetlands continue to recover from the spill. Through a core partnership with the Louisiana Bucket Brigade (LABB), a New Orleans nonprofit, PLOTS helped residents map coastal areas spanning four of the Gulf Coast states including Louisiana, Mississippi, Alabama and Florida.
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> PLOTS staff members visited New Orleans in early May 2010 and after a week of trainings and mapping trips with LABB, were able to hand leadership of the project over to local residents. PLOTS worked with the Louisiana Bucket Brigade to manage the flow of volunteers, plan the logistics for mapping trips, develop weekly training sessions for

new volunteers, and create education programs for different groups of interested individuals including schools, universities, individual community members and other community organizations. PLOTS staff have continued to provide technical support for the project and are responsible for data management.

Gowanus Canal: In January 2011, in partnership with PLOTS, the Gowanus Canal Conservancy began conducting environmental investigations in the Gowanus Canal sub-watershed by using balloon mapping to create aerial surveys. Since the first trip, they have continued mapping every season over the past year. They have also begun flying a double-camera setup to collect infrared imagery. They are primarily concerned with documenting patterns/ concentrations of vegetation and possible contaminants, monitoring the stormwater retention design interventions that the GCC is installing along the canal edge, and identifying unknown or unidentified pipes and sources of groundwater entering the canal. In the long-term, this inquiry effort seeks to address the 300M gallons of untreated sewage that will continue entering the canal yearly even after the EPA finishes their Superfund clean-up of the toxic sediments at the bottom of the canal. More recently, a New Town Creek monitoring project has been started at Brooklyn's "other" EPA Superfund site. The first set of imagery was collected in the summer of 2011, from a Riverkeeper boat during a shoreline infrastructure assessment.

Other Public Laboratory chapters include: Lima, Peru; Rio de Janiero, Brazil; Jerusalem, Israel; Sumava, Czech Republic; Austin, Texas, Somerville, Massachusetts and Rifle, Colorado.

Research & development

The Public Laboratory website is where our community develops open-source documentation and literature around our DIY civic science research. Documentation has dual functions -- first, to create a geographically diverse network of people engaged in civic science activities, and second -- because of the Share-Alike license under which tools are developed -- to ensure that new research based on PLOTS tools will remain open source, and be contributed back to the PLOTS community. Currently there are six main DIY tools at various stages of development by PLOTS community researchers:

Aerial mapping with balloons and kites: This DIY mapping tool was the first developed by PLOTS, as part of the Grassroots Mapping project. Citizens use helium-filled balloons and digital cameras to generate high resolution "satellite" maps of areas such as in the Gulf Coast and Gowanus Canal. Although this tool has been in use for two years, components of the kit -- kite and balloon design, the rig, the camera -- continue to evolve as they are adopted in new places and adapted for new purposes.

Infrared vegetation analysis: Infrared photography can help in assessing plant health, and has been used on satellites and planes for agricultural and ecological assessment primarily by vineyards, large farms and large-scale (read: expensive) research projects. By creating and open-sourcing a low-cost near-infrared camera and working with wetlands advocates, farmers and environmental activists, we have begun to explore grassroots uses for this powerful analytic technique.

Roomba indoor toxin mapping: Public Laboratory contributors from RISD's Environmental Justice Research Cluster in Providence have been working on a Roomba robotic vacuum cleaner as a platform for exploring indoor areas for contaminants like formaldehyde and VOCs. By changing the color of an attached light to the reading from a chemical sensor mounted on the Roomba, it can "paint" trails of light around a room in a long-exposure photo.

Spectrometry: The PLOTS spectrometer is a prototype chemical analysis tool made from simple materials: cardboard, tape, a DVD, and a digital camera. The DVD is the key component: the tightly packed grooves in the disc act as a prism, separating different wavelengths of light. By measuring each and comparing to a database of known spectra, the composition of materials can be inferred. PLOTS researchers hope to enable low-cost identification of contaminants from water and soil samples, diagnosis of crop diseases, and monitoring tools for smokestack emissions.

Hydrogen sulfide sensing: This pilot project explores hydrogen sulfide sensing through iterative prototype

development with at-risk communities. First, leveraging more mature PLOTS tools, aerial maps are being created and used to develop strategies for sensing. A variety of hydrogen sulfide sensing approaches are being tested, and related to community advocacy and health goals. The end goal is to institute a five month pilot study with a community at a natural gas extraction site in Rifle, Colorado.

Thermal camera: The PLOTS thermal camera creates an image of how hot things are, allowing for better insulation and winterization as well as lower heating and cooling costs. Current thermal cameras cost thousands of dollars, and an affordable alternative might also be used to monitor thermal pollution near power plants.

Long-term goals

The term 'civic science' has been used to describe science "that questions the state of things, rather than a science that simply serves the state" (Fortun and Fortun 2005: 50). Too often in the history of science, and particularly in environmental health science, researchers have distanced themselves from the researched. This has been the case particularly in disciplines such as toxicology, laboratory based research and epidemiology which have favored the socially and economically powerful (Murphy 2006, Allen 2001, Fortun and Fortun 2005). PLOTS attempts to develop alternative dynamics and processes for research and development around environmental health issues that enable non-specialists to get involved in -- and even direct -- the questioning of 'the state of things'.

By developing and deploying a kit of investigative tools, we help citizens become more than mere observers in their environments. This allows communities to critically and actively investigate, identify and address environmental concerns. In a society which is increasingly recycling and reblogging information, PLOTS seeks to engage communities in the process of collecting and sharing new information. The PLOTS website gives local communities, educators, activists, and researchers a place to collaboratively discuss techniques, share data, and learn from experiences in other communities. Putting the techniques and tools of information collection and sharing into the hands of communities creates local experts that are able to represent themselves, engage with scientific experts, and participate in the decisions which set environmental justice agendas in their communities. We see participation in this "full data lifecycle" as a critical part of civic science.

It is our hope that the increasing gap between the scientific establishment and the broader public may be overcome, at least in part, by our more participatory and bidirectional approach. We work on the premise that lasting engagement with science can be generated when communities actually do rigorous science in everyday environments. Our work to date has shown that when the public is involved in the process of scientific investigation they will understand and defend both its results and its nuances. For us, a successful project is one which makes an expensive and exclusive technology available at low cost and accessible to people regardless of their professional or educational background. It is one which engages the public not only as consumers but as producers of shared, open-source technologies, and in which, above all, those technologies are applied to real-world problems to create change.