

# The “Pacing Problem” and the Technological Future of Compliance & Enforcement

GWU, March 26, 2015

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Innovating law, policy and ethics for science & technology

# Change is “Dominant Factor” Today

- “It is change, continuing change, inevitable change, that is the dominant factor in society today. No sensible decision can be made any longer without taking into account not only the world as it is, but the world as it will be....”
- “The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom.”



Isaac Asimov

# Change: Another View



“Change is inevitable,  
except from vending  
machines”

- Woody Allen

# Change

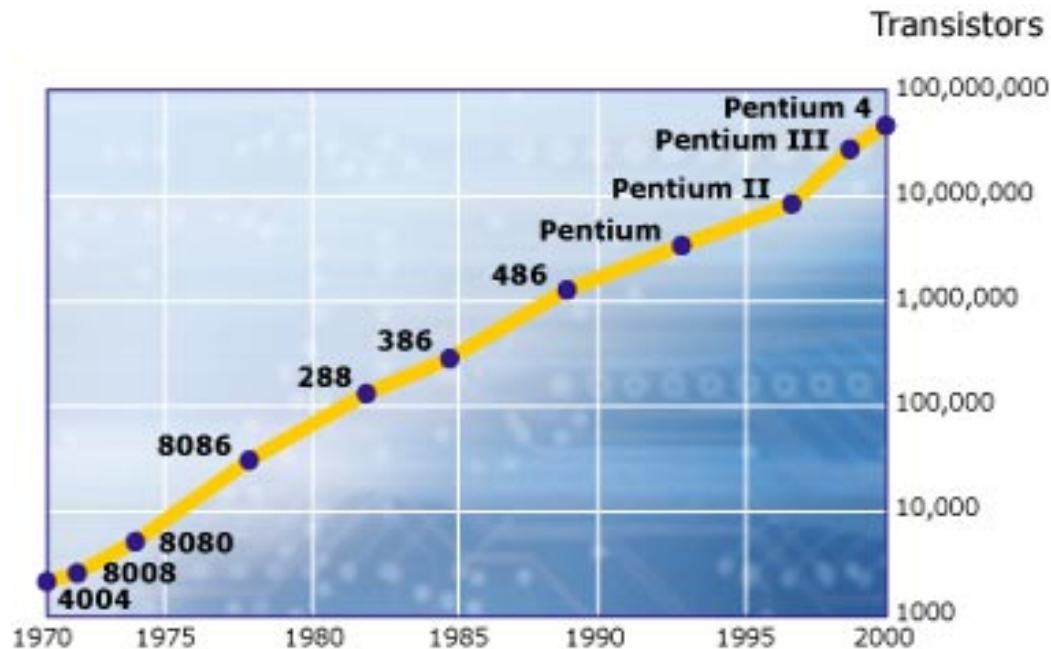
“[P]oliticians – and judges for that matter – should be wary of the assumption that the future will be little more than an extension of things as they are.”

- Jeffrey Rosen, NYT Times Magazine (paraphrasing Chief Justice John Roberts)



# Moore's Law

- Gordon Moore, cofounder of Intel, predicted in 1965 that the number of transistors per square inch of a computer chip will double every 18 months (“Moore’s Law”)
- Despite many predictions of its imminent demise, has continued for 50 years (>30 doublings)



# Tempo Challenge



## Moore's Law

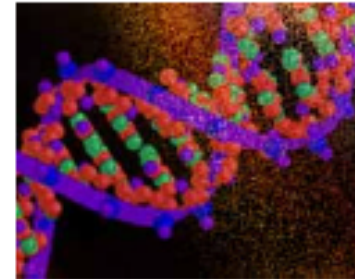
The logic density of silicon integrated circuits doubles every 18 months

Displays = Moore's Law  
Storage = 1.5X's Moore's Law  
Bandwidth = 2X's Moore's Law  
GPU's = 2-3X's Moore's Law



## Metcalfe's Law

Connect any number "n" of machines - whether computers, phones or even cars - and you get "n" squared potential value.



## Monsanto's Law

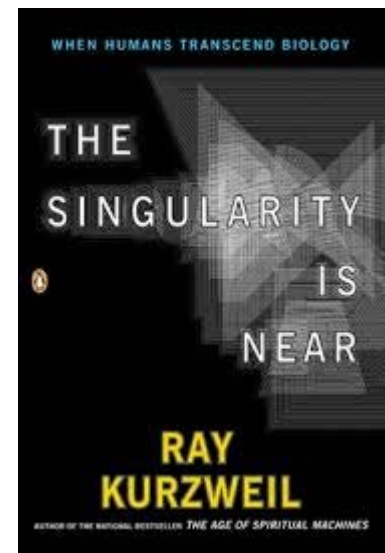
The amount of useful genetic information doubles every 18-24 months.

## Dawkin's Law

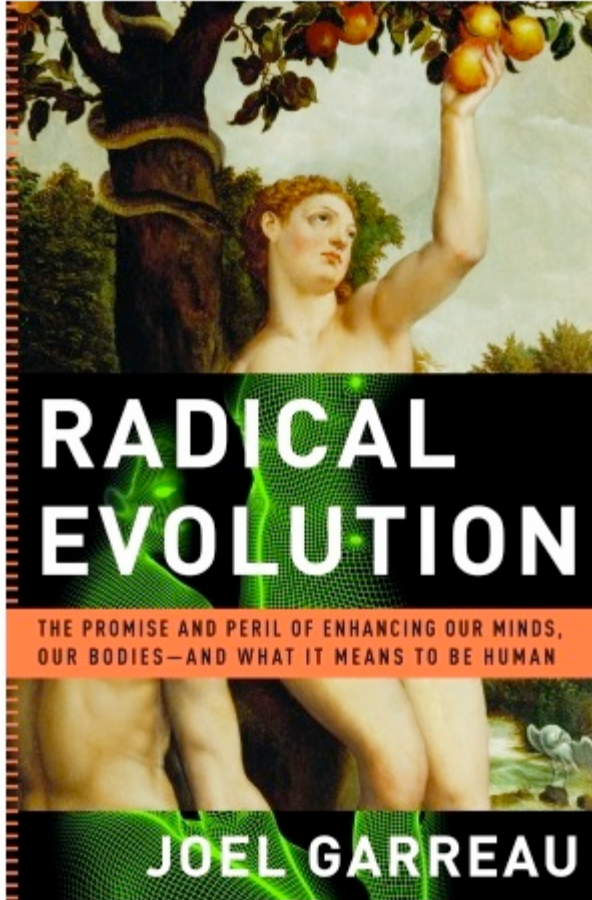
The cost of sequencing DNA base pairs halves every 27 months.

# Ray Kurzweil: The Law of Accelerating Returns

“An analysis of the history of technology shows that technological change is exponential, contrary to the common-sense ‘intuitive linear’ view. So we won’t experience 100 years of progress in the 21<sup>st</sup> century – it will be more like 20,000 years of progress (at today’s rate).”



# Rapid Change Occurring Today



- “The gulf between what engineers are actually creating today and what ordinary readers might find believable is significant.”

- Joel Garreau,  
*Radical Evolution*



# What Will Future Look Like?

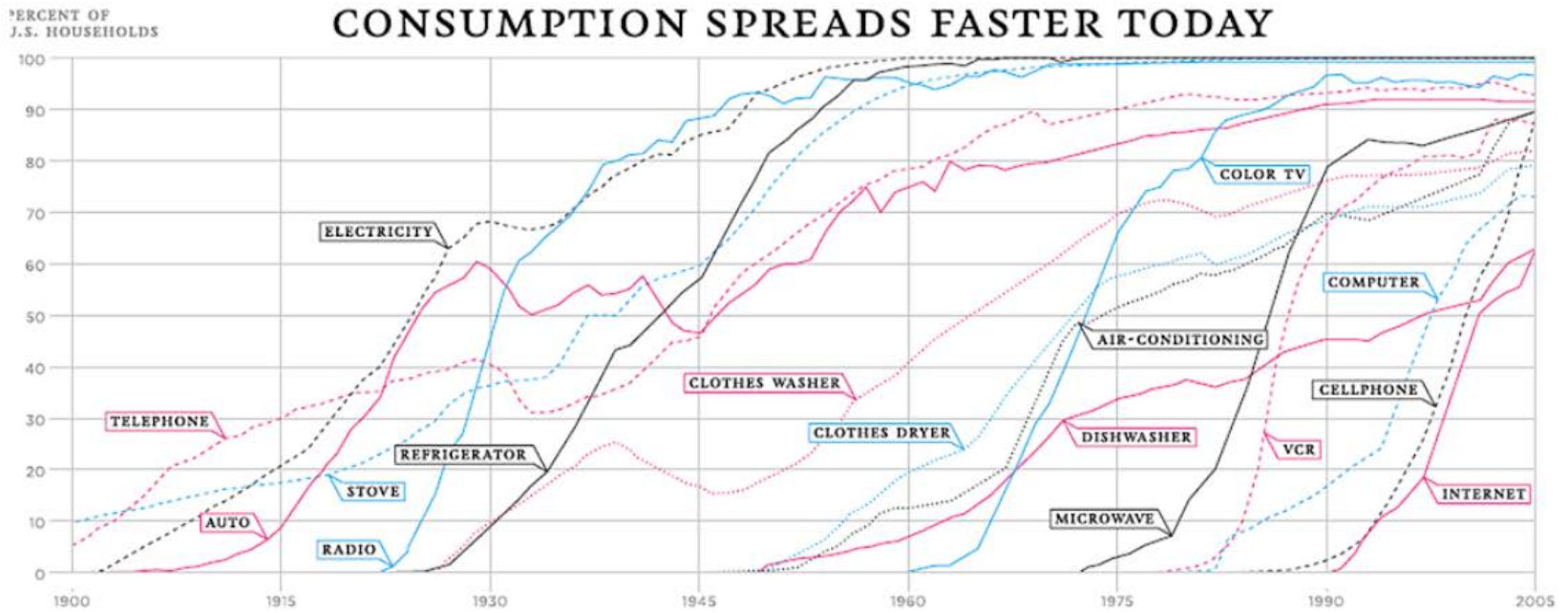
- "If you're looking ahead long-term, and what you see looks like science fiction, it might be wrong. But if it doesn't look like science fiction, it's definitely wrong."

— Christine Peterson

# Today's Emerging Technologies

- Robotics
- Artificial intelligence
- Biotechnology
- Personalized medicine
- Internet of things
- Autonomous vehicles
- Green chemistry
- Sustainable energy
- Mobile health technologies
- Bitcoin
- Brain machine interfaces
- Longevity extension
- Geoengineering
- Whole genome sequencing
- Nanotechnology
- 3D Printers
- Big data
- Synthetic biology
- Brain scanning
- Cognitive enhancement
- Wearable technologies
- Virtual worlds
- Regenerative medicine
- Drones
- Smart dusts
- Gene therapy/gene editing
- In vitro meat

# Technology Adoption Rates Acceleration 7



Source: Charlie Catlett, Argonne Nat'l Laboratory

# Asymmetric Rate of Change: The Pacing Problem



# Three Traditional Governance Institutions



Legislature

“Gridlock”



Executive Agencies

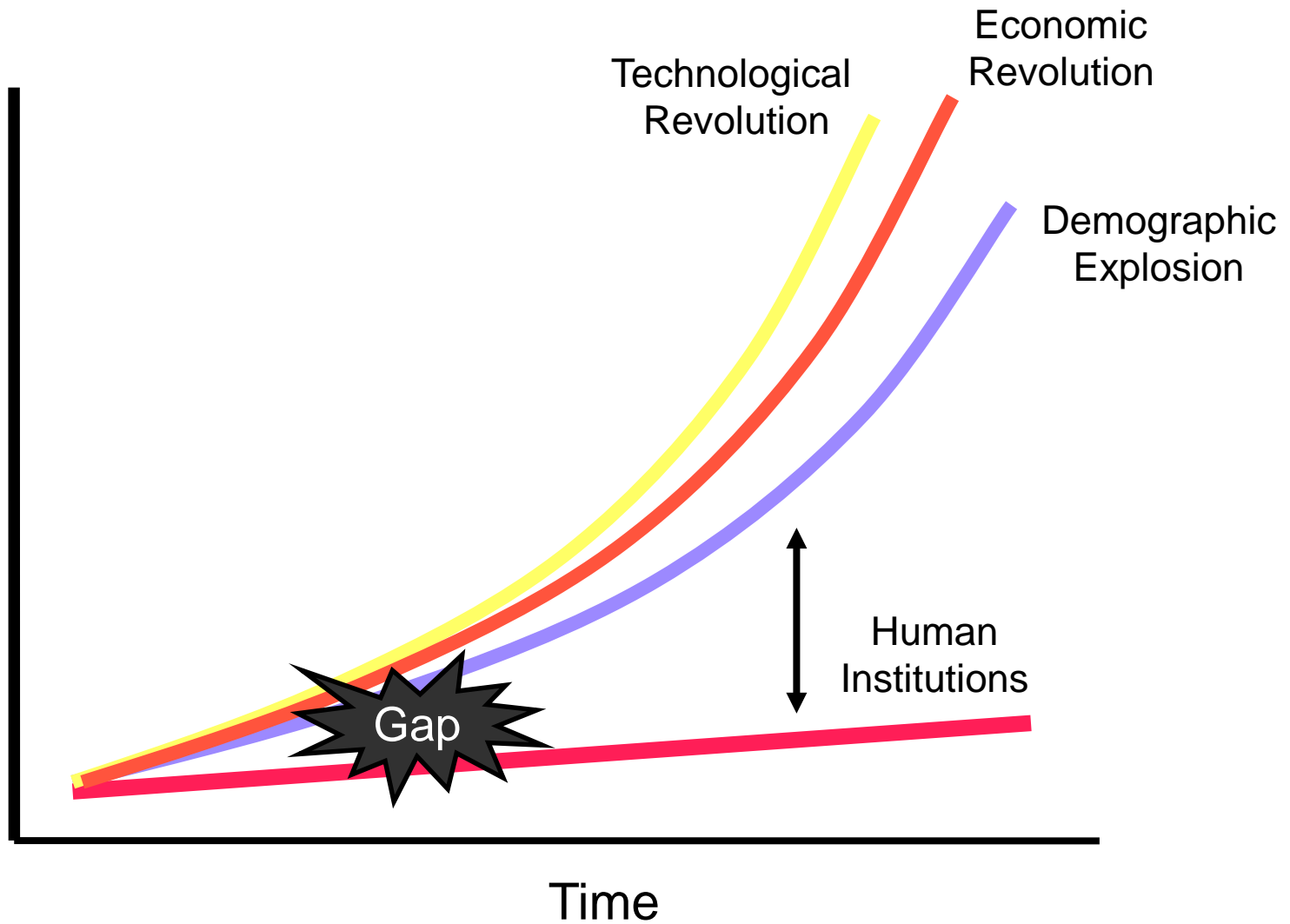
“Ossification”



Courts

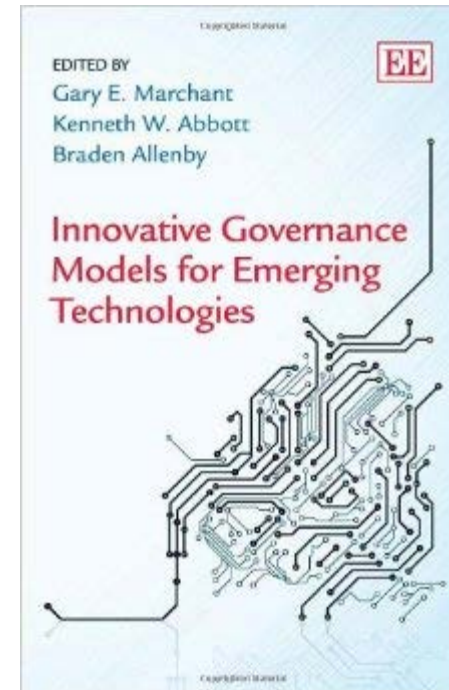
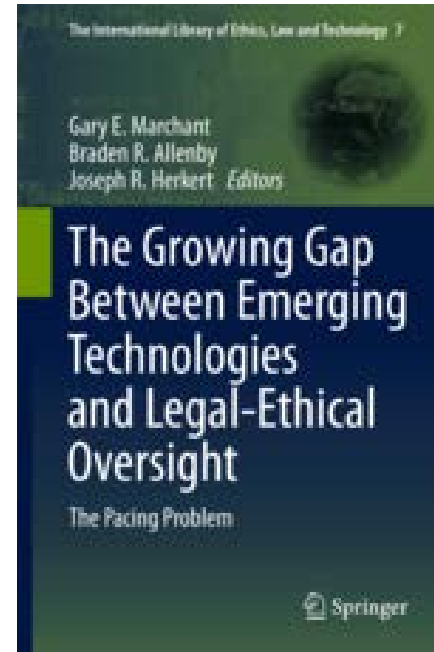
“Glacial”

# The Gap



# Some New Approaches?

- Administrative Law Reforms
- Soft Law/Collaborative Approaches
- Standards/Principles
- Adaptive Management
- Anticipatory Technology Assessment
- Governance Coordination Committees



# Emerging Technologies for Envtl Enforcement/Compliance

- Drones
- Satellites
- Remote Sensing
- Sensors
- Smart Dusts
- Genetic Screening
- Environmental DNA
- Telematics
- GPS
- GIS
- Smart Meters
- Social Media
- Smartphone Apps
- Internet of Things
- RFIDs
- Digital Epidemiology



# eDNA

- Environmental DNA sampling
  - Detection of invasive species
  - Monitoring of endangered species
  - Clean Water Act enforcement
  - Detection of pathogens at beaches



## ENVIRONMENTAL MONITORING

### *Harnessing DNA to improve environmental management*

Genetic monitoring can help public agencies implement environmental laws

By Ryan F. Kelly,<sup>1,2\*</sup> Jesse A. Port,<sup>2</sup> Kevan M. Yamahara,<sup>3</sup> Rebecca G. Martone,<sup>3</sup> Natalie Lowell,<sup>1</sup> Philip Francis Thomsen,<sup>2</sup> Megan E. Mach,<sup>2</sup> Meredith Bennett,<sup>2</sup> Erin Prähler,<sup>2</sup> Margaret R. Caldwell,<sup>1</sup> Larry B. Crowder<sup>2</sup>

**R**esponsive environmental policy demands a constant stream of information about the living world, but biological monitoring is difficult and expensive. For many species and eco-

ence the spatial scale of detection for eDNA monitoring—flowing rivers might be quite different from soil samples, for example—but species have been detected within meters to kilometers of a monitoring site (7).

Genetic analysis has long been useful to identify source species for whale meat, sturgeon eggs, shark fins, and other high-value (and imperiled) species subject to illegal trade (2). But such applications require invasive or hard-to-obtain tissue samples and focus only on a single species; the po-

first photo). Because the DNA fragments of interest often degrade beyond detection in days to weeks in contemporary aquatic and marine ecosystems, eDNA provides the here-and-now view of the living world that policy decisions demand (6). Genetic methods are consequently beginning to allow us to collect high-resolution biological information from lakes, rivers, and bays; recent publications have reported surveys of species' distributions, which point the way toward assessing relative abundance or even numbers of key species (7). Takahara and colleagues, for example, used eDNA to estimate the biomass of common carp in freshwater lagoons (8).

eDNA monitoring has two strong advantages over conventional techniques: increased sensitivity and reduced cost. DNA-based detection outperforms other common biological survey techniques in terms of number of species detected (3) and does so with noninvasive sampling. As the costs of sequencing continue to plummet, generating

POLICY

Science 27 June 2014:  
Vol. 344 no. 6191 pp. 1455-1456

## Review

# Digital Epidemiology

**Marcel Salathé<sup>1,2\*</sup>, Linus Bengtsson<sup>3</sup>, Todd J. Bodnar<sup>1,2</sup>, Devon D. Brewer<sup>4</sup>, John S. Brownstein<sup>5</sup>, Caroline Buckee<sup>6</sup>, Ellsworth M. Campbell<sup>1,2</sup>, Ciro Cattuto<sup>7</sup>, Shashank Khandelwal<sup>1,2</sup>, Patricia L. Mabry<sup>8</sup>, Alessandro Vespignani<sup>9</sup>**

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**Abstract:** Mobile, social, real-time: the ongoing revolution in the way people communicate has given rise to a new kind of epidemiology. Digital data sources, when harnessed appropriately, can provide local and timely information about disease and health dynamics in populations around the world. The rapid, unprecedented increase in the availability of relevant data from various digital sources creates considerable technical and computational challenges.

and disseminated in near real-time through an array of online sources including chat rooms, social networks, blogs, web search records, and online news media. These online sources provide a picture of global health that is often different [9] from the picture created by traditional surveillance systems. In fact, these data streams have become invaluable data sources for a new generation of public health surveillance systems that operate across international borders, fill in gaps in public health infrastructure, and complement existing traditional surveillance systems [10,11]. While for many of the most vulnerable countries, lab and clinical surveillance capacity are still years from being realized, health

# Twitter and Food Poisoning Detection

- **Foodborne Chicago** follows-up with citizens who tweet about food poisoning after eating at a restaurant
- **nEmisis** looks for tweets coming from GPS coordinates of 29,904 NYC restaurants
- Follows tweets from senders for 100 days; looks for reports of food poisoning symptoms



**Foodborne Chicago**  
@foodbornechi

Helping Twitter users report food poisoning to the Chicago Department of Public Health. Tweets by @reedmonseur & @danxoneil.

Chicago · foodbornechicago.org

# Smart Phone Apps

## Search TRAFFIC

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NOTE: To search *inside* TRAFFIC's PDFs use the [Publications Search](#)

## Help stop wildlife trafficking



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## New app to build awareness and information on illegal wildlife trade in South-East Asia

**Kuala Lumpur, Malaysia, 9th April 2014**—From bear paw soup to pangolin scales, people can now report suspected illegal wildlife trade in South-East Asia using a smartphone app developed by the Taronga Conservation Society Australia in partnership with TRAFFIC.

The 'Wildlife Witness' app enables users to report suspected illegal wildlife in trade in the region easily and quickly by taking a photo, pinning the exact location of an incident and sending these important details to TRAFFIC.

Reports by app users will be analysed by a Wildlife Crime Data Analyst and over time, the information will help build data and enrich understanding of illegal wildlife trade across the region, help prioritise response action and highlight areas in need of increased enforcement resources.

Wildlife Witness will also feature information on species threatened by trade, how they are often traded, as well as tips for reporting wildlife crime safely.



## Turning smartphones into personal, real-time pollution monitors

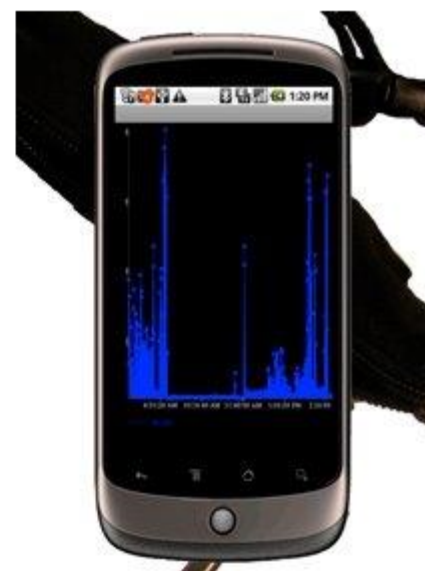
["Variability in and Agreement between Modelled and Personal Continuously Measured Black Carbon Levels using Novel Smartphone and Sensor Technologies"](#)

*Environmental Science & Technology*

As urban residents know, air quality is a big deal. When local pollution levels go up, the associated health risks also increase, especially for children and seniors. But air pollution varies widely over the course of a day and by location, even within the same city. Now scientists, reporting in the ACS journal *Environmental Science & Technology*, have used smartphone and sensing technology to better pinpoint where and when pollution is at its worst.

Mark J. Nieuwenhuijsen and colleagues note that many studies have investigated people's exposure to air pollution, which is associated with respiratory and cardiovascular problems. But they usually create a picture of exposure based on air pollution levels outside people's homes. This approach ignores big differences in air quality in school and work environments. It also ignores spikes in pollution that happen over the course of the day such as during rush hour. Nieuwenhuijsen's team wanted to test technology's ability to fill in these gaps.

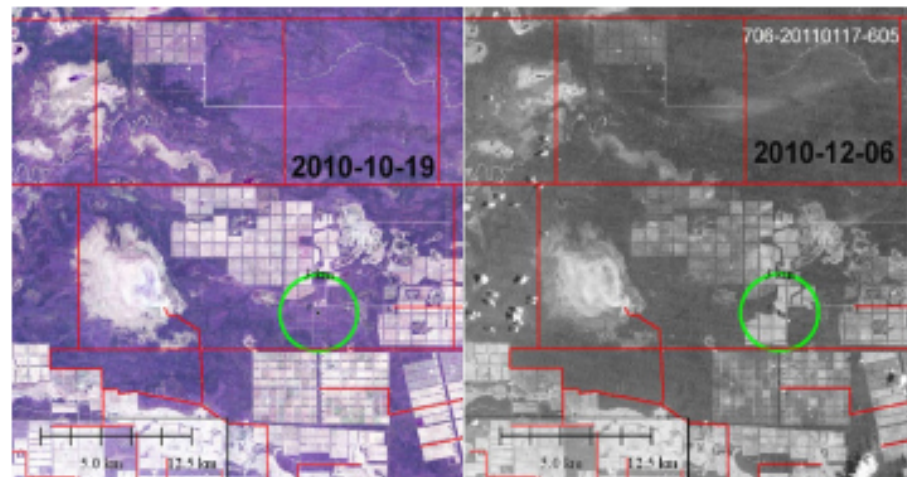
The researchers equipped more than 50 school children with smartphones that could track their location and physical activity. The children also received sensors that continuously measured the ambient levels of black carbon, a component of soot. Although most children spent less than 4 percent of their day traveling to and from school, commuting contributed to 13 percent of their total potential black carbon exposure. The researchers conclude that mobile technologies could contribute valuable new insights into air pollution exposure.



Mobile technology can help pinpoint when and where children are exposed to air pollution.

Credit: American Chemical Society  
[High-resolution image](#)

# SATELLITES SPOT ILLEGAL LOGGING OF UNCONTACTED TRIBES' HOME



Source: Wired

If you can see it, you can change it.

 Search


### Global Fishing Watch

SYDNEY, AUSTRALIA — Today, SkyTruth, Oceana and Google announced Global Fishing Watch, a big...



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SkyTruth releases a dynamic map of satellite data visualizing the wasteful practice of natural gas...



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On Monday, August 4, 2014, an approximately 580 acre tailings impoundment failed at a Canadian...

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# Louisville: Asthma Tracker

- “More than 500 Louisville asthma sufferers are being equipped with special, high tech inhalers – ones that collect data about where and under what circumstances the inhaler is used. By GPS plotting that information along with data from other sources about air quality – neighborhood risk factors, school conditions, etc. – we hope to get new insight into what prompts an asthma attack.” Greg Fischer, Mayor





# High-tech carts will tell on Cleveland residents who don't recycle ... and they face \$100 fine



By Mark Gillispie, The Plain Dealer

[Email the author](#)

on August 20, 2010 at 8:00 AM, updated August 20, 2010 at 8:09 AM

[Print](#)



*Plain Dealer file*

CLEVELAND, Ohio -- It would be a stretch to say that Big Brother will hang out in Clevelanders' trash cans, but the city plans to sort through curbside trash to make sure residents are recycling -- and fine them \$100 if they don't.

The move is part of a high-tech collection system the city will roll out next year with new trash and recycling carts

embedded with radio frequency identification chips and bar codes.

The chips will allow city workers to monitor how often residents roll carts to the curb for collection. If a chip show a recyclable cart hasn't been brought to the curb in weeks, a trash supervisor will sort through the trash for recyclables.

Trash carts containing more than 10 percent recyclable material could lead to a \$100 fine, according to Waste Collection Commissioner Ronnie Owens. Recyclables include glass, metal cans, plastic bottles, paper and cardboard.

# Sewage Monitoring

## Working Upstream: How Far Can You Go with Sewage-Based Drug Epidemiology?

Daniel A. Burgard,<sup>\*,†</sup> Caleb Banta-Green,<sup>‡</sup> and Jennifer A. Field<sup>§</sup>

<sup>†</sup>Chemistry Department, University of Puget Sound, Tacoma Washington 98416, United States

<sup>‡</sup>Alcohol and Drug Abuse Institute, University of Washington, Seattle Washington 98105, United States

<sup>§</sup>Department of Environmental and Molecular Toxicology, Oregon State University, Corvallis Oregon 97331, United States



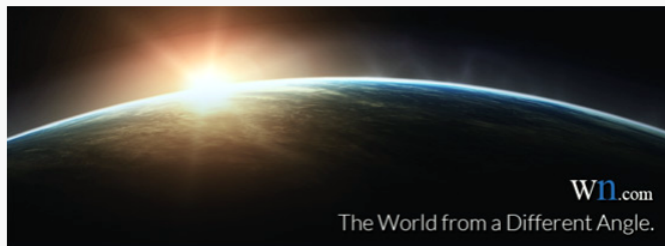
analytes by 2–4 orders of magnitude. With these techniques, quantification of drugs at even the subpart per trillion range (ppt) is possible.

Jones-Lepp et al. reported the first detection of two drugs, methamphetamine (a pharmaceutical and illicitly manufactured drug) and methylenedioxymethamphetamine (MDMA, commonly referred to as ecstasy, an illicit drug) in the effluent of two wastewater treatment plants (WWTPs) in the U.S.<sup>2</sup> Interestingly, the idea of a community-scale surveillance tool using sewage was actually proposed three years earlier by Christian Daughton at the U.S. Environmental Protection Agency.<sup>3</sup> The field received worldwide media attention when a

... from the Media News Institute for Pharmaceutical

# Drones

## Florida Keys Turns To Drones In Battle Against Mosquitos



'Maveric' drone made by company which supplies Canadian troops in Afghanistan will seek out mosquito breeding grounds The Condor Aerial Maveric unmanned aerial vehicle system, or drone, will be considered for use by the Florida Keys Mosquito Control District. Photograph: Condor Aerial/Reuters To the casual observer, it will look like a group of grown men and women playing with model aeroplanes. But in a carefully planned mission next week, a small airshow in the Florida Keys will mark a dramatic escalation in the war on the state's army of mosquitoes. Officials responsible for curtailing the swamp-heavy island...[more »](#)

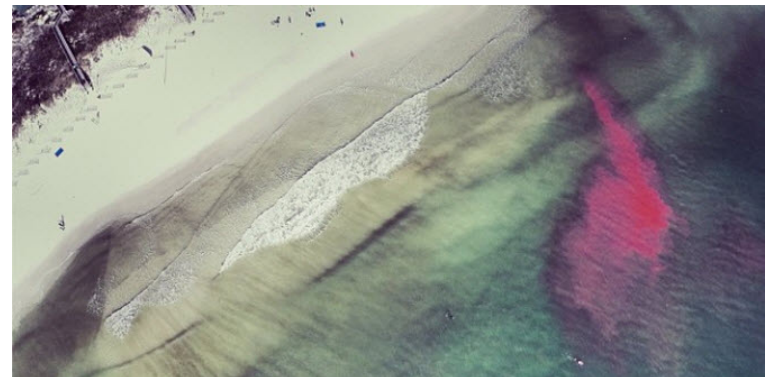
UNEP Global Environmental Alert Service (GEAS)  
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Thematic focus: Climate change, Ecosystem management, Environmental governance

### A new eye in the sky: Eco-drones

A drone is generally thought of as a military weapon or surveillance tool. Commonly referred to as an unmanned aerial vehicle (UAV), unmanned aerial system (UAS) or remotely piloted aircraft (RPA), a drone can also provide a low-cost and low-impact solution to environmental managers working in a variety of ecosystems. Drones used for these purposes are referred to as "eco-drones" or "conservation drones." Their agility and quality imaging abilities make them advantageous as a mapping tool for environmental monitoring, but there are still several challenges and concerns to be surmounted.



## Drone on the Farm: An Aerial Exposé



What are factory farms hiding with "ag-gag" laws? I'll combine drone photography with investigative reporting to find out.

Created by

Will Potter



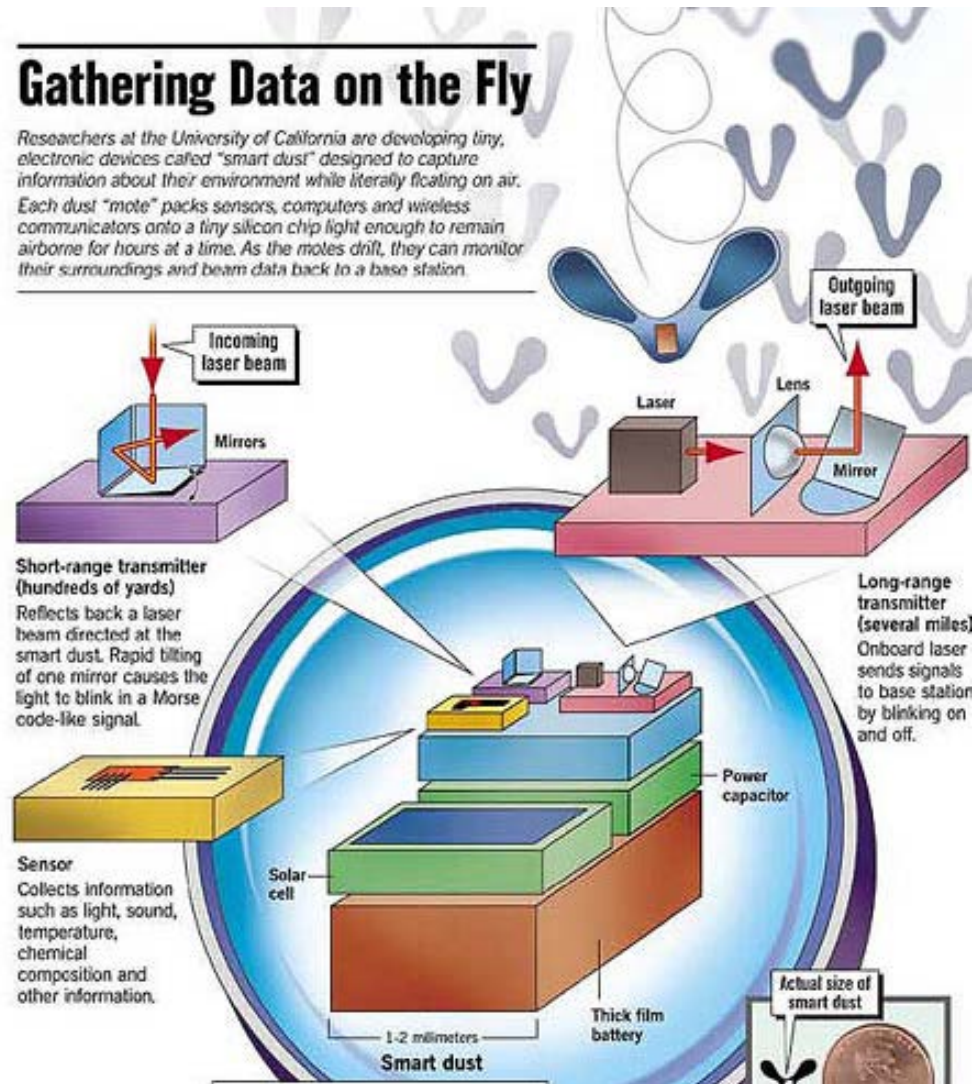
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1,312 backers pledged \$75,064 to help bring this project to life.

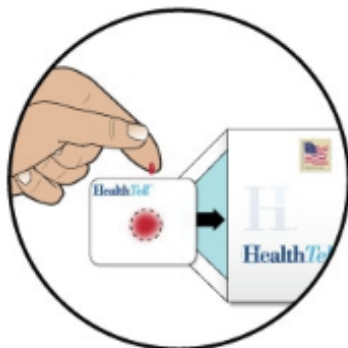
# Nano Smart Dusts

## Gathering Data on the Fly

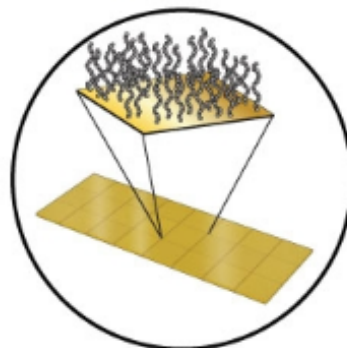
Researchers at the University of California are developing tiny, electronic devices called "smart dust" designed to capture information about their environment while literally floating on air. Each dust "mote" packs sensors, computers and wireless communicators onto a tiny silicon chip light enough to remain airborne for hours at a time. As the motes drift, they can monitor their surroundings and beam data back to a base station.



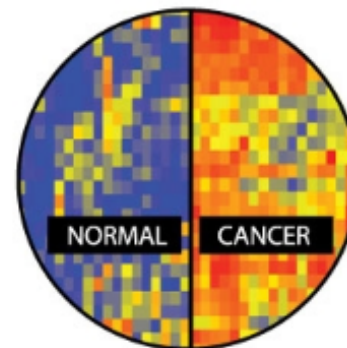
## COLLECT



## MEASURE



## SIGNATURE



HealthTell News

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HealthTell @HealthTell 18 Feb  
@privatedoctors #HealthTell is coming to The Big Easy! Stop by our booth Feb. 21st-22nd to learn more! #AAPP #NOLA  
[pic.twitter.com/Z9aho8vGIE](http://pic.twitter.com/Z9aho8vGIE)



Expand

## HealthTell - One Test™

HealthTell is an early stage start-up company that is developing powerful new tools to help individuals monitor their health status. This technology has already been demonstrated to work for over 30 diverse illnesses, ranging from cancer to infectious disease. The test is simple and inexpensive, and can be performed with only a single drop of blood.

One of the largest challenges in modern medicine is the ability to detect the presence of disease much earlier, before it spreads or becomes difficult to treat. Unfortunately, this generally requires complex, expensive monitoring systems capable of detecting small numbers of cancer cells, viruses, or other pathogens in the bloodstream.

HealthTell has taken a radically different approach to solving this problem. Instead of trying to measure the pathogen directly, we are measuring the body's unique response (it's "immunosignature") to a given disease or disease state. By understanding what each immunosignature means and how it changes over time, we can provide a broad menu of highly accurate tests that are capable of detecting diseases much earlier and less invasively than is

# Advantages of New Monitoring Technologies

- Real time monitoring
- Instant/online reporting
- More comprehensive monitoring (spatial and temporal)
- Transparency of compliance data
- Greater 3<sup>rd</sup> party role/verification
- Reduce staffing/human inspectors

# From Promise to Reality: Law & Policy Must Keep Pace

- “The technological breakthroughs of the Information Age are not ... a panacea. The new tools and the institutional refinements that they make possible offer the prospect of ...an environmental protection regime that is more data-driven, refined, individualized, and efficient. But the precise contours of the path toward Information Age environmental protection are not well defined.... Legislators, policymakers, judges, scholars, businesses, consumers, and citizens will have to do significant work to turn the promise into a reality.” – Daniel Esty



# Limitations and Challenges

- Budgetary limitations
- Validation delays
- Compliance vs other purposes (e.g., program evaluation)
- Continuity and consistency of data
- Validity/objectivity of volunteer monitoring
- Coordination issues
- Over-zealous enforcement
- Admissibility/Evidentiary issues
- Appropriate scale
- Statistical significance
- Uncertainty
- Reduced deterrence from more collaborative approaches

# New Technology Legal/Policy Obstacles

- Privacy
- 4<sup>th</sup> Amendment
- State/local regulation
- Costs
- System Failure/Malfunctions
- Hacking
- Harm from RF
- Stress from constant surveillance
- Worried well
- Data overload
- Public perceptions
- Political critiques



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Floor Action feed 

June 20, 2012, 02:11 pm

# GOP looks to block EPA from using drones to enforce clean-water rules

By Pete Kasperowicz

 43   34  2 

COMMENTS 12

Rep. Shelley Moore Capito (R-W.Va.) and 11 other House members introduced a bill Tuesday that would prevent the Environmental Protection Agency (EPA) from conducting aerial drone surveillance of farms to enforce the Clean Water Act, or using any other overhead surveillance.

"Unemployment has been at or above 8 percent for 30 consecutive months. Is conducting flyovers of family farms across the country really the best use of taxpayer money?" Capito asked on Tuesday.

"It's getting to the point that I'll have to file for a Clean Water Act permit if I want to turn the hose on in my backyard," she said. "The EPA will take any opportunity to make it harder for farmers, energy operators or any business that deals with the EPA to operate."



**Megyn Kelly**

@megynkelly

Follow

The EPA now wants to monitor how long hotel guests spend in the shower. What do you think? [#KellyFile](#)



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85

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81



6:54 PM - 18 Mar 2015



**Margaret Harrington** @62jerseygirl · Mar 18

@megynkelly Disband the EPA



**Dolly Key** @cherokeehottie · Mar 18

@megynkelly I think that is insane and I agree with you "Butt out"!



# Possible Innovative Approaches

- Adaptive management (e.g., pilot projects, safe harbors)
- Tiered enforcement/triggers
- Third party verification/certification
- Collaborative approaches (e.g., public-private partnerships)
- Insurance companies
- Private standards (e.g., ISO)
- Private enforcement (e.g., citizen suits)
- Anticipatory technology assessment

# Conclusion:

## Need for Dynamic Approach

- “the contextual reality of dynamism suggests that an indispensable component of regulatory design is awareness of the likelihood that normative objectives may change over time. It is also important to consider the shifting capabilities and interests of different key actors throughout the entire regulatory enterprise and the extent to which these developments should influence design of regulatory structures.”
  - David Markell & Robert Glicksman , *A Holistic Look at Agency Enforcement*, N. CAR. L. REV. (2014)

# Too Much Information?

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## Your faeces, my furry friend, are blowin' in the wind

- › 12 August 2011
- › Magazine issue [2825](#). [Subscribe and save](#)

**NewScientist**

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GO FOR a bracing winter stroll in a major US city and you will be inhaling more than vehicle fumes. A new study has demonstrated for the first time that during winter most of the airborne bacteria in three large Midwestern cities come from dog faeces.

[Noah Fierer](#) at the University of Colorado, Boulder, found the high proportions of airborne dog faecal bacteria after analysing samples of winter air from Cleveland, Detroit and Chicago. His team checked the DNA in their samples against reference banks which "barcode" organisms according to their genes.

They discovered that most of the bacteria they found came from dog faeces by checking the bacterial profiles against reference samples of bugs typically present in soils, leaves and faeces from humans, cows and dogs.

In summer, the proportions of bacteria in the air come almost equally from soils, dog faeces and the leaves of trees. But come winter, the trees have shed all their leaves and aerosols from soils are limited by overlying snow or ice, reducing absolute counts of airborne bacteria by about 50 per cent. This means that dog faeces becomes the dominant remaining source.