Scalable

Sustainable

Affordable

Breakthrough technologies to

Remake farming for modern cities

BERKELEY LAB

Agriculture…

as we know it…

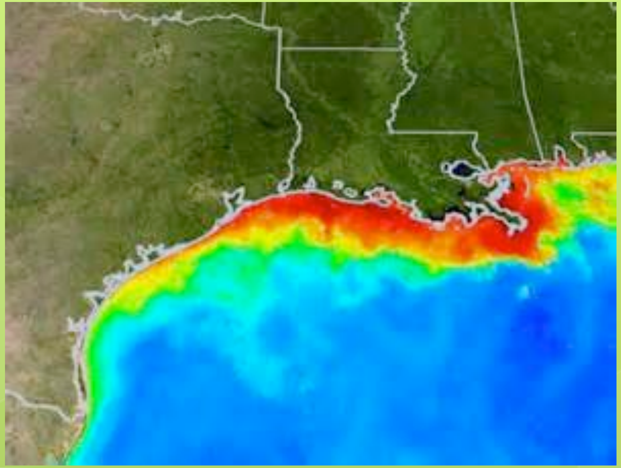
Does Not Work

Water

- In the US irrigation accounts for 37% of freshwater withdrawals.
- In a state like CA agriculture accounts for 80% of water use.
- Intensive irrigation can waste as much as 40 percent of the water withdrawn.
- 44% of US streams and waterways are estimated to be impaired with agriculture the largest contributor

Fertilizer

- In the US we use of 60 million tons of fertilizer each year.
- Excess fertilizer pollutes streams and water ways and leads to algal blooms and dead zones in the Great Lakes and oceans

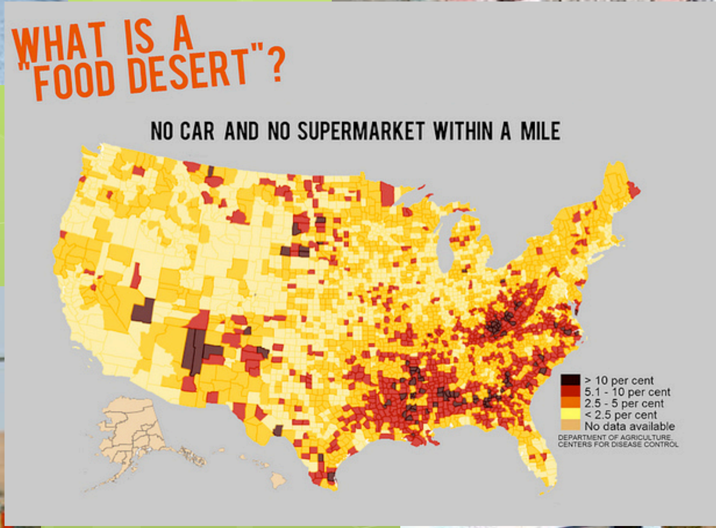


Pesticides

- In the US we use of 1 billion pounds of pesticides each year, with a cost of over $12B dollars.
- 95 to 98% of pesticides reach a destination other than their target species.
- Pesticide use is associated with health problems for both consumers and farm workers as well as environmental damage


Nothing
healthy
local
affordable?


BREAD MILK SODA BEER
Snapple
79¢


WHAT IS A
"FOOD DESERT"?
NO CAR AND NO SUPERMARKET WITHIN A MILE
> 10 per cent
5.1 - 10 per cent
2.5 - 5 per cent
< 2.5 per cent
No data available
DEPARTMENT OF AGRICULTURE,
CENTERS FOR DISEASE CONTROL

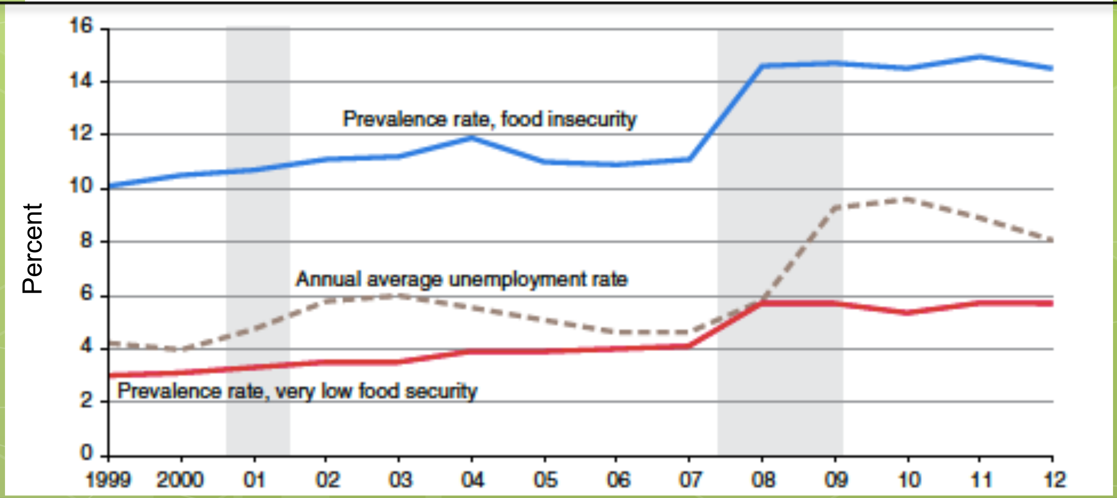

McDonald's
Grinder
PLAYPLACE


LIQUORS
GROCERY
14.99
LOW LOW PRICES

Food insecurity in America: Core statistics

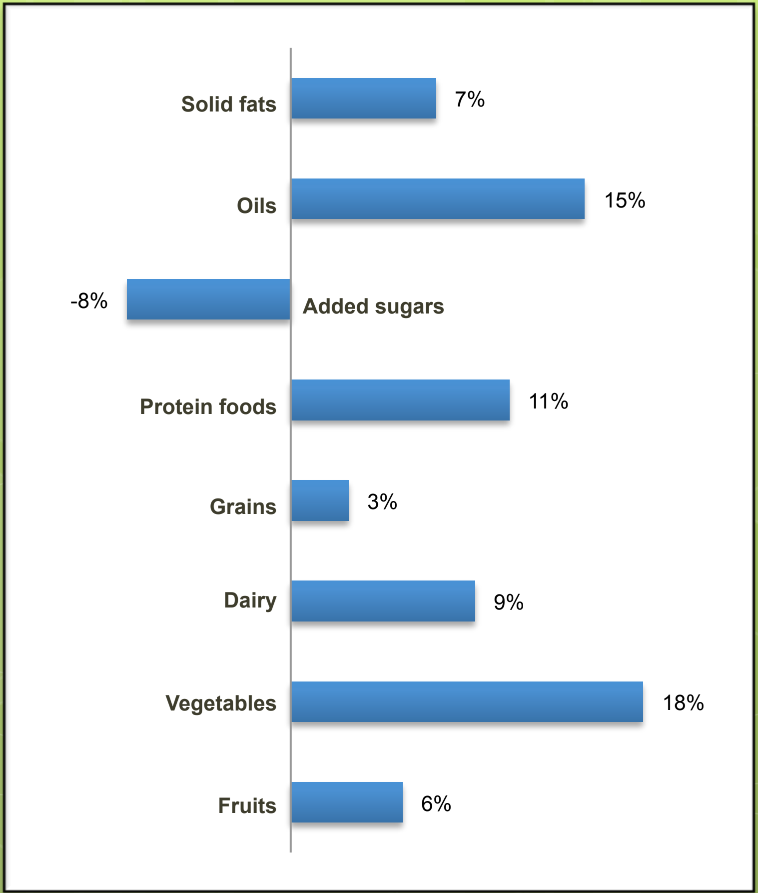
USDA Definitions		
	Low food security (*aka* Food insecurity without hunger)	• Reports of reduced quality, variety, or desirability of diet • Little or no indication of reduced food intake
	Very low food security (*aka* Food insecurity with hunger)	• Reports of multiple indications of disrupted eating patterns and reduced food intake

Prevalence of food insecurity and very low food security vs. national unemployment rate (1999-2012)



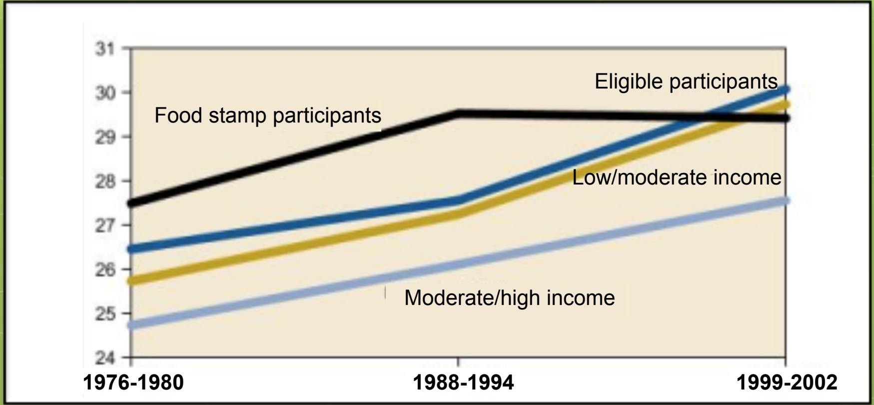
Food insecurity in America: Consumption patterns

Food consumption gap, higher vs. lower income population

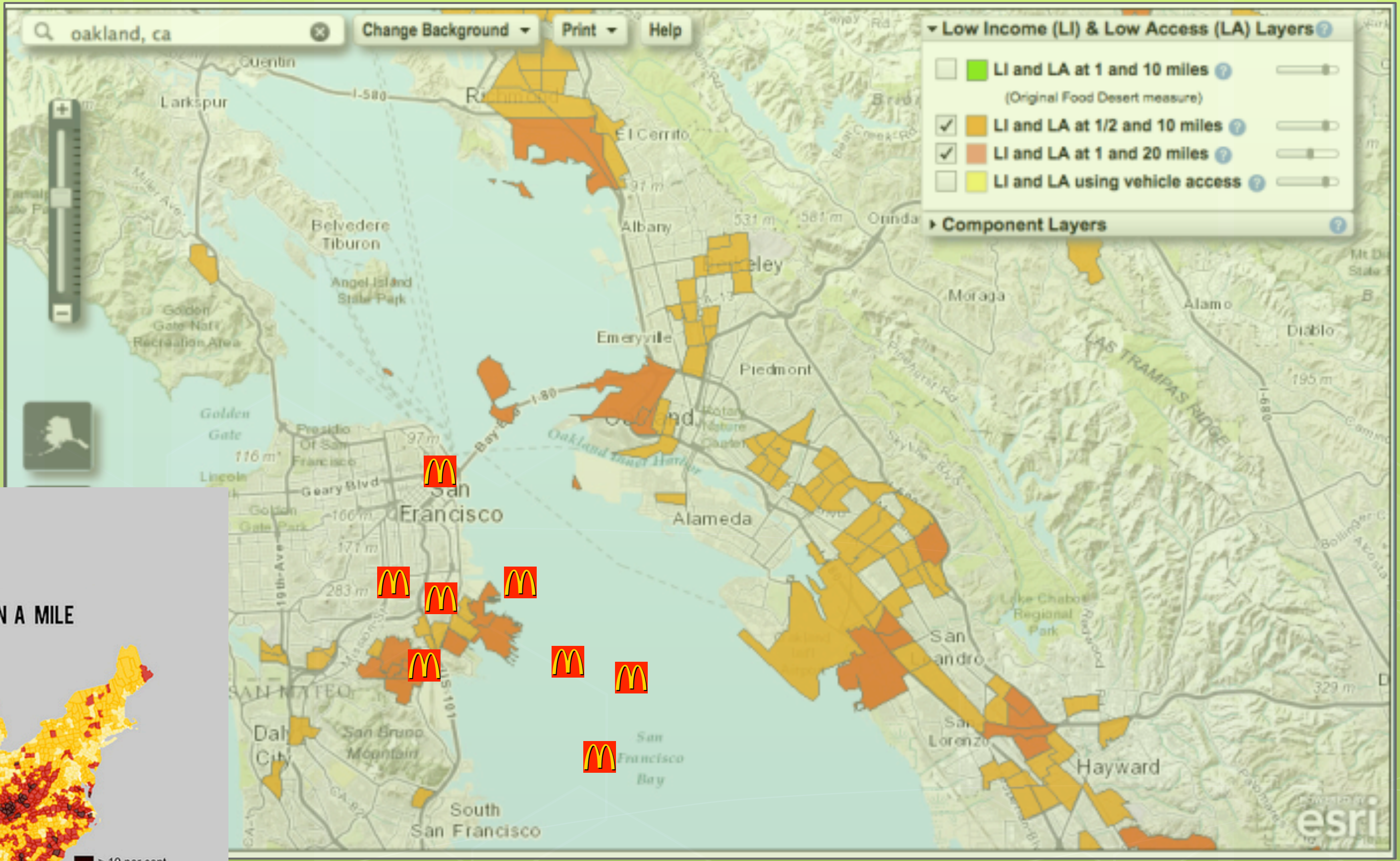


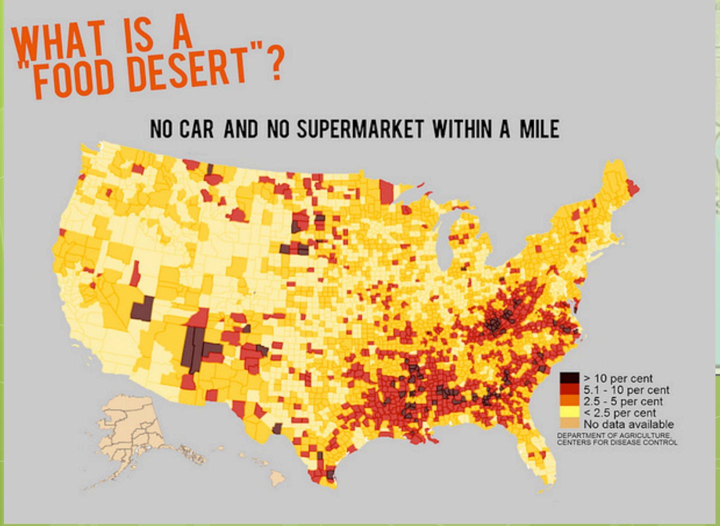
Percent of population that is obese, by income group

Convergence of obesity across income groups, BMI



Food desert map in Oakland





Feeding Oakland Lettuce

- Annual consumption 9,709,447 lbs.
- 151.6 Million gallons of water
- 20.6 tons of fertilizer
- 229 lbs. of pesticide
- 16,827 gallons of diesel fuel to transport
- 167.5 tons of CO_2 to transport

What would it take to grow nutritious food…

Locally?

Sustainably?

Cost effectively?

Precision Urban Agriculture

Targeted use of resources

- Sharply limiting use of water, nutrients, and space
- No pesticides

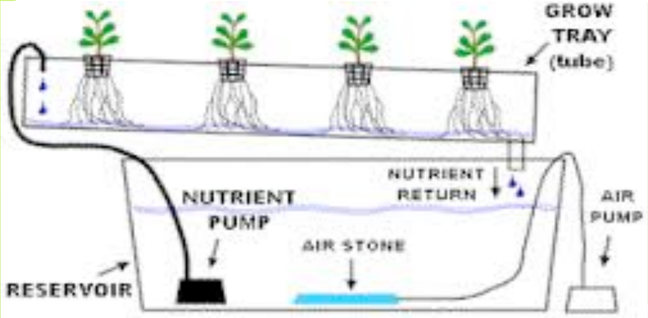
Environmental Controls

- Lighting
- Heating and cooling
- Air flow

Efficiencies in the production to consumer chain

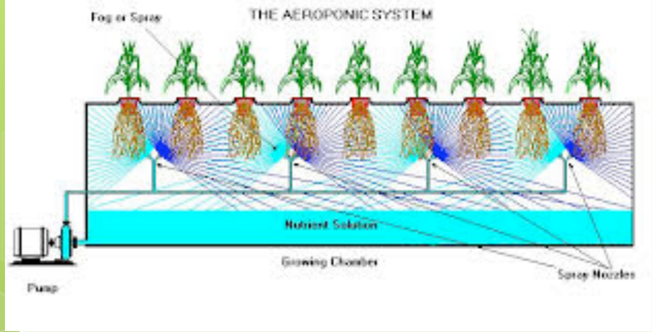
- Reduce waste in transportation and marketing
- On demand harvest
- Year round growing
- Efficient integration with urban scale users

New Growing Techniques



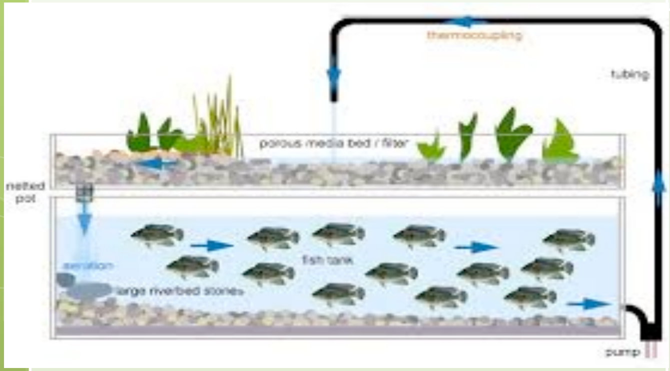
Hydroponics

- Plant roots grow in water
- 5-10% of the water
- No pesticides



Aeroponics

- Plant roots grow in air
- Nutrient and water mist
- 3-10% of the water
- No pesticides
- Faster growth cycles



Aquaponics

- Plants and food fish grown in a symbiotic biosystem
- 10-30% of the water
- No pesticides
- No fertilizer

Innovation in Action

Aerofarms,

Newark, NJ

- 69,000 Sq/foot former factory
- Will produce 1.5M pounds of produce a year
- 5% of water use to traditional agriculture
- 70 jobs
- Enough produce to supply 60,000 people

Innovation in Action

Gotham Greens,

Brooklyn, NY

- Hydroponic growing
- 15,000 Sq/foot rooftop greenhouse
- Produces 200,000 lbs of greens per year
- No pesticides, insecticides, or herbicides
- 5% of water use
- All electrical needs supplied by solar
- Gets heat and provides insulation to building below

Innovation in Action

Sky Vegetables,

Massachusetts and NY

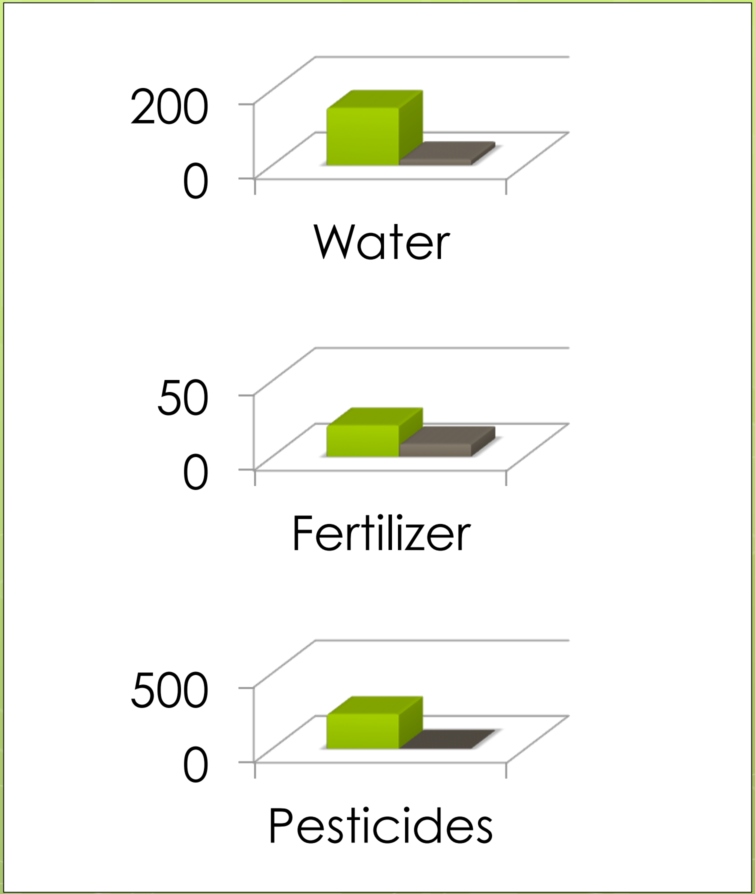
- Partnership with NYC
- 8,000 SF farm on top of an affordable housing development
- Uses 10% of the water; water used is harvested rainwater
- Produces 130,000 lbs of vegetables a year
- Local hiring
- Full approach integrates solar, aquaculture and composting

Innovation in Action

Local Roots Farms,
Los Angeles, CA

- 320 Sq/ft shipping containers produce up to 5,000 lbs leafy greens/month
- 1 container ~ 1 job
- No pesticides, insecticides, or herbicides
- 5% water usage of traditional agriculture
- Co-locate with customers to eliminate supply chain waste
- Just-in-time crop production

Feeding Oakland Lettuce

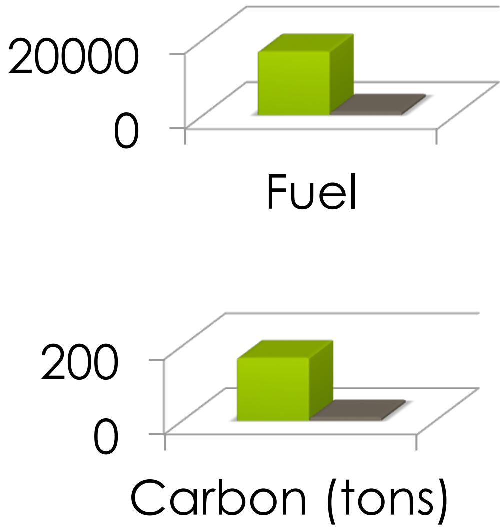


Savings = 136.44 Million Gallons

Savings = 12.36 Tons

Savings = 229 pounds

Feeding Oakland Lettuce



Savings = 15,986 Gallons

Savings = 159 Tons

What are the issues

- Cost competitiveness with traditional agriculture
- Ability to operate at scale
- Understanding growing efficacy in a non-traditional environment

Four Stage Study

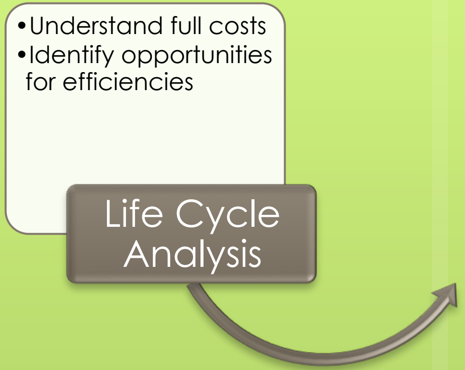
Life Cycle Analysis
- Understand full costs
- Identify opportunities for efficiencies

Plant Growth Analysis
- Compare nutrient profiles to traditional agriculture
- Explore strategies to enhance nutrient profile & plant growth

Tech Solutions
- Harness breakthrough technologies to support precision agriculture

City Pilots
- 3 Urban pilots
- Identify policy synergies
- Produce at scale

Life Cycle Analysis

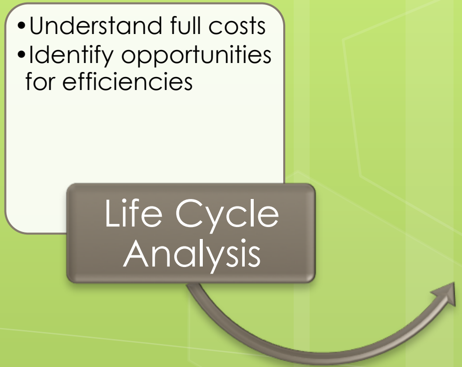


- Questions to be answered
  - What are the full costs of the most efficient urban agriculture efforts and how do they compare to traditional agriculture
  - Given the current costs what are the opportunities for efficiency
- Study
  - Analyze figures from ten most efficient growers

Understanding the state of the field

1. Critical review of existing scientific and technical literature

- Understand base-line conditions: cost and environmental footprint of conventional agriculture
- Status of existing and emerging technologies for precision urban agriculture
- Breakdown of main drivers of cost structure, energy use, resource use
- Identify and monetize indirect costs and impacts, e.g. pollution, erosion, water depletion



2. Collect and analyze operational data from existing urban growers

- Compile and compare original data on production rates, economy, energy, resources, etc.
- Breakdown of main drivers of cost structure, energy use, resource use
- Identify similarities and differences between growers, to discern success factors
- Determine best practices for urban farming in different geographic/ environmental conditions

Plant Growth Analysis

- Questions to be answered
  - How do the nutrient and micro-nutrient profiles of plants grown without soil compare to those grown in traditional farming?
  - How do changes in lighting, nutrient delivery, seed coating, etc. impact plant growth and nutrient profile
- Study
  - Plant nutrient profiles based on samples from crops currently in production with existing growers
  - Use experimental units to collect data on how input changes impact plant growth and nutrient profile

Tech Solutions

Problem: Optimizing Lighting

- Harness breakthrough technologies to support precision agriculture

Tech Solutions

Solution space:

- Increased efficiency in LEDs,
- lighting recipes (variations in wavelength, strobe, pulse and daylight cycles to optimize growth),
- fiber optics for daylight harvest,
- nanotechnology for self-cleaning and condensation run off in greenhouse glass.

Tech Solutions

Problem: Climate Control

- Harness breakthrough technologies to support precision agriculture

Tech Solutions

Solution space:

- Reduced excess heat from lighting,
- symbiotic heating and cooling with surrounding buildings,
- high efficiency greenhouse materials,
- heat exchanges,
- enhance uniform airflow distributions

Tech Solutions

Problem: Optimizing nutrient uptake

Solution Space:

- Test how to support biome plant interaction in soilless growing
- Develop plant specific nutrient recipes
- Identify soluble organic nutrients appropriate to hydro, aero and aquaponic growing
- Test seed coatings and other mechanisms to promote efficient uptake

Tech Solutions

Problem: Efficient use of water

Solution Space:

- Address issues with water recapture: Desalinization; nutrient rebalancing; sterilization; ion specific probes for water analysis
- Compare effectiveness of hydroponic and aeroponic technologies

City Pilots

- 3 Urban pilots
- Identify policy synergies
- Produce at scale

City Pilots

- Partnership with three cities (West Coast, Midwest, East Coast)
- Integrate precision agriculture into urban policy environment
- Implementation design to ensure food produced impacts health in food deserts

Needed commitments from urban partners

City Pilots

- 3 Urban pilots
- Identify policy synergies
- Produce at scale

- Help identifying and acquiring suitable space
- Shifts in zoning, regulations and tax policy to support urban farming
- Support negotiating electrical rates comparable to current farm rates
- Help build partnerships with key scale consumers reaching low income populations (schools, WIC, hospitals, etc.)
- Tie ins to other programs for the urban poor (jobs programs, efforts to impact healthy life styles, urban redevelopment, etc.)

Tracing sources of phosphorus to Lake Erie using the LBNL Phylochip

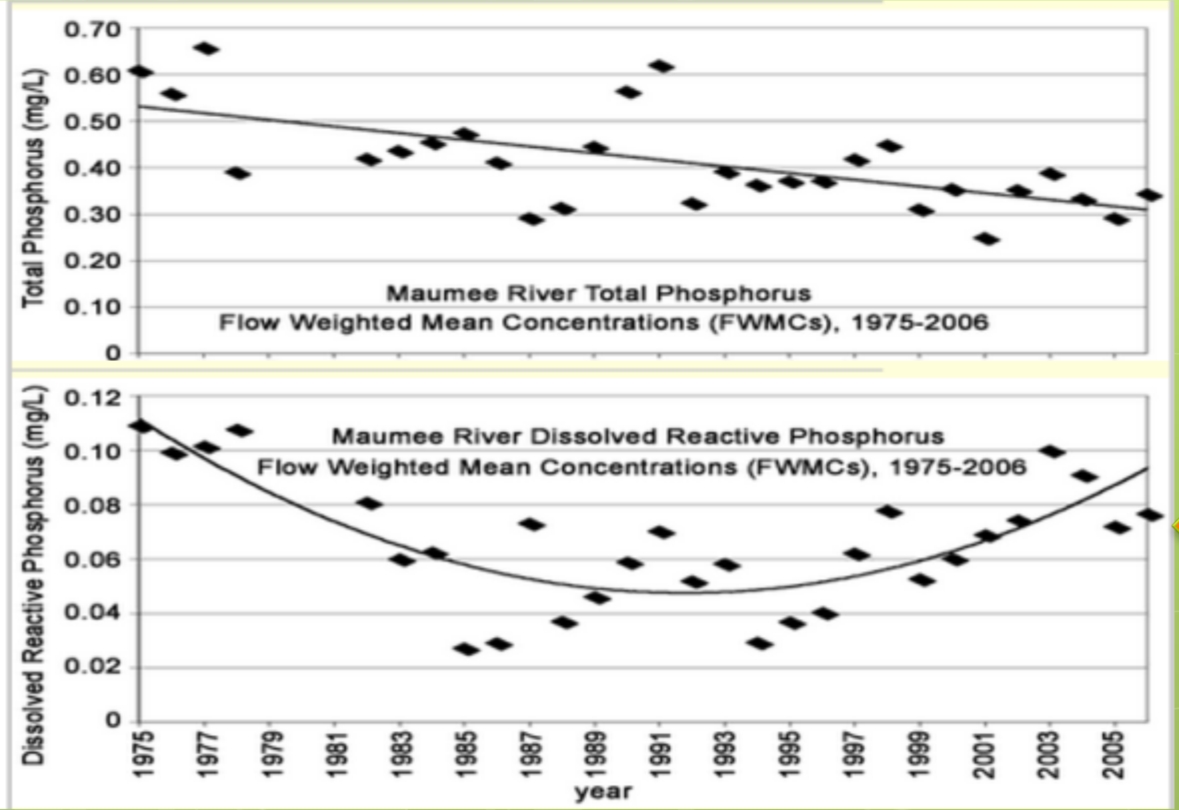
Gary Andersen
Lawrence Berkeley National Laboratory

Excess phosphorus runoff from Maumee River fueling harmful algal blooms in western Lake Erie

Considerable uncertainty about importance of various sources of increased phosphorus

LBNL PhyloChip can help resolve sources

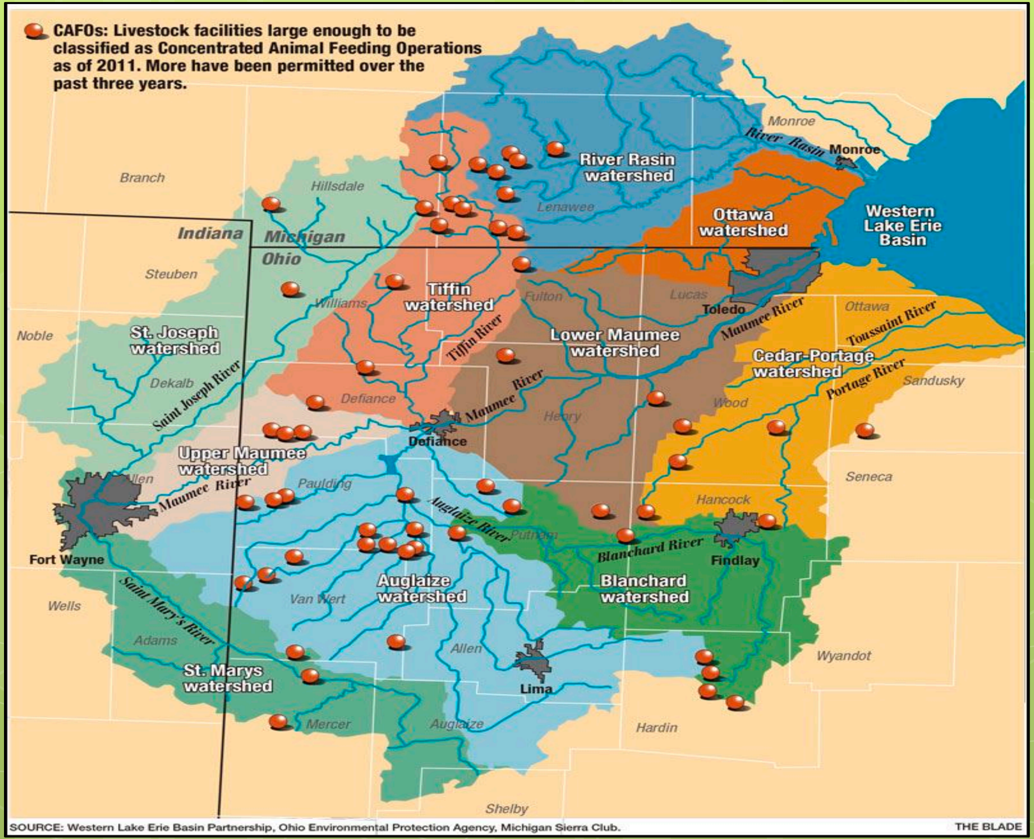
Total P in Maumee River trending down but dissolved P and algal blooms in Lake Erie are increasing



bioavailable to algae

Possible cause of dissolved P increase: manure application to non-tilled cropland and increasingly severe runoff events

Potential cause of increased dissolved P: More Concentrated Animal Feeding Operations (CAFOs)



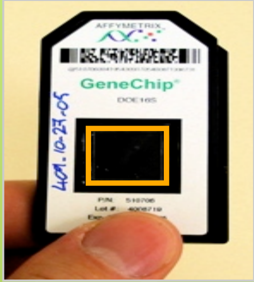
Increasing size and numbers of CAFOs, dairies

More swine, cattle and poultry in watershed

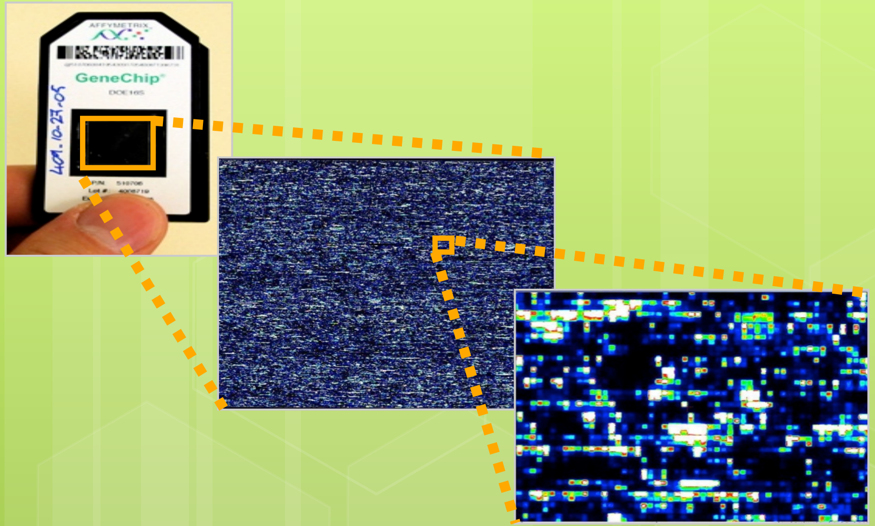
More manure applied to landscape

Not all manure types have equal impact on P load (e.g. liquid swine lagoon vs. solid cattle waste)

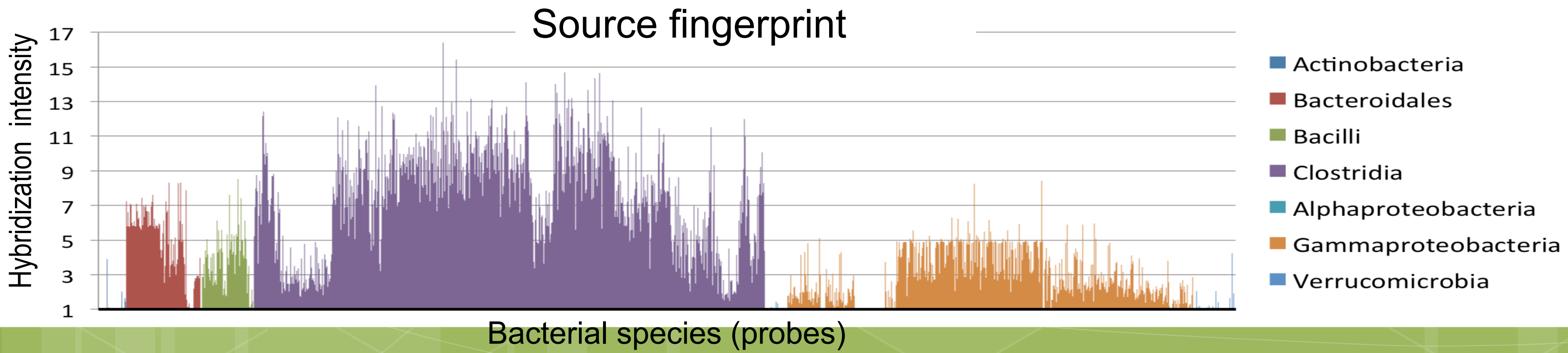
LBNL PhyloChip detect impacts of manure on Maumee River



- Manure phosphorus co-occurs with manure bacteria
- PhyloChip is a superior method for identifying sources of bacteria
- Thousands of measurements work together to give high confidence of detection using a DNA fingerprint approach
- Conventional tests rely on single markers and are unreliable
- PhyloChip also detects cyanobacteria and potential pathogens



- Analysis based on fingerprint of 1.1 million 16S rRNA gene probes
- Reference database of contaminated samples used to train predictive model for detection in unknowns



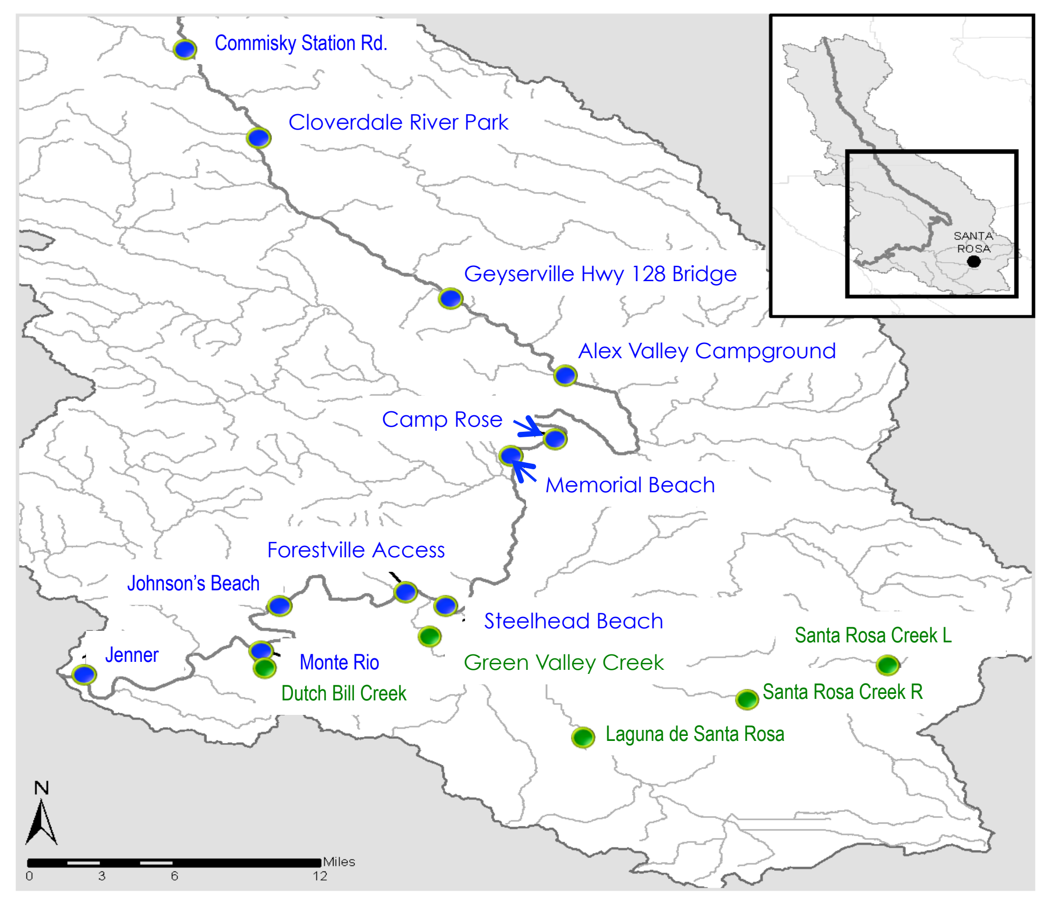
Fecal source reference library



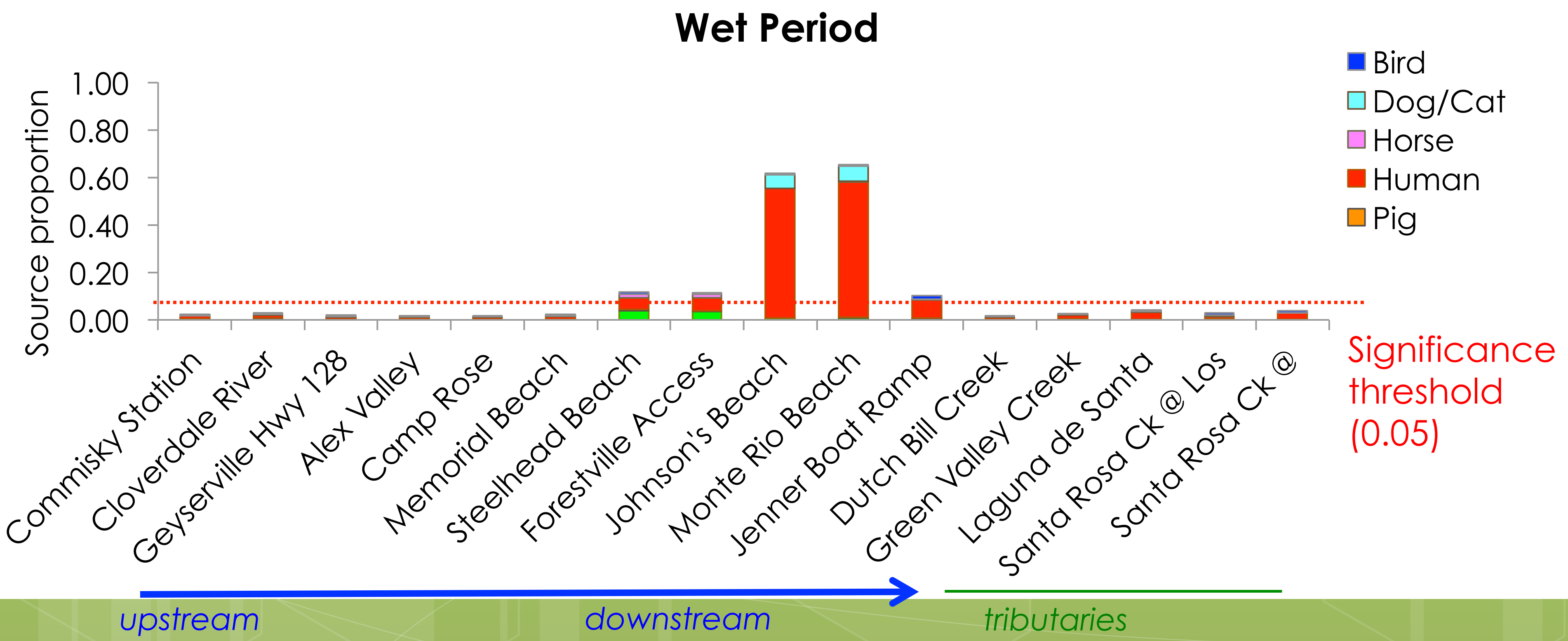


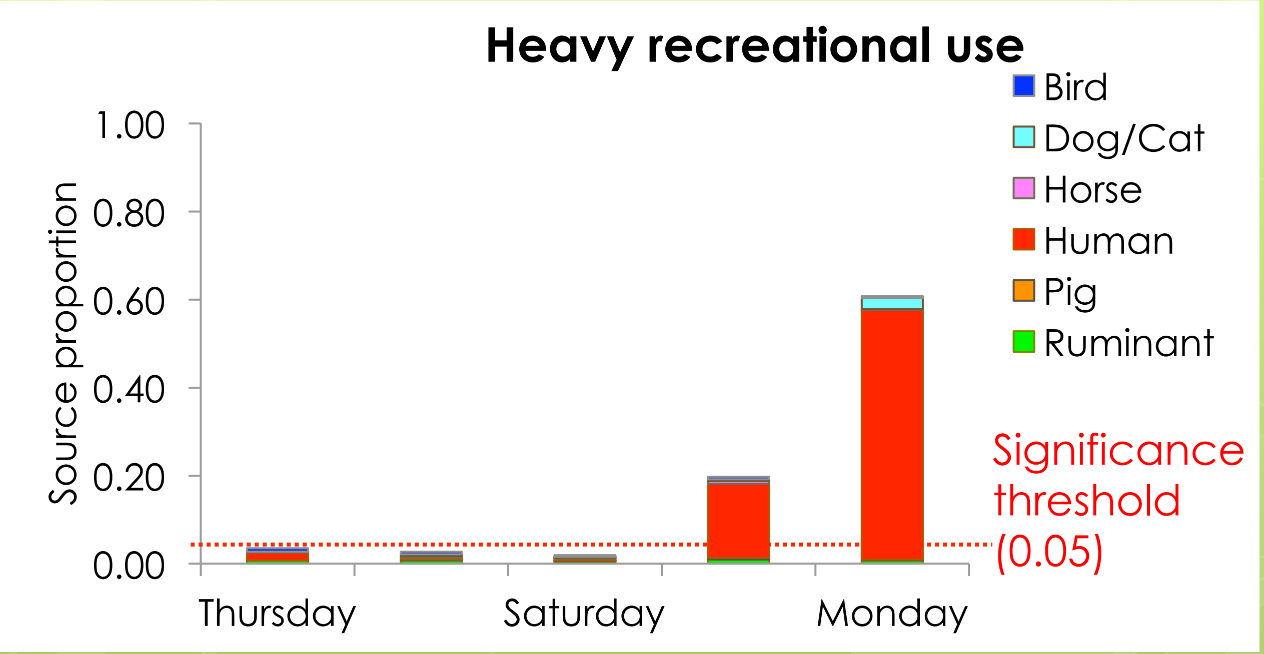

Russian River Watershed Study

- 16 locations along lower and middle Russian River
- 5 Impaired tributaries
- Wet and dry period sampling



Human (septic) and domestic animal contamination revealed in lower watershed during wet periods





Heavy recreational use increases human signal during busy Labor Day weekend