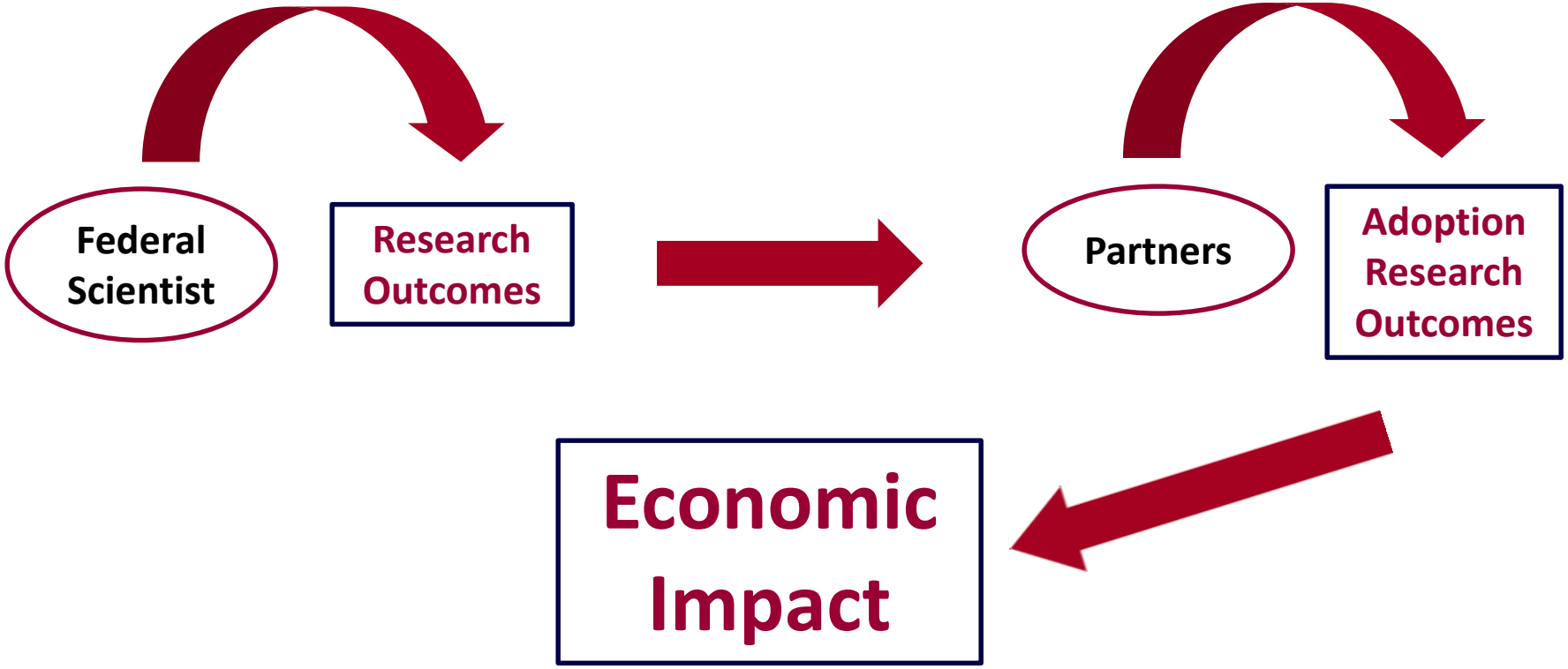
# What is the FLC ?

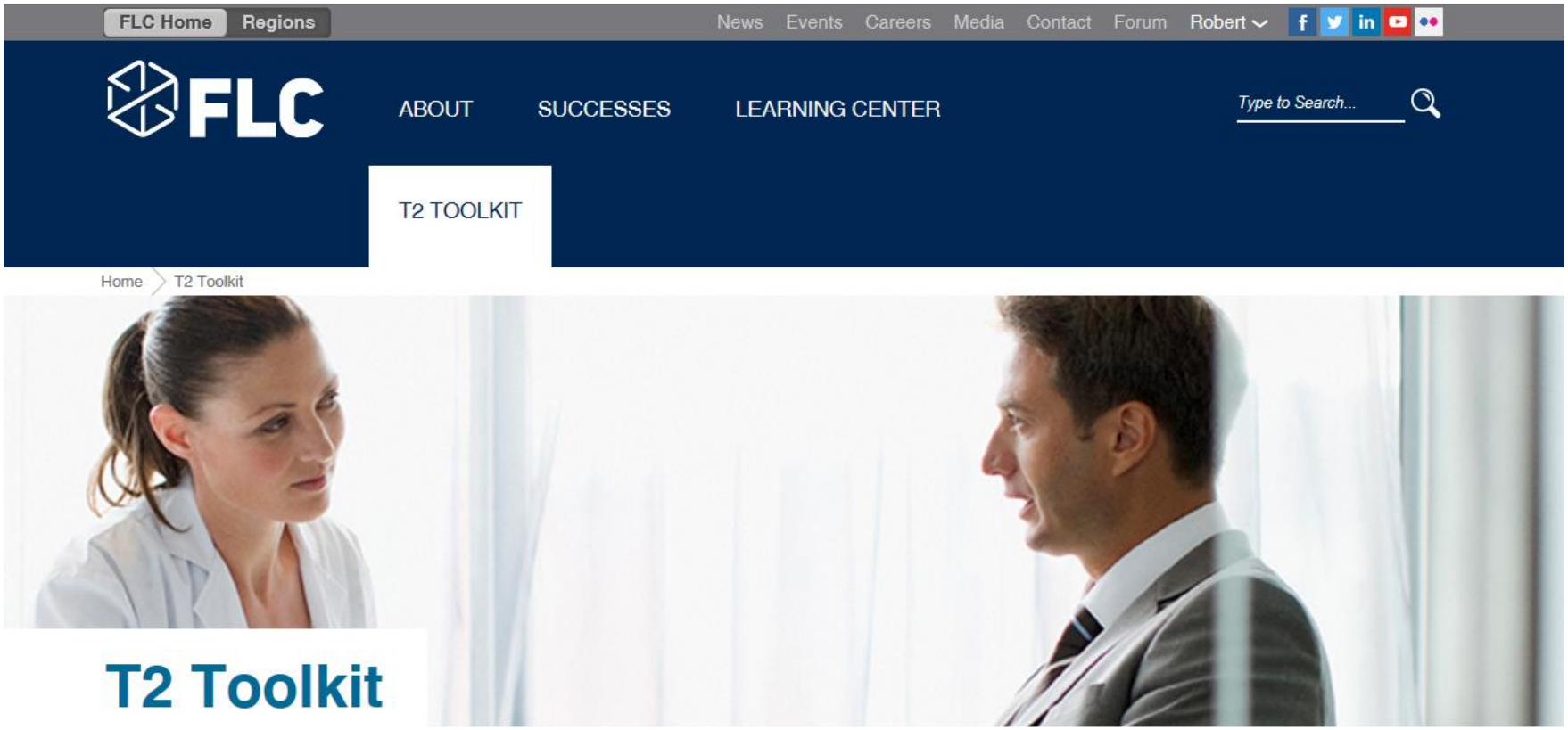
- **Nationwide network of federal laboratories that provides the forum to develop strategies and opportunities for linking laboratory mission technologies and expertise with the marketplace**

- **18 federal departments/agencies**
  - ✓ **>700 R&D laboratories/centers**
  - ✓ **> 100,000 scientists & engineers**

# Partners play key role



# https://www.federallabs.org



# Water Availability:
## Research Outcomes Define Quality and Quantity Concerns
## -
## Technological Innovations Address Problems

(Slides courtesy of ARS scientists)

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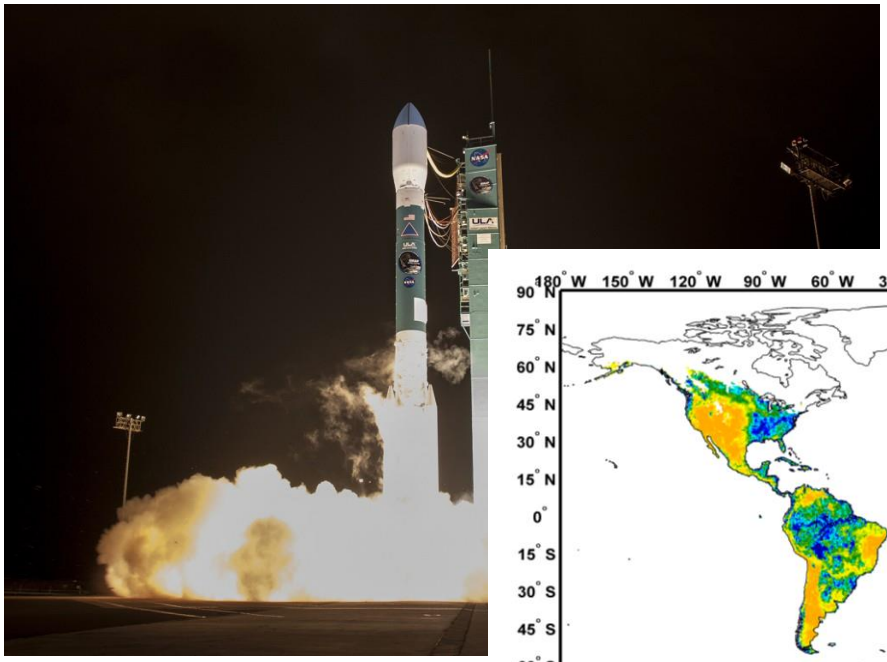
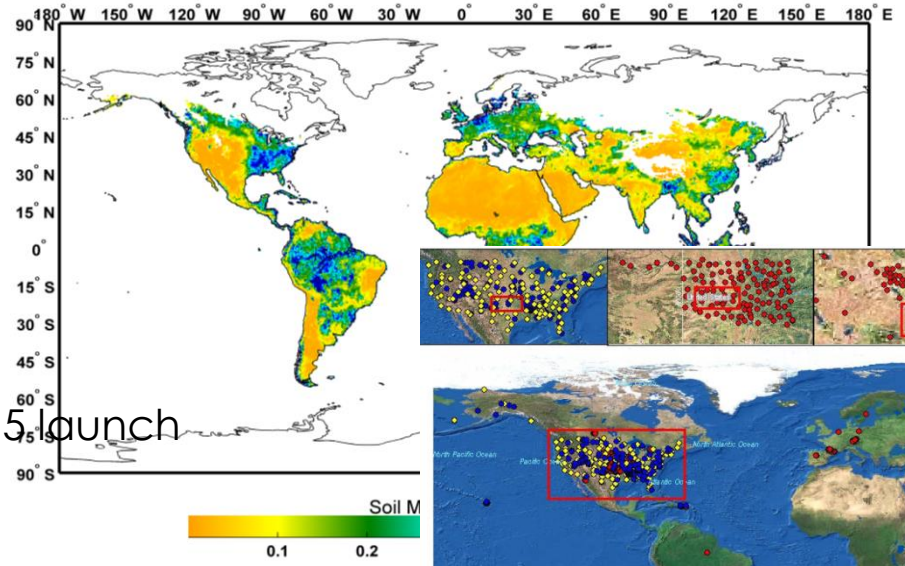
NASA soil moisture mission

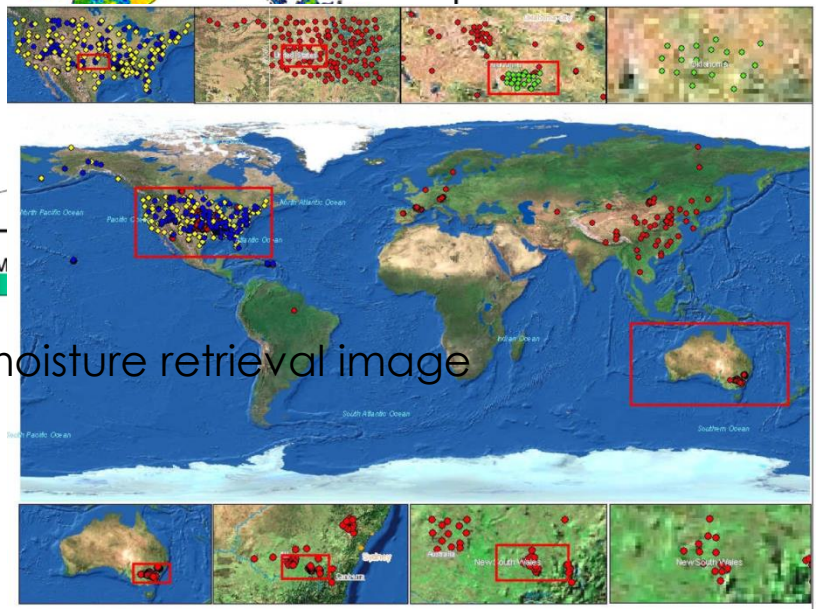
# Launch of the NASA Soil Moisture Active/Passive Mission



January 31, 2015 launch




April 2015 first soil moisture retrieval image



April 2016 end of validation phase

Hydrology and Remote Sensing Laboratory
Beltsville Agricultural Research Center

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# Launch of the NASA Soil Moisture Active/Passive (SMAP) Mission

NASA soil moisture mission

**Role of USDA ARS NP 211 Researchers:**

1) Design of primary SMAP soil moisture retrieval algorithm (Beltsville)

2) Design of SMAP ground validation strategy (Beltsville, Tifton, Boise, West Lafayette, Tucson, Ames and El Reno).

3) Development of new agricultural applications (Beltsville, Tucson and Ames).

Applications include: agricultural drought monitoring, yield forecasting, crop insurance monitoring, irrigation scheduling and flood forecasting.

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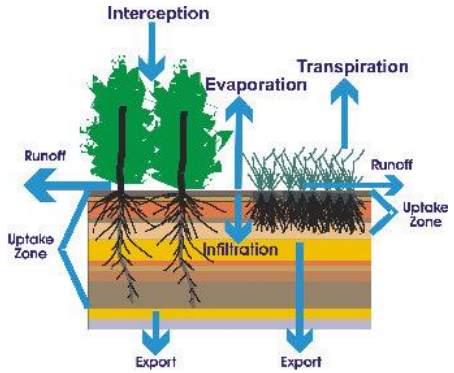
Global root-zone monitoring

# Global Root-Zone Soil Moisture Monitoring for USDA FAS

## Soil Water Balance Model

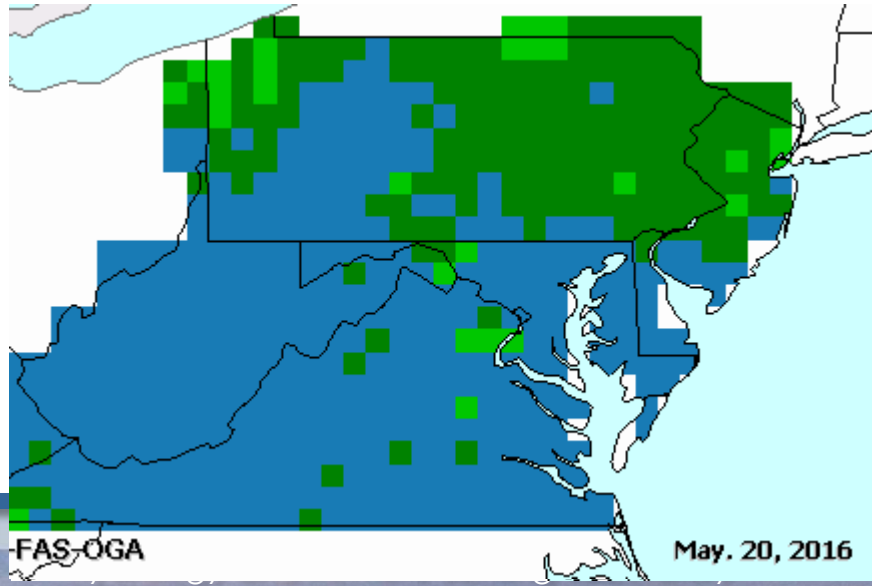



## ESA SMOS


Data Assimilation

FAS USDA

**Model** **Model + SMOS**




3-day, global, 0.25° root-zone soil moisture products posted at:
http://www.pecad.fas.usda.gov/cropexplorer/

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# Mapping Crop Phenology and Daily Water Use/Stress at Sub-Field Scales

Multi-sensor data fusion

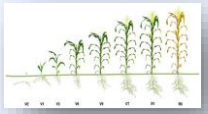
**TOOLS**

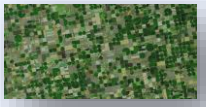
| | |
|---|---|
| STARFM | Multi-sensor data fusion |
| DMS | Thermal image sharpening |
| ALEXI | Multi-scale ET modeling |

**SATELLITE ASSETS**

| | | SW/TIR |
|---|---|---|
| GEO | Hourly | 5km/5km |
| MODIS | Daily | 250m/1km |
| Landsat | 16 day | 30m/100m |
| Lsat-like | | ~20-60m/ -- |

**APPLICATIONS**
*(daily/30 m resolution)*


Crop phenology metrics

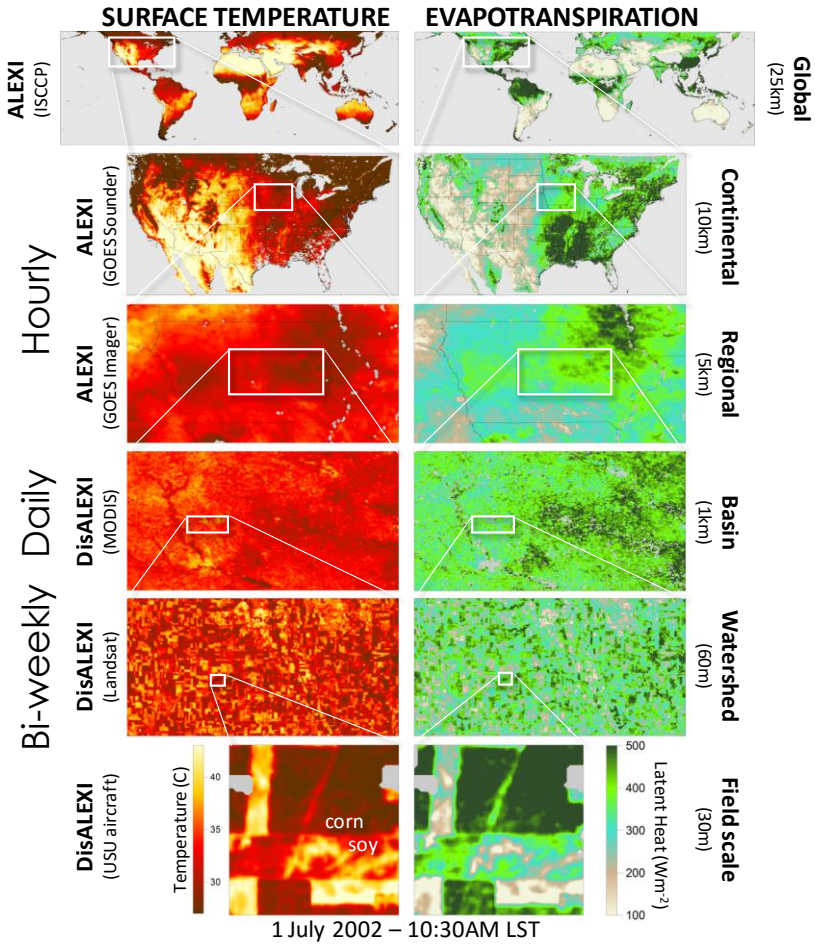

Crop water use (Evapotranspiration)


Crop stress (drought early warning)

# MAPPING DAILY/SEASONAL CROP WATER USE

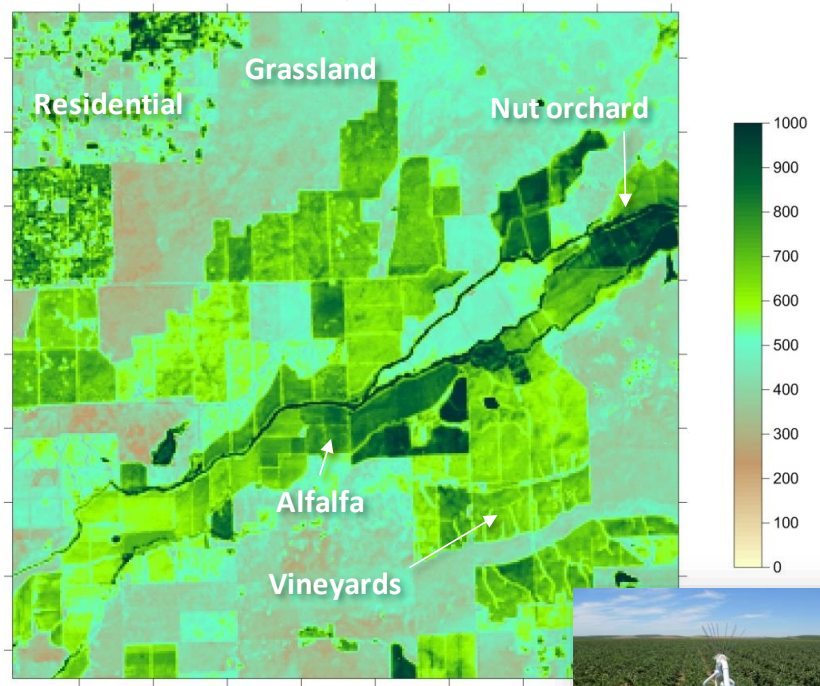
Multi-sensor data fusion

The same data fusion techniques are being used to fuse evapotranspiration (ET) estimates from multiple satellites to map daily crop water use down to sub-field spatial scales.




SEASONAL WATER USE (mm)

Central Valley, California




**GRAPEX: Grape Remote sensing Atmospheric Profiling Experiment**

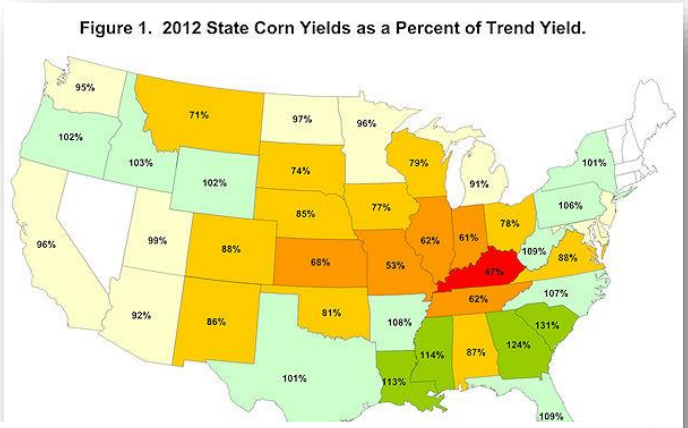
In collaboration with E&J Gallo, HRSL scientists are conducting field and remote sensing research to improve irrigation management and water use accounting in California vineyards.

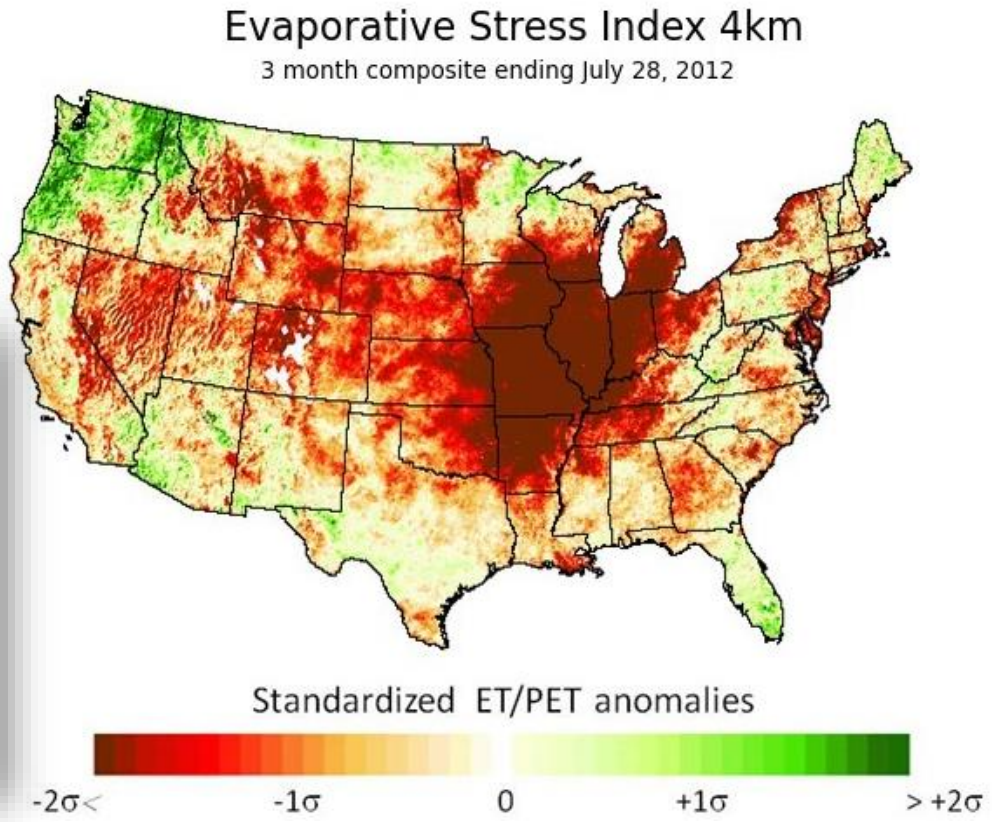
# THE EVAPORATIVE STRESS INDEX
## An early warning indicator of agricultural drought

Drought early warning

HRSL scientists, in collaboration with NOAA and academic researchers, have developed a satellite-based Evaporative Stress Index (ESI), mapping anomalies in crop water use – a physiological indicator of vegetation health – that is being generated regionally and globally in near real-time.

The ESI showed early signs of developing crop stress in the Corn Belt states during the flash drought of 2012, preceding many other standard indicators by several weeks.

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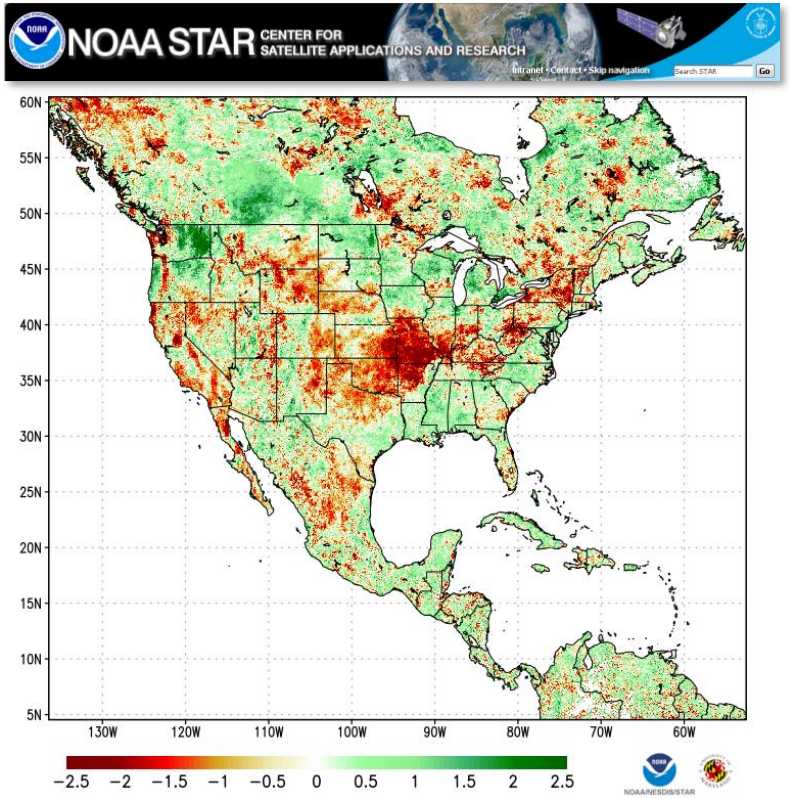
# OPERATIONAL ESI PRODUCTS
# NOAA GOES Evapotranspiration and Drought system

The ESI algorithm developed by USDA-HRSL was transitioned to operational (24-7) production by the National Oceanic and Atmospheric Administration (NOAA) as the core model of their GOES Evapotranspiration and Drought Product (GET-D) system in support of land-surface modeling verification and drought monitoring over the North American continent (8-km resolution). GET-D will be released to the public in 2016.

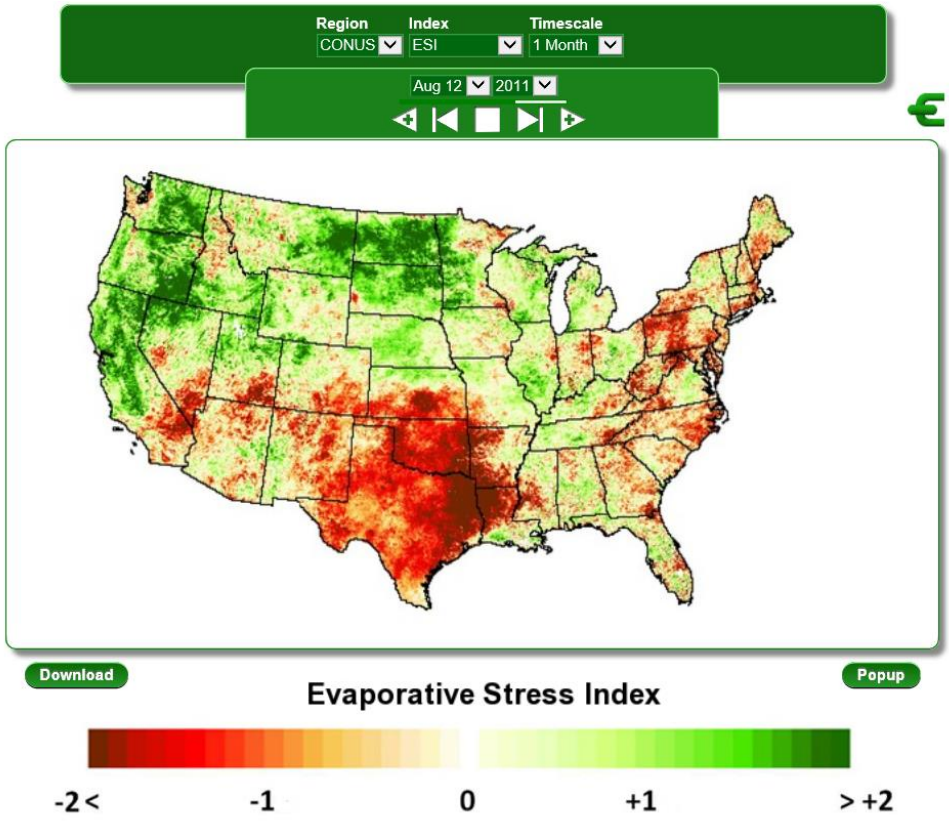
GET-D products are also hosted at hrsl.arsusda.gov/drought, and through the National Drought Information System (NIDIS) at drought.gov.

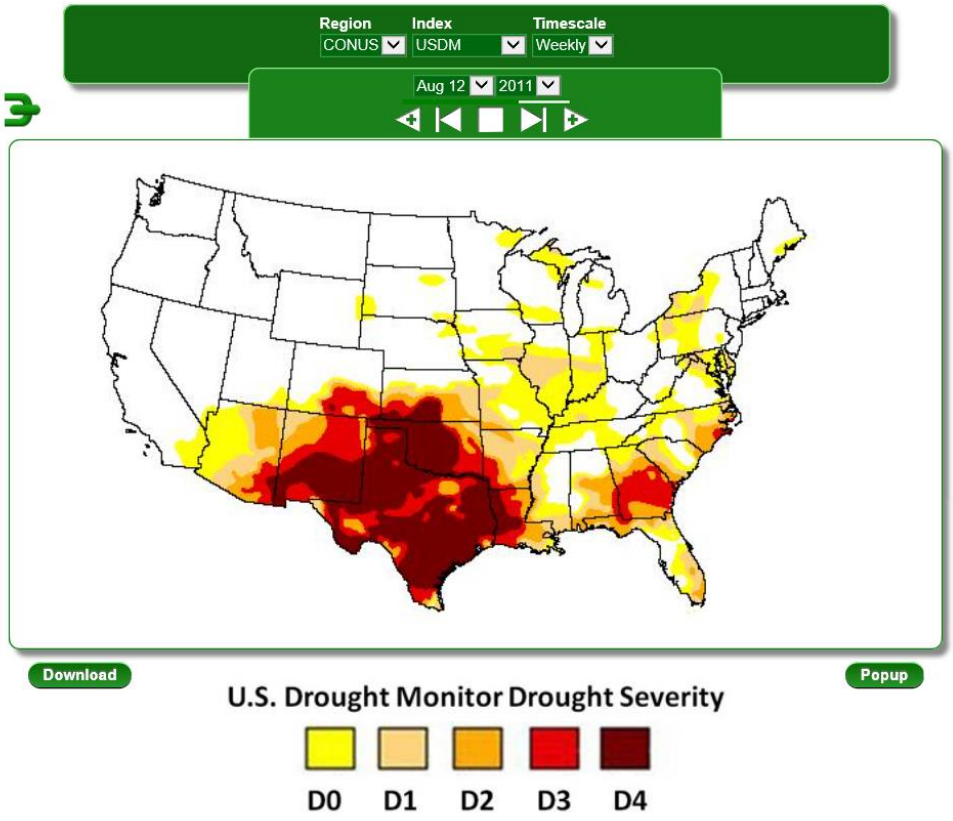
ESI products over North America are being assessed for drought monitoring and yield forecasting activities by:

- the National Drought Mitigation Center
- US Drought Monitor (USDM)
- Agriculture and Agri-Food Canada
- NOAA North American Drought Briefing
- USDA National Ag Statistics Service
- Academic researchers



# Evaporative Stress & Drought Monitor August 12, 2011

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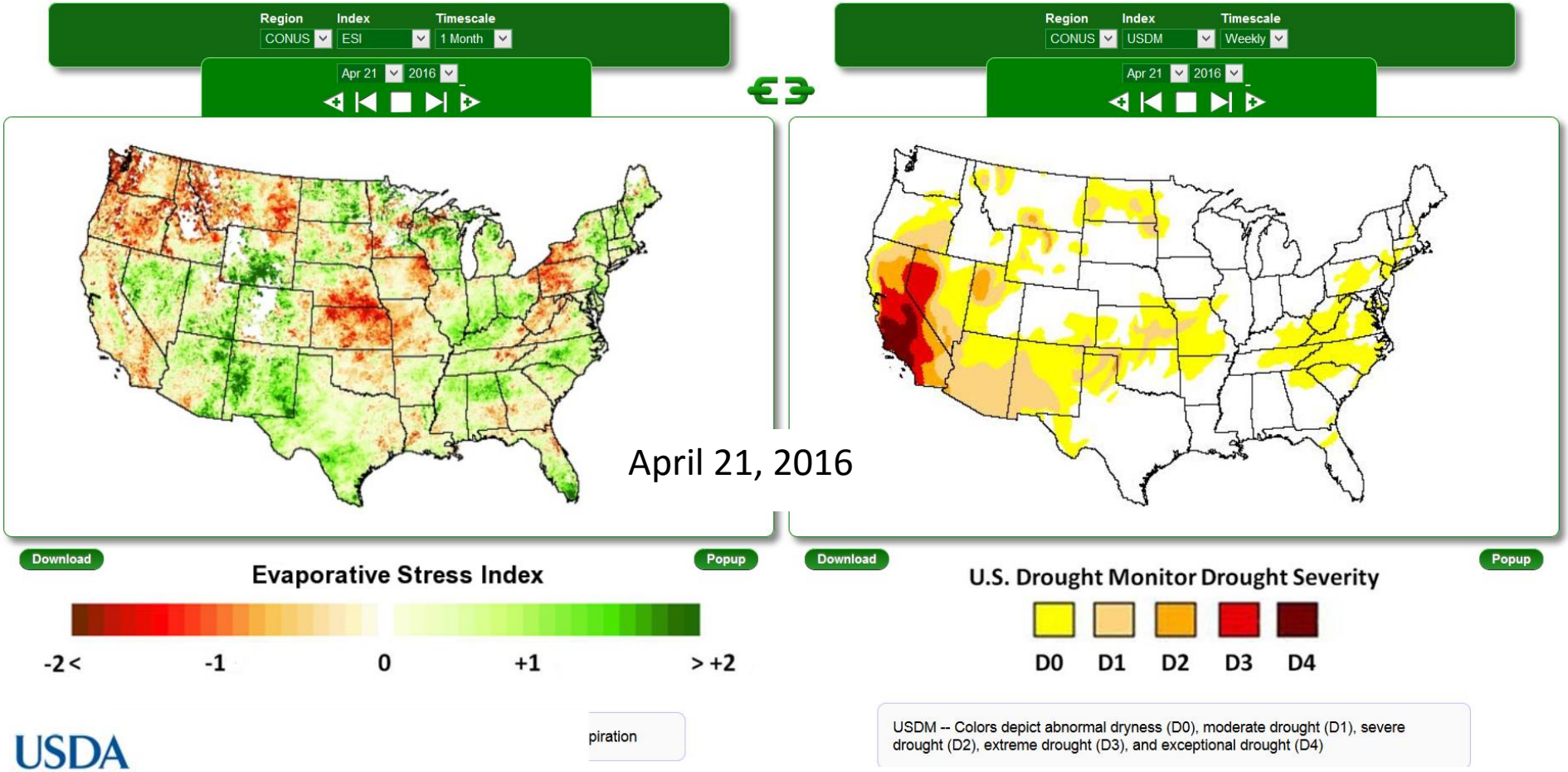
# Evaporative Stress & Drought Monitor Progression in Time

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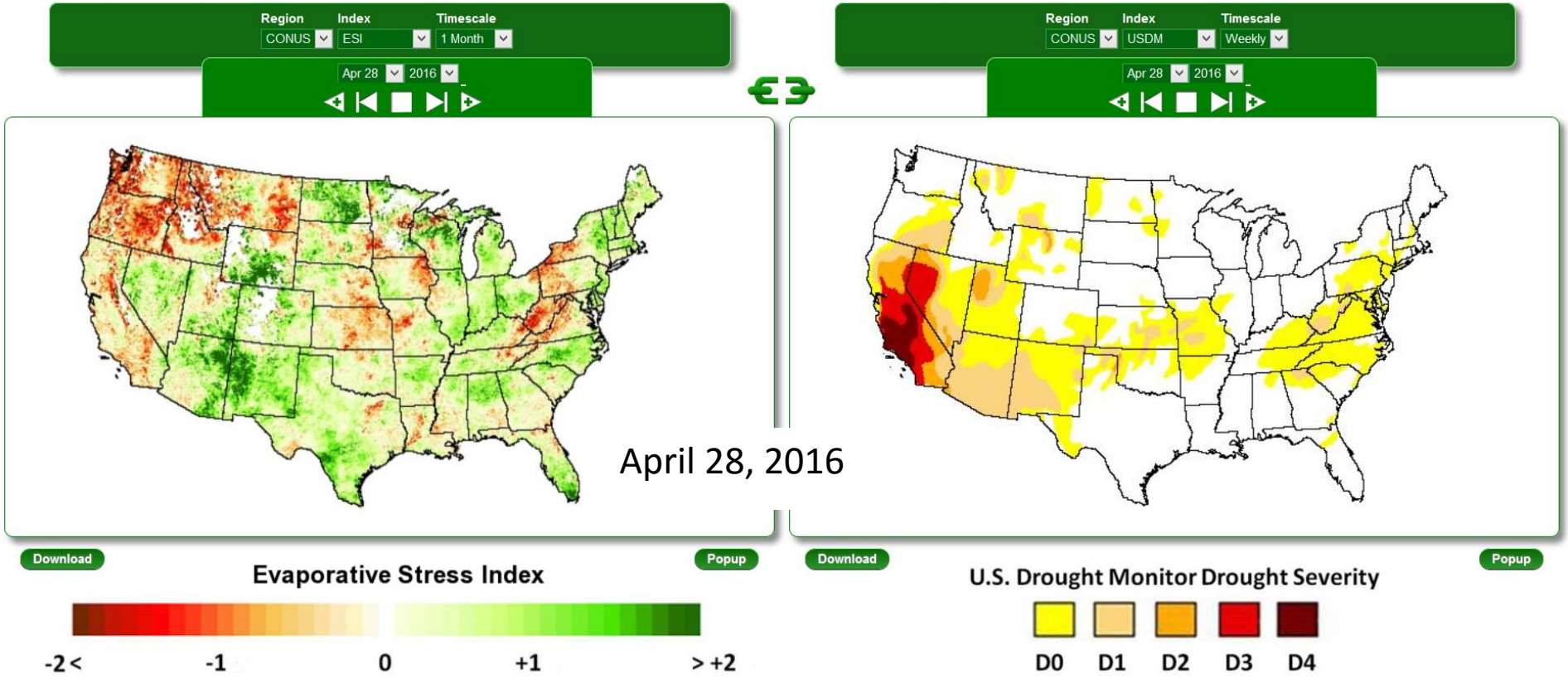


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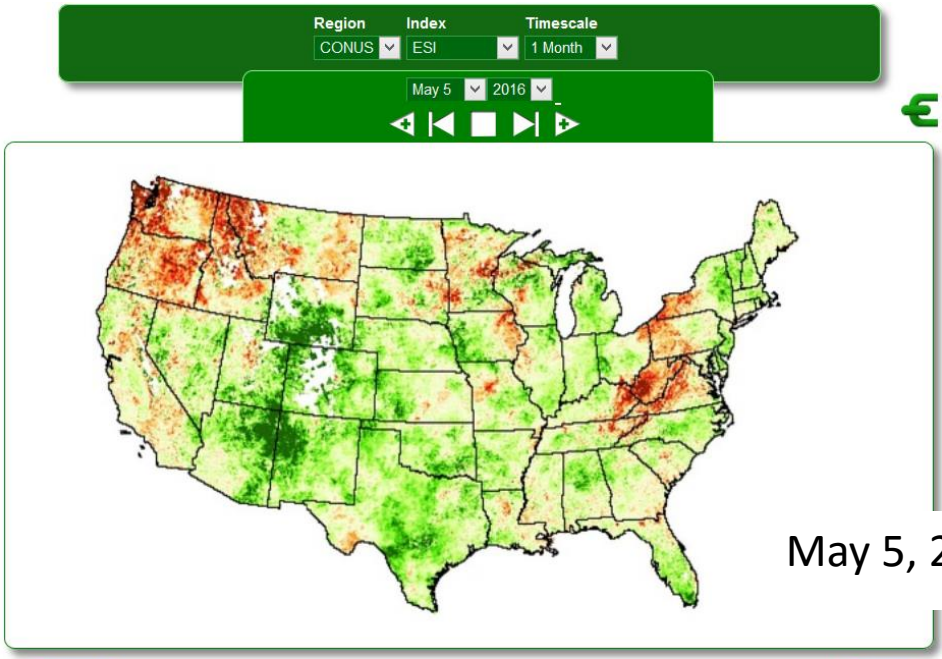
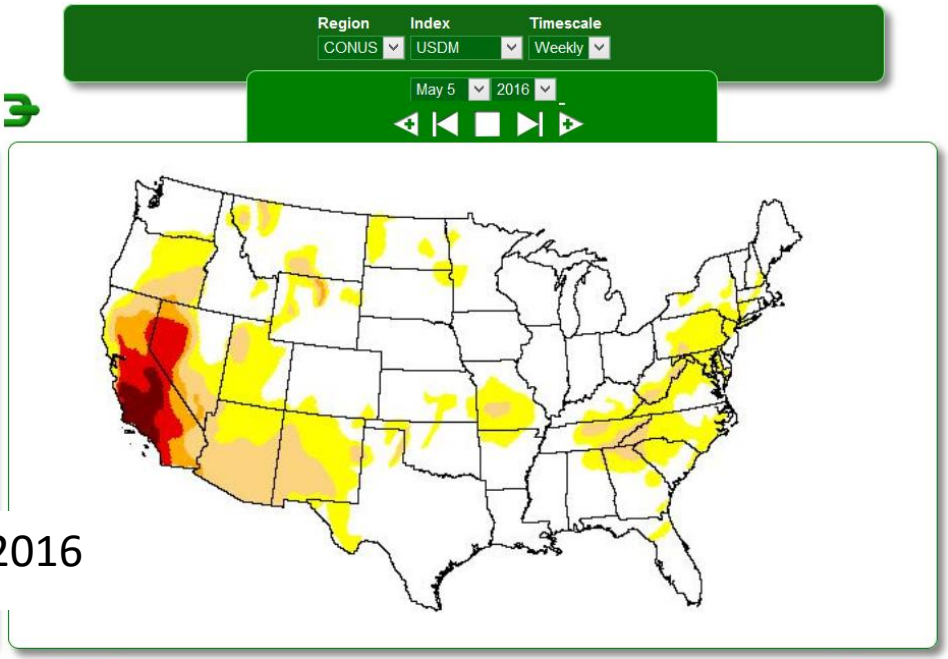



May 5, 2016




piration

USDM -- Colors depict abnormal dryness (D0), moderate drought (D1), severe drought (D2), extreme drought (D3), and exceptional drought (D4)

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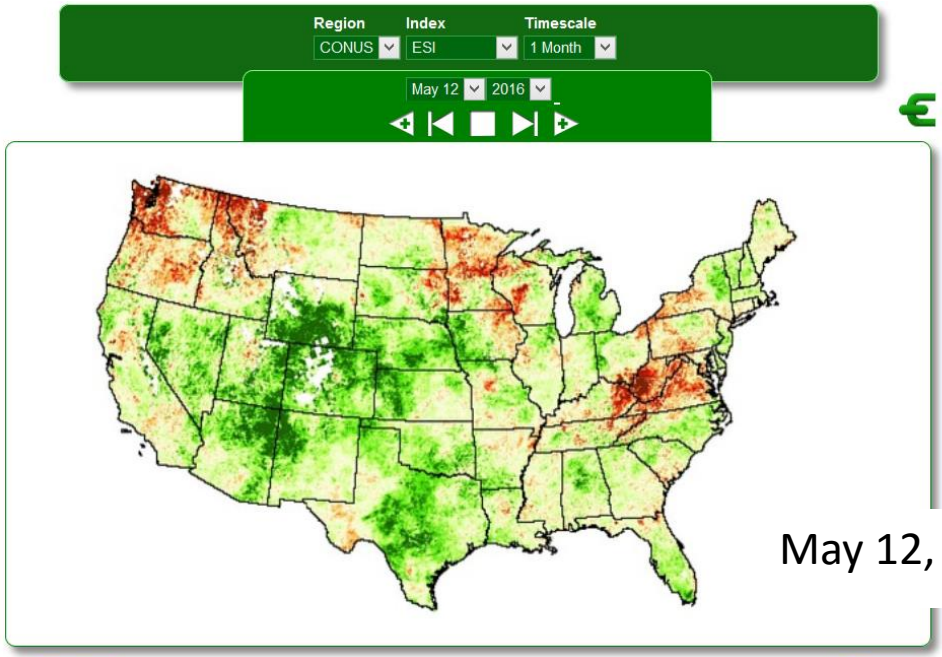
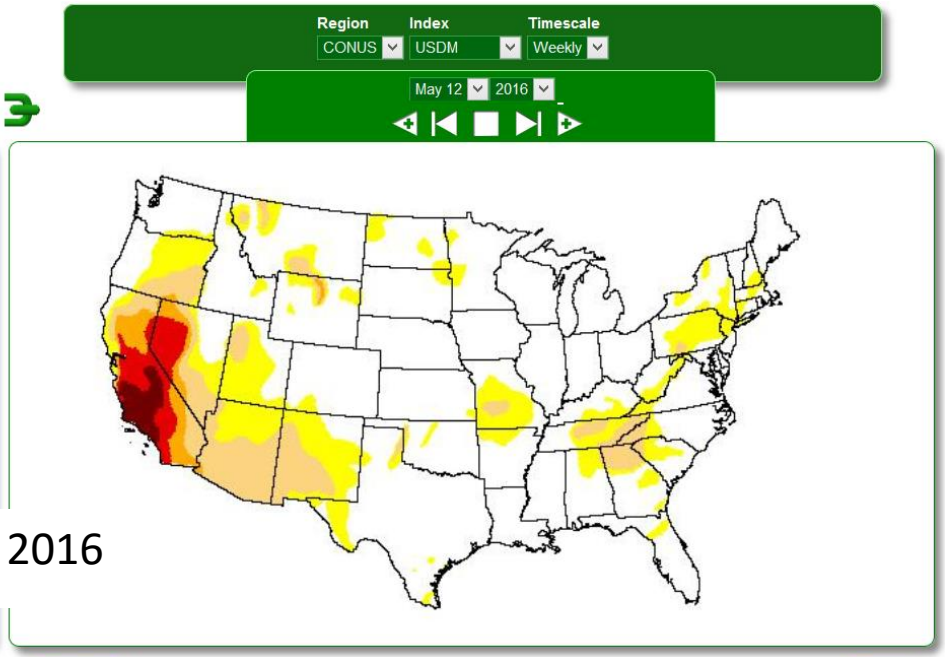
# Evaporative Stress & Drought Monitor Progression in Time




May 12, 2016

Download

Popup

Evaporative Stress Index

-2 < -1 0 +1 > +2

Download

Popup

U.S. Drought Monitor Drought Severity

D0 D1 D2 D3 D4

piration

USDM -- Colors depict abnormal dryness (D0), moderate drought (D1), severe drought (D2), extreme drought (D3), and exceptional drought (D4)

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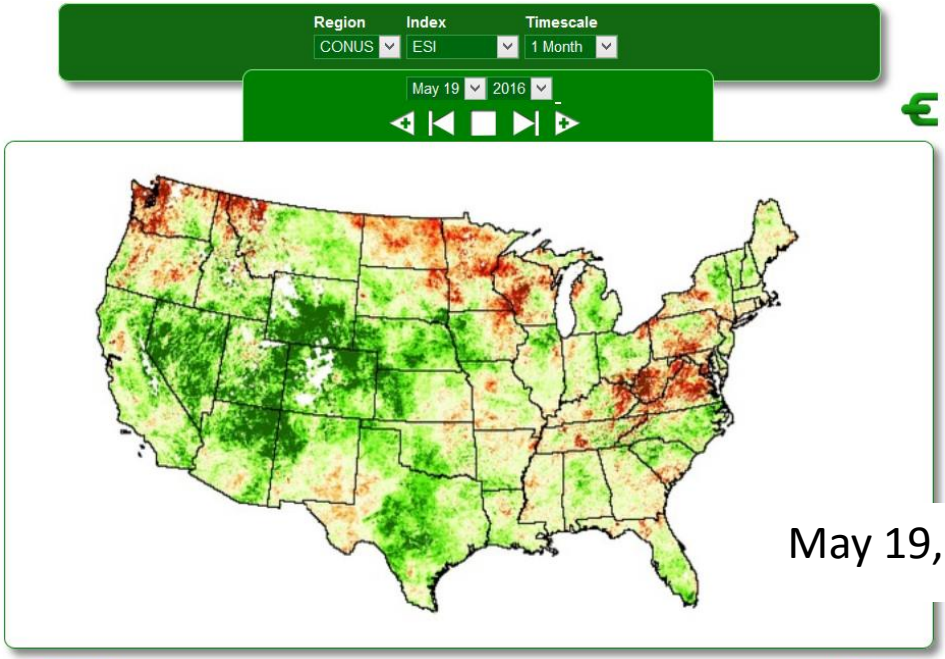
# Evaporative Stress & Drought Monitor Progression in Time

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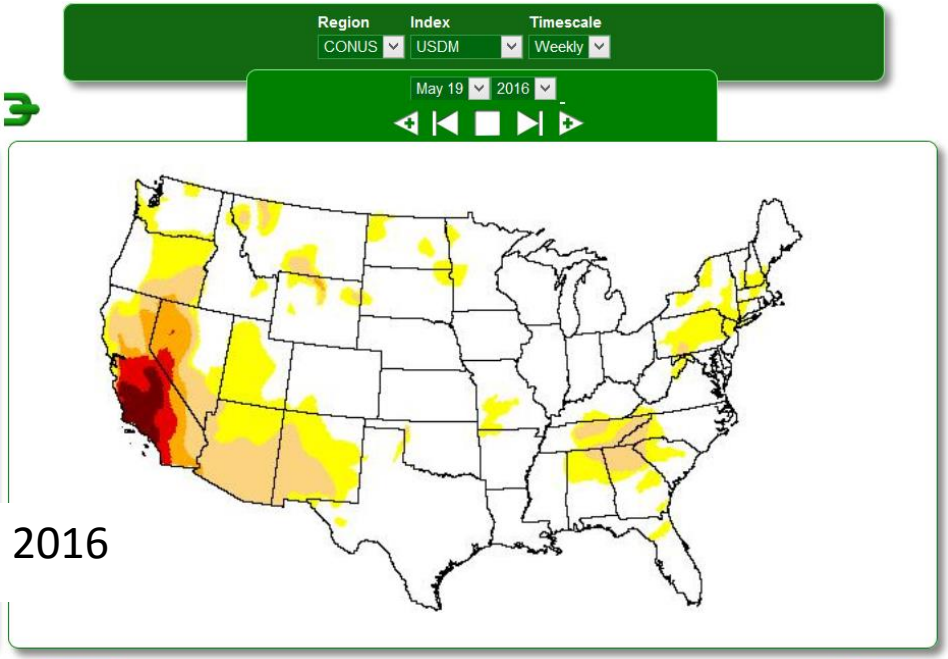


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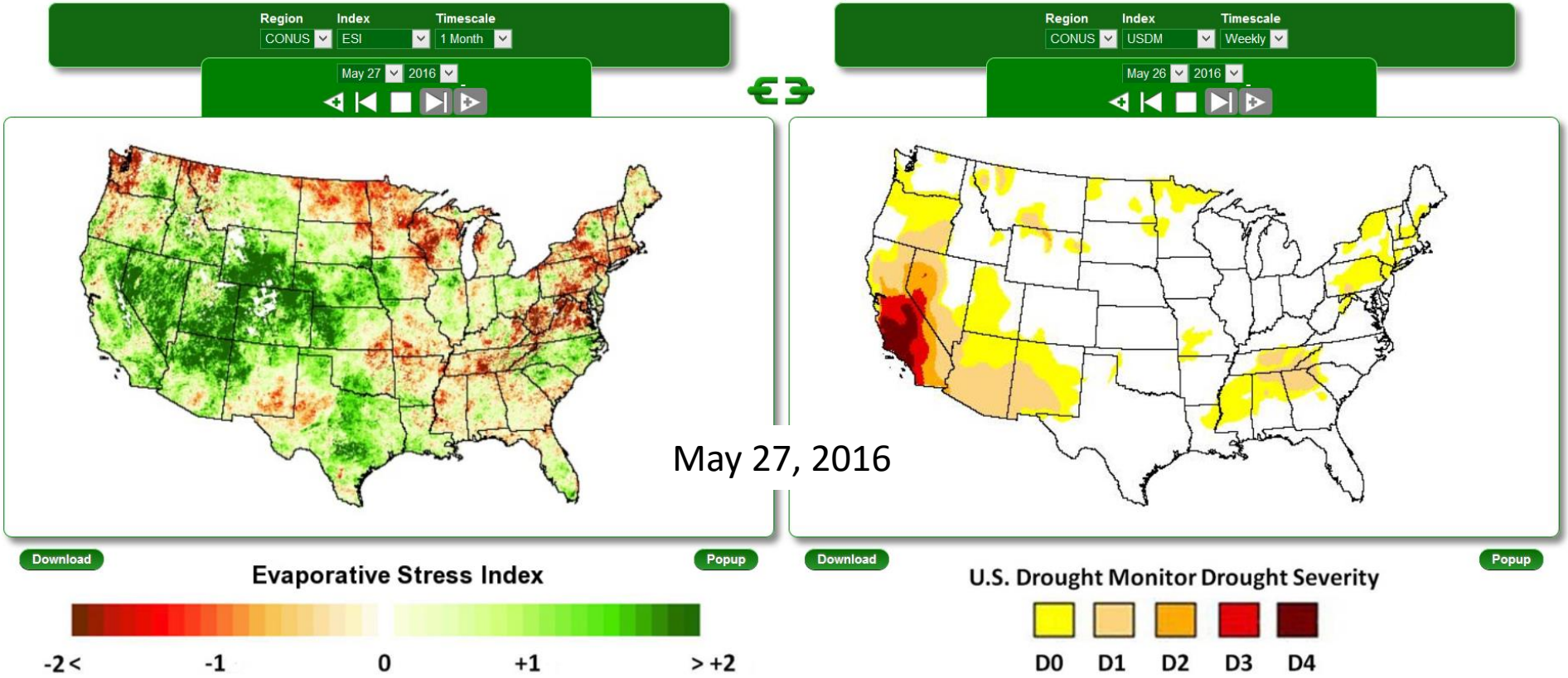
# Evaporative Stress & Drought Monitor Progression in Time

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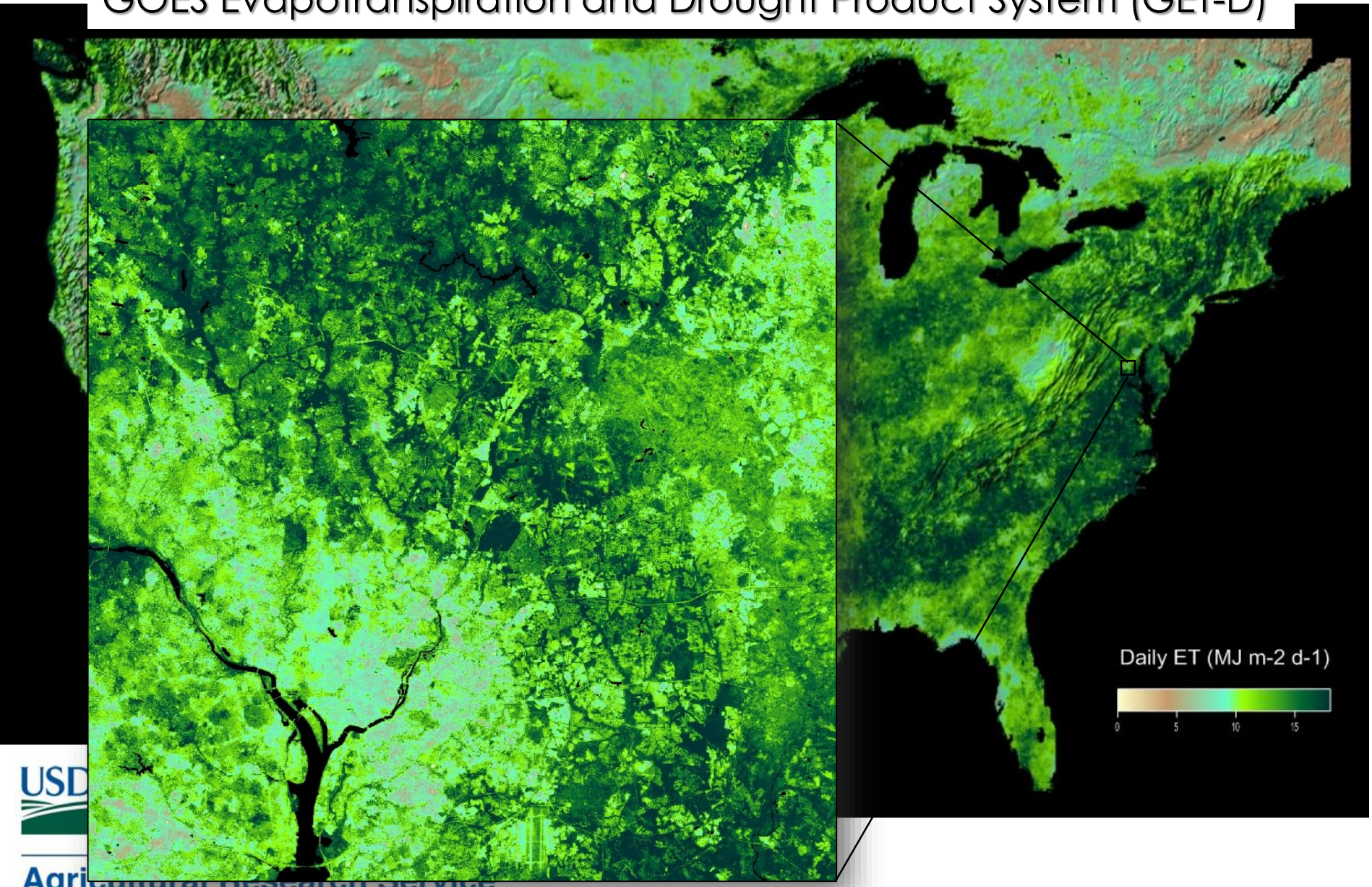
# NOAA – NESDIS – STAR
# GOES Evapotranspiration and Drought Product System (GET-D)

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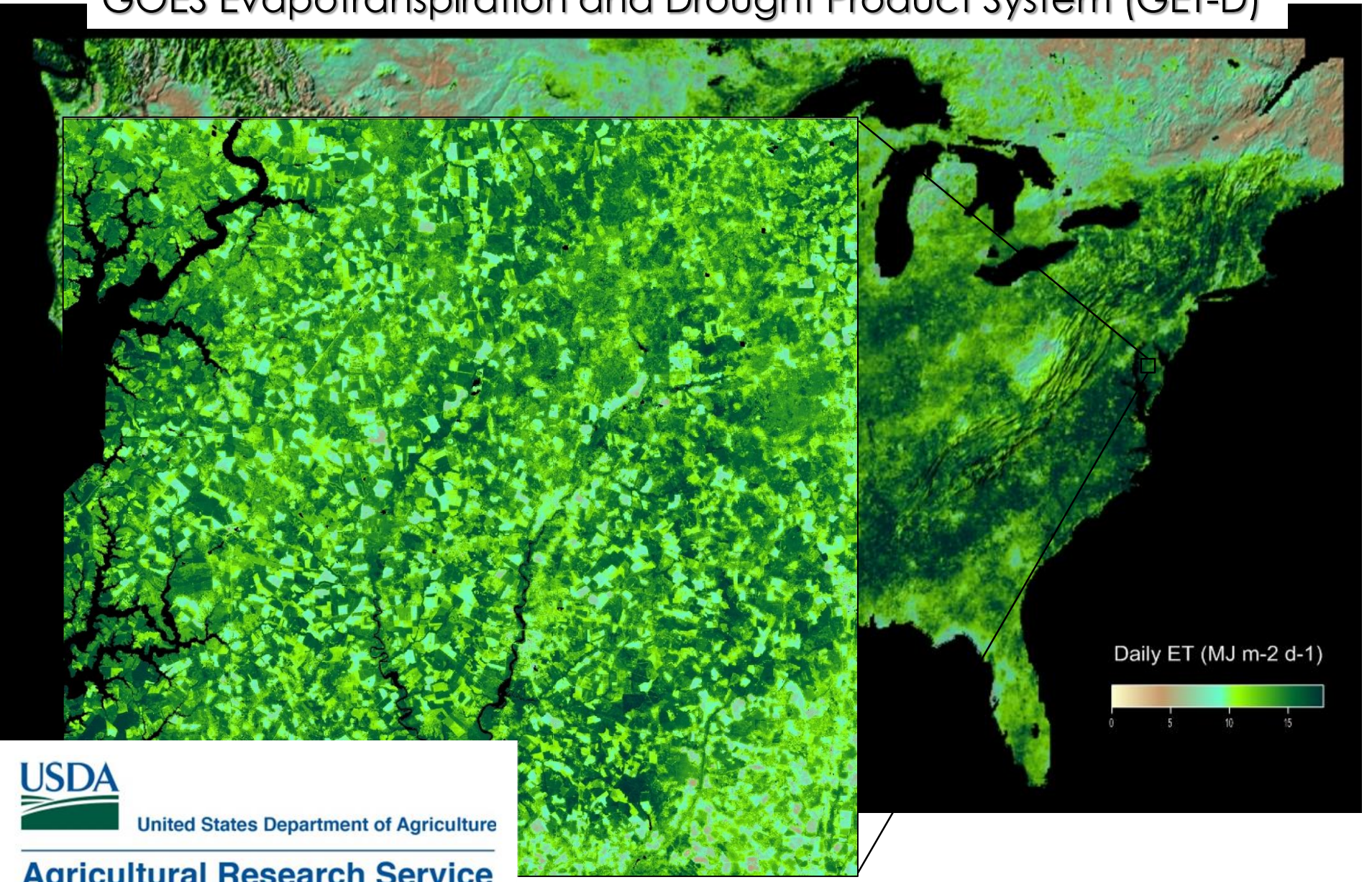
# NOAA – NESDIS – STAR
# GOES Evapotranspiration and Drought Product System (GET-D)

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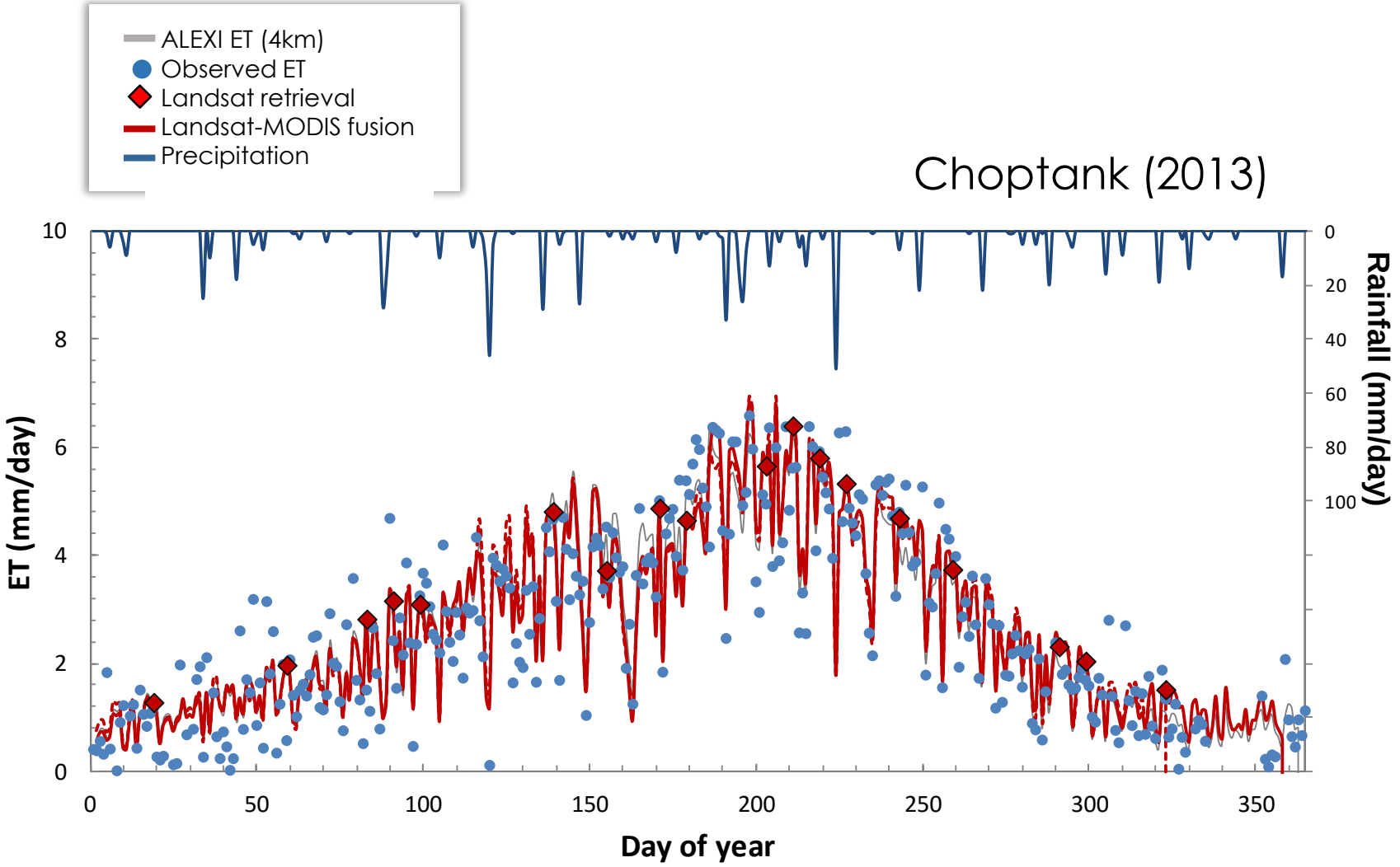
# Comparisons with flux tower data

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# Beltsville Agricultural Research Center (BARC)

- BARC collaborated with NASA and a company in Easton, MD, to develop an airborne imaging system that serves as the core of the company's remote sensing business.
- A company in Bowie, MD, uses methods developed by BARC research for flying unmanned aerial vehicles (UAVs) to obtain high-resolution, remotely-sensed imagery for precision agriculture. Within 18 months of contacting BARC, the company began taking orders for UAV flights and is franchising the technology to other companies.

# Biosensors to Biofuels

- BARC entered into a three-way agreement with the Navy and Creatv MicroTech (Potomac, MD) to develop a biosensor for the detection of a wide range of food- and water-borne human pathogens. A prototype instrument has been developed and pathogen-specific assays are being optimized.
- An agreement between BARC and Chesapeake Green Fuels, LLC allowed Beltsville to use its technical and scientific expertise and specialized equipment to ensure the product being produced in a biodiesel pilot plant met ASTM specifications. Also, BARC expertise allowed for experimentation during research with variable feedstock and by-product sources. With financial support from Maryland Technology Development Corporation (TEDCO), Chesapeake Green Fuels worked with BARC to test and evaluate biodiesel made from Chesapeake's novel process.

# Improving the Chesapeake While Saving Dollars

- Soils research at BARC led to adoption of the PSNT (pre-side dress soil nitrate test) soil test for Nutrient Management Programs in the Chesapeake Bay watershed.
- Nitrogen fertilizer is an energy-intensive input in agriculture and one that has nearly doubled in price.
- The PSNT is used in Maryland on 25,000 to 40,000 acres annually, resulting in average savings of 25 to 40 lbs nitrogen per acre compared to common practices.
- Use of the PSNT in Maryland alone has translated into savings of over 14 million lbs of fertilizer nitrogen, worth over $5 million, reducing nitrogen losses to the Chesapeake Bay.

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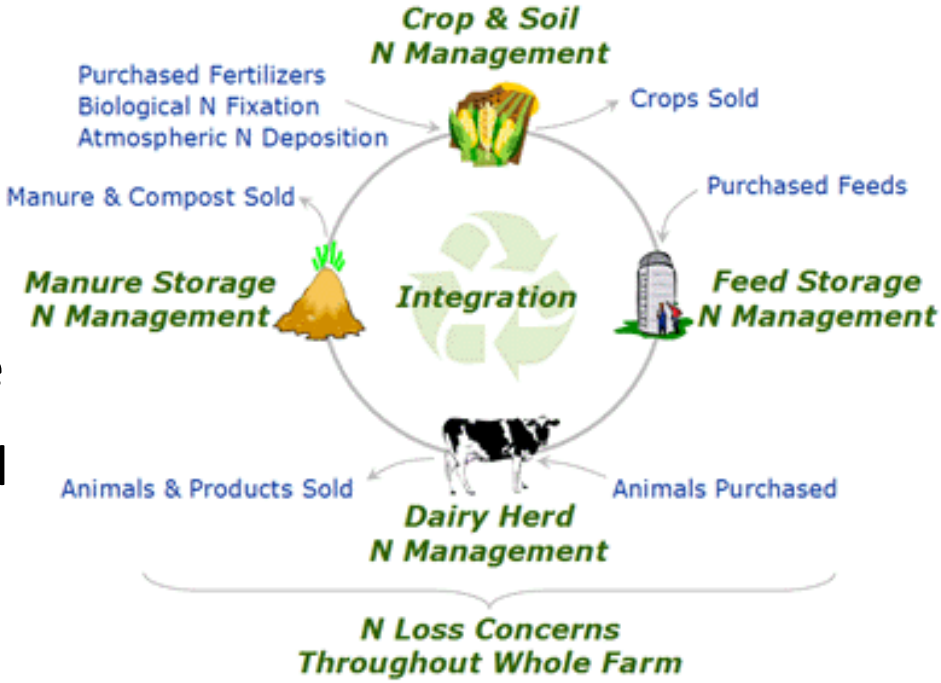
# Reducing Costs – Helping the Bay

- In the Chesapeake Bay watershed, dairy cattle produce about 200 million pounds of nitrogen annually – about equal to that from the Bay's 16 million residents. Nitrogen is an essential nutrient for crops and animals, but too much nitrogen in feed, or in the fertilizer and manure added to crops, can increase nitrogen losses to ground and surface waters.
- BARC and Cornell University developed a website (www.DairyN.cornell.edu) to help manage nitrogen.




- Dairy farmers can conserve about 40 million pounds of nitrogen annually, with potential economic savings of $14 million and reductions of nitrogen losses to the environment.

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# Improving Chesapeake Bay Health

- BARC scientists partner with NRCS, the Maryland Dept. of Agriculture, and the University of Maryland to improve implementation of Maryland winter cover crop programs and keep nutrients out of the Bay.
- Remote sensing technology monitors the effectiveness of cover crops to sequester nutrients.
- This technology is being implemented on more than 6000 acres in the Choptank River watershed in Maryland.

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# Sensor Development and Commercialization

- **CRADA** for wireless infrared thermometer
- **CRADA** for patented soil water sensor
- **Multi-location CRADA** for patented site-specific irrigation control system


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# THANK YOU

Steven R. Evett

Acting National Program Leader – Water Resources

USDA

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steve.evett@ars.usda.gov

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# Taking Advantage of Federal Laboratory Innovation & Technology

Dr. Fred Hauchman
Director, Office of Science Policy
Office of Research and Development

June 2, 2016

# Overview

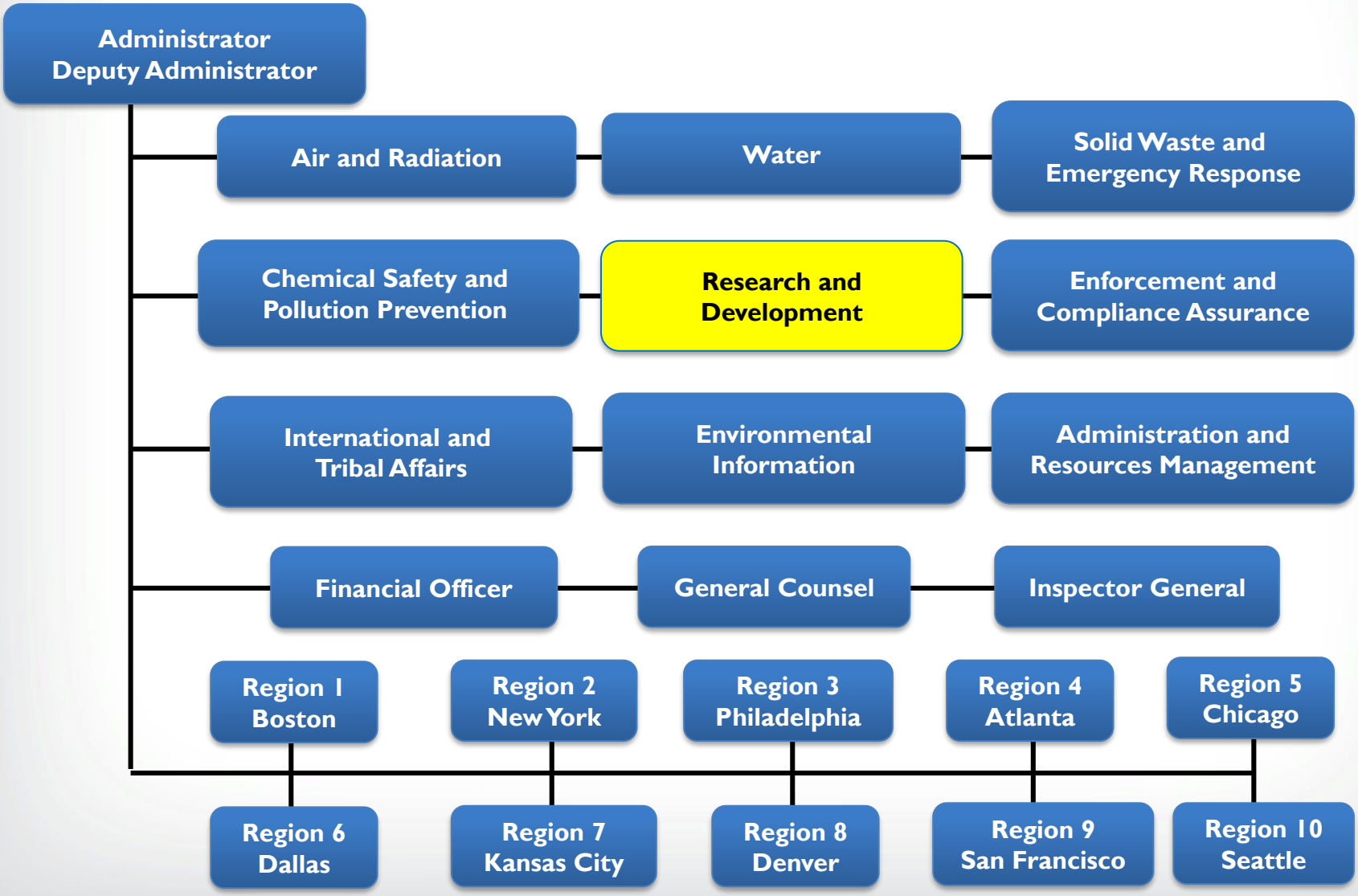
I. About EPA & the Office of Research and Development

II. Advancing Environmental Science & Technology

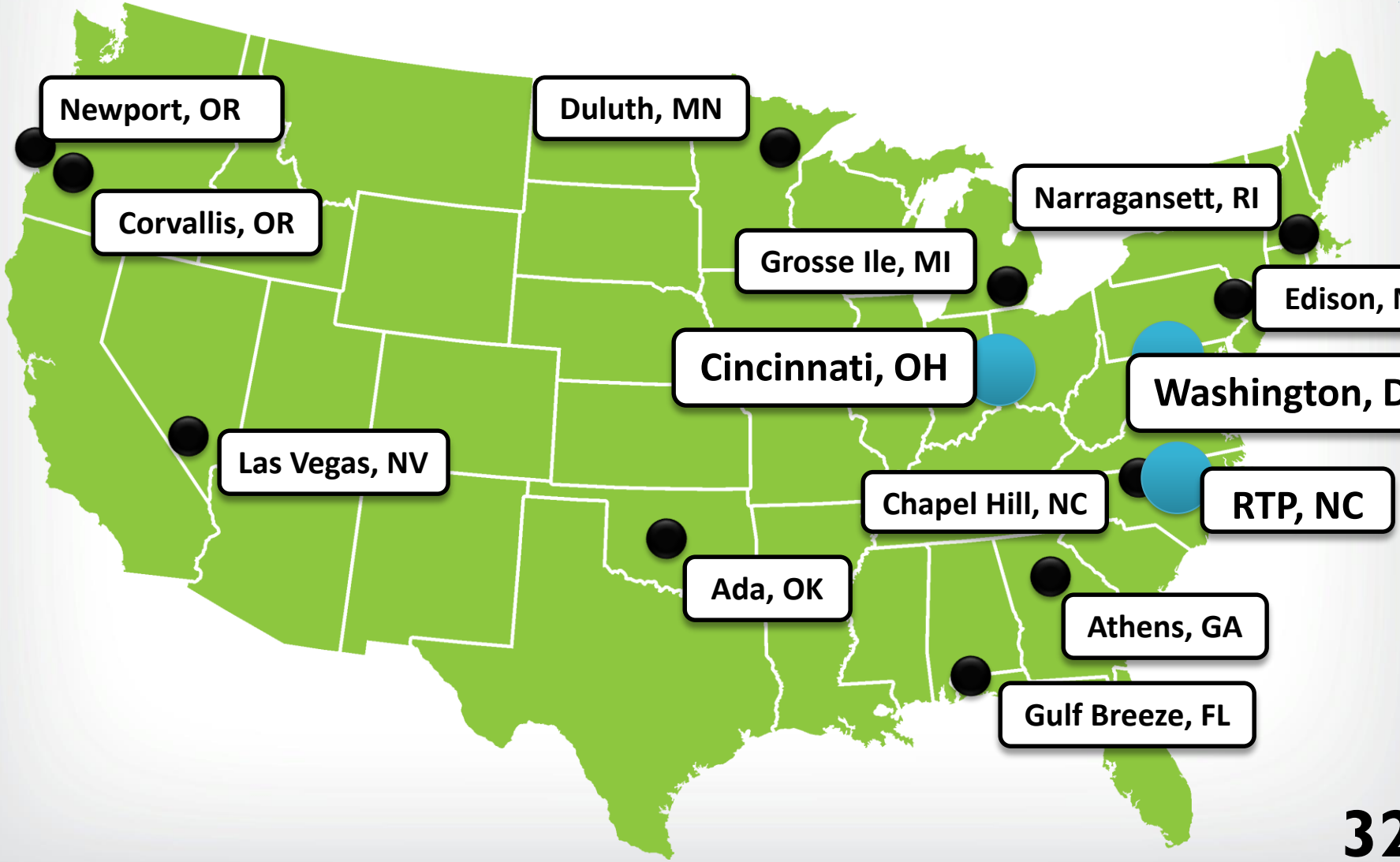
III. Innovative Tools & Research

IV. Communication & Outreach

# U.S. EPA Organizational Chart



# ORD Research Facilities



# ORD: Advancing Environmental Science and Technology

## Responsive to Urgent Needs

- Hydraulic fracturing impacts
- Drinking Water & Small Water Systems
- Hazardous Algal Blooms
- Flint, Michigan

## Innovative and Sustainable Solutions

- Sustainability decision support tools for communities and tribes
- Portable, miniature air pollution monitors for states, communities and citizen science
- Green Infrastructure and the Stormwater Calculator

## Leadership in Environmental Science

- National Water Quality Benefits modeling framework
- Improving Nutrient Management Practices
- Report on the Environment

## Partnerships & Grants

- Collaboration with other agencies
- STAR Grants to universities
- Cooperative R&D agreements
- Competitions and prizes
- International collaborations
- SBIR program (Phase I and II)

# Catalyzing innovative research

Support innovation at the bench in ORD labs

Find new ways to conduct research

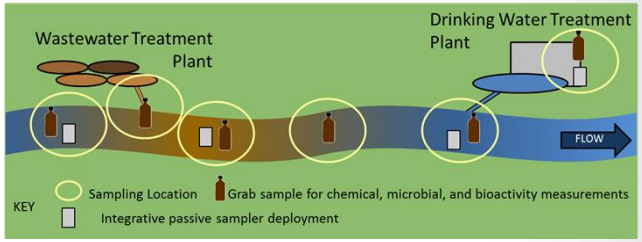
Demonstrate the power of transdisciplinary research


Broaden the network of environmental problem solvers

Innovation Strategy

# Innovative Research

- **MIT's SENSEable City Lab - measuring community health via sewage.**

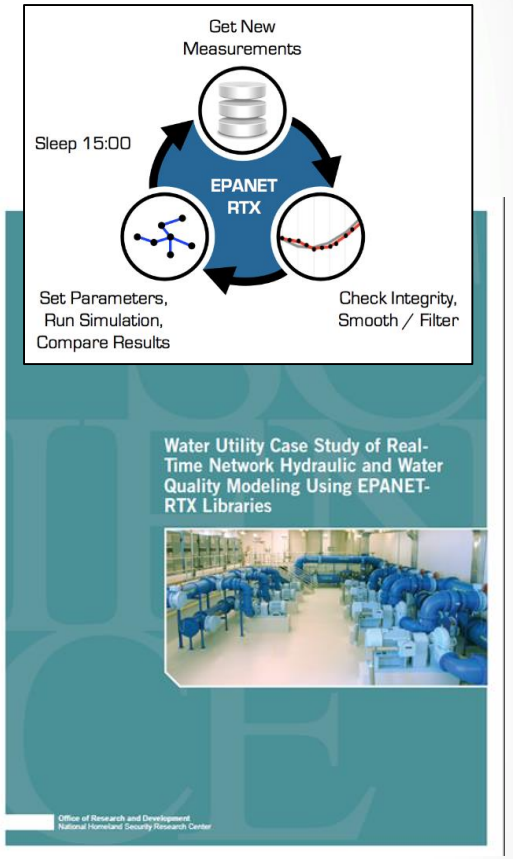



- **NASA, NOAA, and USGS partnership – detects algal blooms from space**


- **Federal Challenge Competitions**
  - **Nutrient Sensor**
  - **Arsenic Sensor**

# Innovative Tools

- **EPANET-RTX (Real-time EPANET)**
  - **Real-time analytics to water distribution system modeling, planning, and operations.**
- **CANARY**
  - **Early warning system for detecting contaminants in drinking water.**
- **Stormwater Calculator**
  - **Online tool to assess the impact of incorporating green infrastructure features into their projects that could help to immediately reduce stormwater runoff.**
- **Village Blue**
  - **Working with Baltimore to install real-time water monitoring that would provide new ways for communities to learn about local water quality.**



# Water Technology Innovation Clusters


1. **Clean Urban Water Technology Zone** (Tacoma, WA)
2. **Oregon Water Tech Innovators**
3. **The BlueTechValley** (Central and San Joaquin Valleys, CA)
4. **WaterStart** (Nevada)
5. **The Maritime Alliance** (San Diego, CA)
6. **H2OStream** (Tucson, Arizona)
7. **Colorado Water Innovation Cluster** (Fort Collins, CO)
8. **AccelerateH2O** (San Antonio, TX)
9. **The Water Council** (Milwaukee, MI)
10. **Current** (Chicago, IL)
11. **Michigan Water Technology Initiative**
12. **Cleveland Water Cluster** (NE Ohio)
13. **Akron Global Water Alliance** (Akron, OH)
14. **Confluence WTIC** (SW Ohio/N Kentucky/SE Indiana)
15. **Water Economy Network** (Pittsburgh, PA)
16. **Water Technology Innovation Ecosystem** (Philadelphia, PA)
17. **New England Water Innovation Network** (Massachusetts)

Full map available at www2.epa.gov/clusters-program/clusters-map.

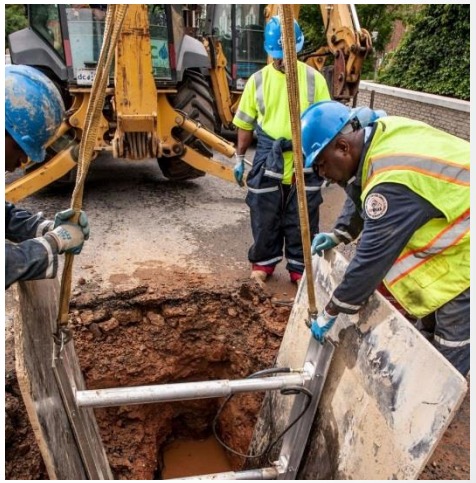
This map is not intended to be comprehensive, and may not include some emerging water clusters.

# Water Technology Transfer

# Finance Center to Improve Community Water Infrastructure and Resiliency

- **Goals:**
  - **Promote effective use of funding**
  - **Pair financing with life cycle design solutions**
  - **Support technical collaboration**
  - **Serve as a clearinghouse**

- **Current activities include:**
  - **Regional Finance Forums**
  - **The Community Assistance for Resiliency and Excellence (WaterCARE) Program**
  - **Water Infrastructure Public-Private Partnership and Public-Public Partnership Study and Local Government Training**
  - **Stormwater Financing Clearinghouse**



# Communication & Outreach

## Workgroups and Workshops

- **Annual small systems workshop**
  - 259 attendees from 46 states at 2015 workshop
- **Energy-Water workgroup**
  Work plan on Sustainable and Resilient Water and Wastewater Utilities
- **WTIC Innovation Showcase**
- **Water sensors (2016)**

## Webinars

- **Research Monthly Webinar Series**
  - 100-400+ attendees
- **Small DW & WW Systems Monthly Webinar Series**
  - 600-900 attendees (5,500+ to-date)
  - Offer certificate for one contact hour (2,100+ given to-date)
- **ECOS, ACWA, etc.** (targeted topics)

# Water Technology Innovation Clusters


1. **Clean Urban Water Technology Zone** (Tacoma, WA)
2. **Oregon Water Tech Innovators**
3. **The BlueTechValley** (Central and San Joaquin Valleys, CA)
4. **WaterStart** (Nevada)
5. **The Maritime Alliance** (San Diego, CA)
6. **H2OStream** (Tucson, Arizona)
7. **Colorado Water Innovation Cluster** (Fort Collins, CO)
8. **AccelerateH2O** (San Antonio, TX)
9. **The Water Council** (Milwaukee, MI)
10. **Current** (Chicago, IL)
11. **Michigan Water Technology Initiative**
12. **Cleveland Water Cluster** (NE Ohio)
13. **Akron Global Water Alliance** (Akron, OH)
14. **Confluence WTIC** (SW Ohio/N Kentucky/SE Indiana)
15. **Water Economy Network** (Pittsburgh, PA)
16. **Water Technology Innovation Ecosystem** (Philadelphia, PA)
17. **New England Water Innovation Network** (Massachusetts)

Full map available at www2.epa.gov/clusters-program/clusters-map.

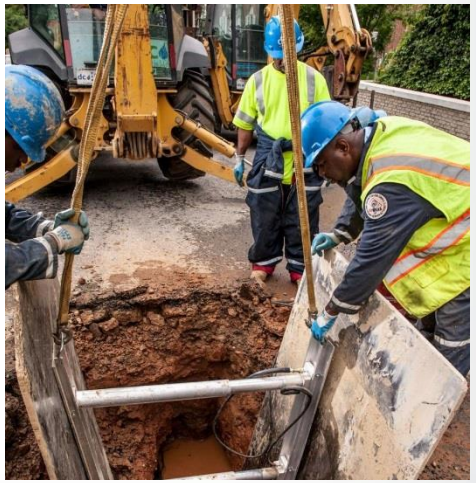
This map is not intended to be comprehensive, and may not include some emerging water clusters.

# Water Technology Transfer

# Finance Center to Improve Community Water Infrastructure and Resiliency

- **Goals:**
  - **Promote effective use of funding**
  - **Pair financing with life cycle design solutions**
  - **Support technical collaboration**
  - **Serve as a clearinghouse**

- **Current activities include:**
  - **Regional Finance Forums**
  - **The Community Assistance for Resiliency and Excellence (WaterCARE) Program**
  - **Water Infrastructure Public-Private Partnership and Public-Public Partnership Study and Local Government Training**
  - **Stormwater Financing Clearinghouse**



# Communication & Outreach

## Workgroups and Workshops

- **Annual small systems workshop**
  - 259 attendees from 46 states at 2015 workshop
- **Energy-Water workgroup**
  Work plan on Sustainable and Resilient Water and Wastewater Utilities
- **WTIC Innovation Showcase**
- **Water sensors (2016)**

## Webinars

- **Research Monthly Webinar Series**
  - 100-400+ attendees
- **Small DW & WW Systems Monthly Webinar Series**
  - 600-900 attendees (5,500+ to-date)
  - Offer certificate for one contact hour (2,100+ given to-date)
- **ECOS, ACWA, etc.** (targeted topics)

# USACEHR Mission and Vision

- **Mission**
  - Develop surveillance capabilities to detect, assess, and prevent health effects from adverse environmental, physiological, and psychological exposures.

- **Vision**
  - Protect the health of Soldiers from environmental and mission related threats through innovative science.

# Location and Personnel

Building (33,400 sq ft of floor space total)

- Completely renovated in 2003-04
- Automated monitoring and controls system for building
- Office and cubicle space for > 60 personnel (support MRMC HQ offices as tenants)
- Fully equipped conference center with video teleconferencing

In-House Laboratories (~10,000 sq ft)

- Rodent vivarium addition (2014) 1,500 sq ft
- Conversion of office space to laboratories (projected Oct 2014) 2500 sq ft
- Complete aquaculture facilities
  - Well water supply and aquaculture distribution system
  - Exposure / Diluter facilities
- Sterile culture / *in vitro* research facilities
- Extensive analytical chemistry
- OMICs Center
  - Mass spectrometry proteomics
  - Gene expression microarray platforms
  - NextGen sequencing platforms

## Number of Personnel

| Military | Civilians | On-site Contr. | TOTAL |
|---|---|---|---|
| 5 | 18 | 31 | 54 |

# Water in the Army

- Production of Water
  - Quartermaster Corps

- Certification of Potable Water
  - Preventive Medicine Personnel (MEDCOM)

- Certification of Bottled Water
  - Army Medical Department Veterinary Corps (food)

# Previous Water Technologies

- Trailer based technologies

- Fish Biomonitor – 4 US and 1 Canadian Patent
  - MWCOG, Aberdeen Proving Ground,

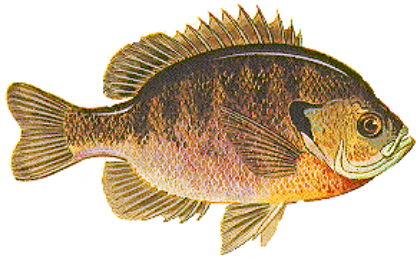
    New York City DEP, Fort Detrick, and other water treatment facilities.
  - Submersible biomonitor

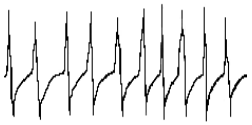
- Killifish Hatching kit for toxicity tests – 2 US Patents

- Environmental Sentinel Biomonitor
  - Cell-based chip
  - Pesticide Assay

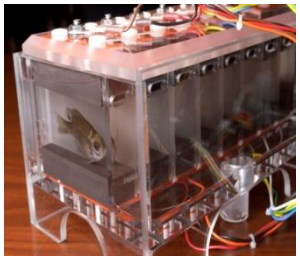
- Coliform Bacteria Analyzer

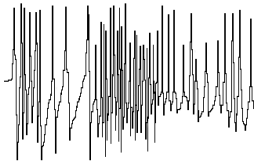
# Aquatic Biomonitor Example



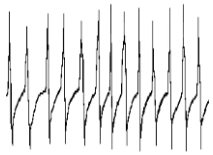


Ventilatory Frequency

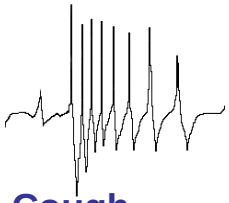




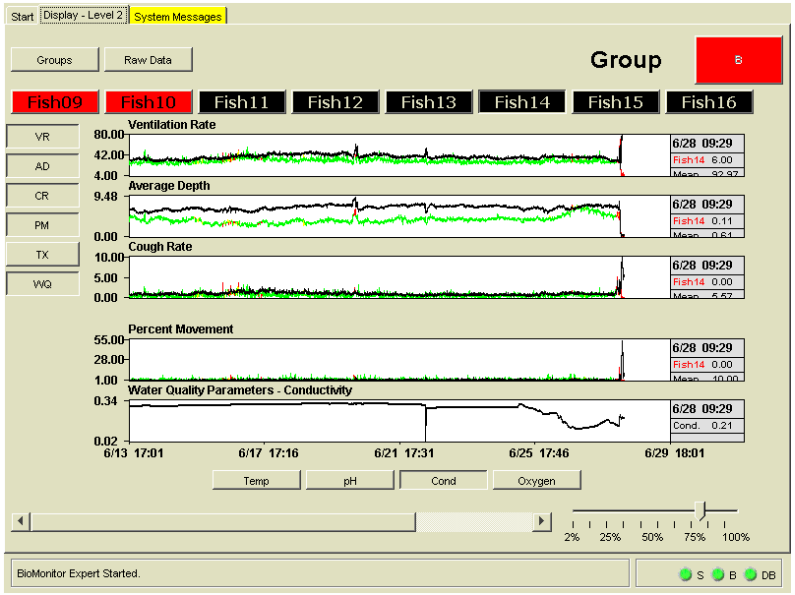
Whole Body Movement



Ventilatory Depth



Cough Frequency

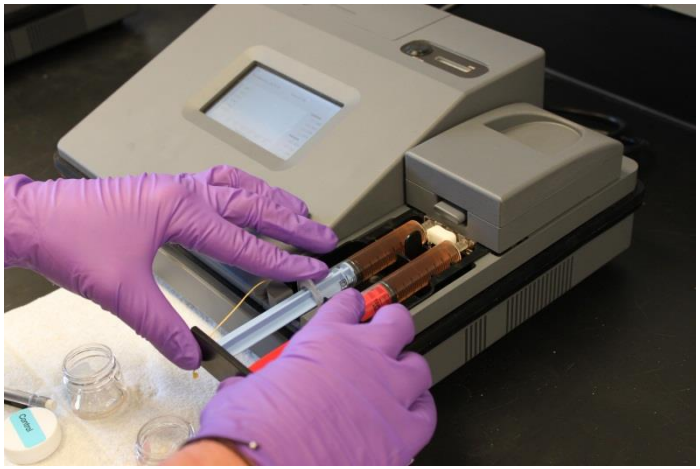


# Environmental Sentinel Biomonitor (ESB) for Drinking Water Toxicity Assessment

## Test Kit Description:

The ESB system includes two hand-held toxicity sensors to be used in conjunction with the Water Quality Analysis Set – Preventive Medicine (WQAS-PM). The ESB system will rapidly identify toxicity associated with a broad spectrum of industrial chemicals in Army field water supplies.

Electric cell-substrate impedance sensor (ECIS)



ACE sensor

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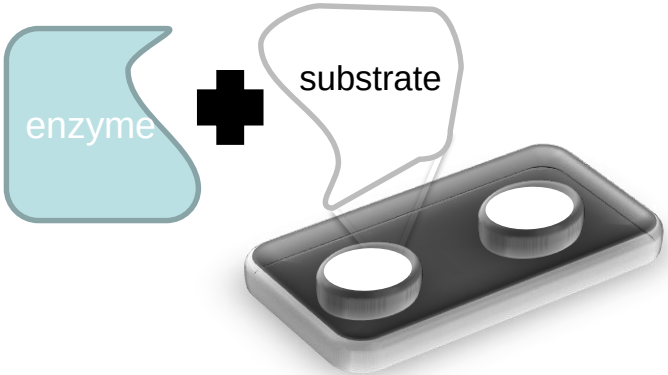
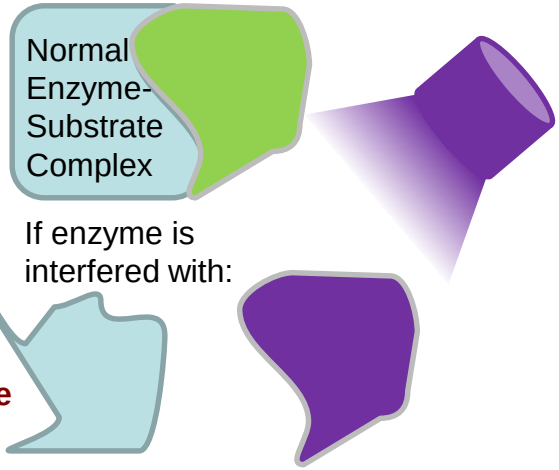
# Principles of ACE Inhibition Test

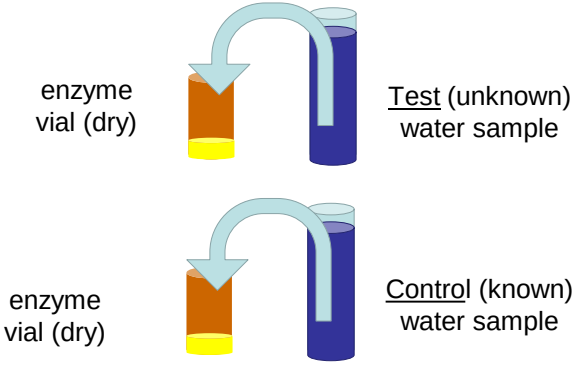

If enzyme is interfered with:

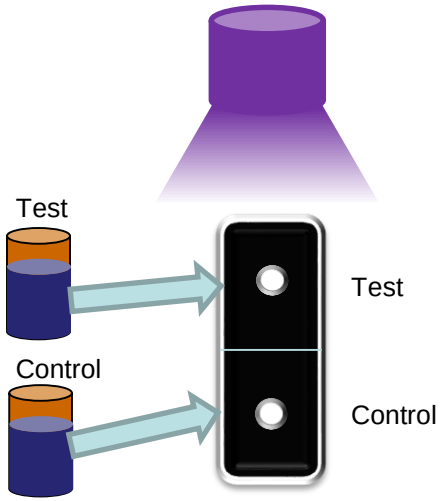


**Naked enzymes are freeze-dried with temperature stabilizing reagents and reconstituted with a water sample**

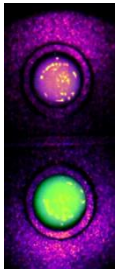
**The active form of the enzyme binds to the substrate which is impregnated on the ticket to form a green color (fluoresces under UV light)**

**Toxic materials that interfere with the enzyme-binding will result in the absence of a green hue. A purple-blue color in the test well will result instead**

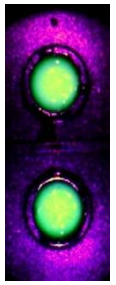



Contaminated (Positive)

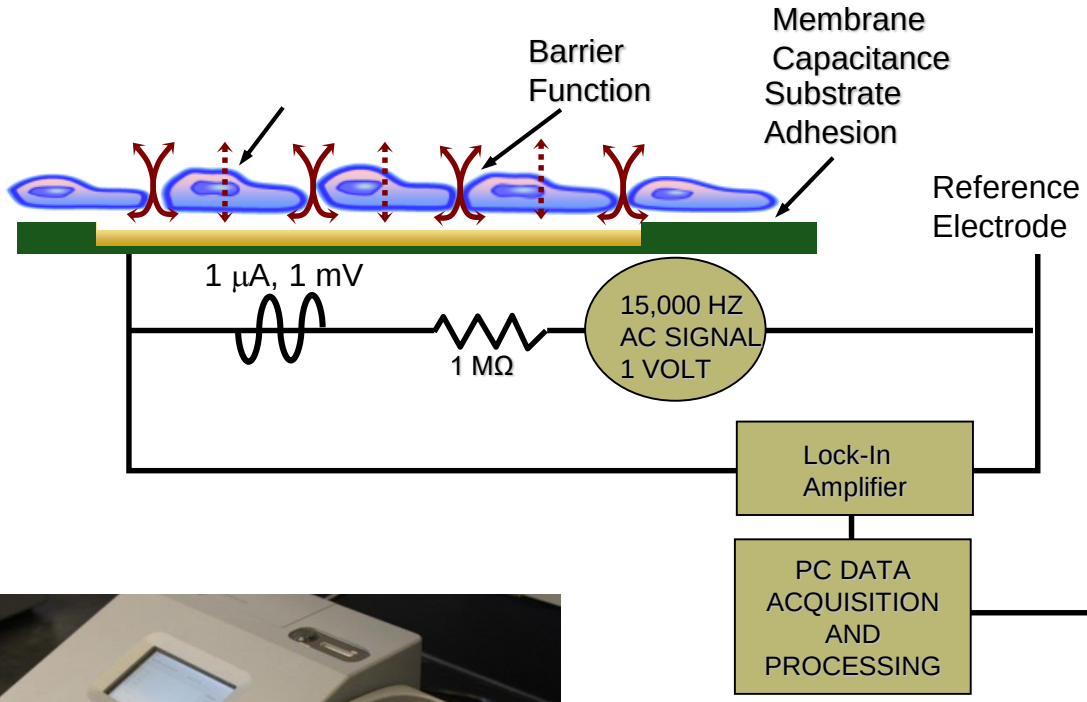


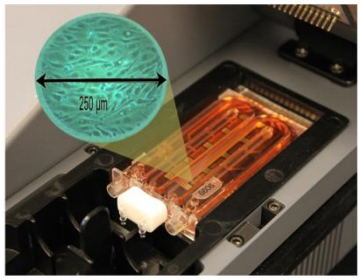
Not Contaminated (Negative)

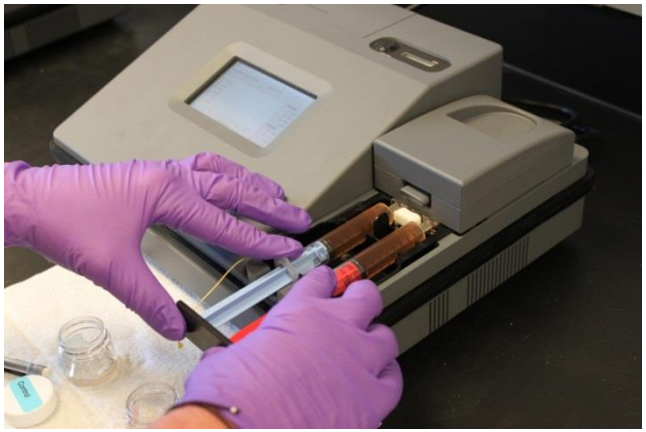


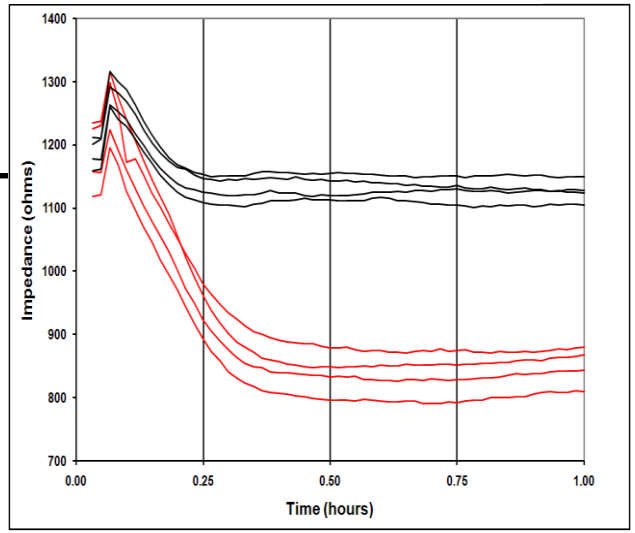
*David E. Trader (301-619-7626) david.e.trader2.civ@mail.mil*

# Principles of Electric Cell Substrate Impedance Sensing (ECIS)



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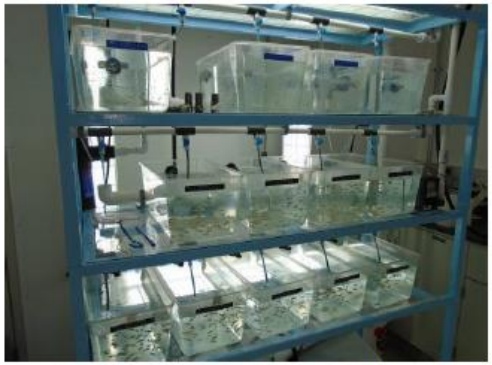
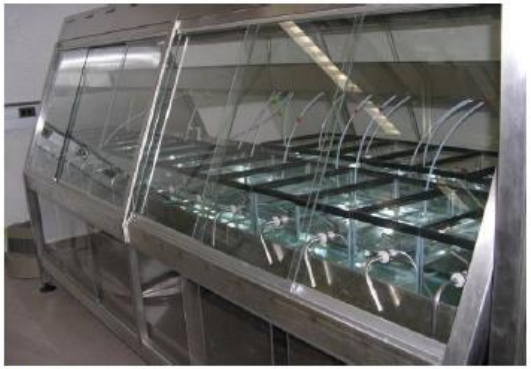
# Aquatic Toxicology Capabilities

- Zebrafish models
- Toxicology models, defined strains, in house breeding capabilities
- Hussainzada N, JA Lewis, CE Baer, DL Ippolito, DA Jackson and JD Stallings (2014). "Whole adult organism transcriptional profiling of acute metal exposures in male Zebrafish." BMC Pharmacol Toxicol 15(1): 15.



In-house breeding



Diluter (exposure chambers)

- Baer CE, DL Ippolito, N Hussainzada, JA Lewis, DA Jackson and JD Stallings (2014). "Genome-wide gene expression profiling of acute metal exposures in male Zebrafish." Genomics Data. Dec;2:363-365.

# Aquatic Toxicology Capabilities

- Xenopus models
- Bluegill models

- Custom high quality water system and diluter, and biomonitoring

- Porter KL, Olmstead AW, Kumsher DM, Dennis WE, Sprando RL, Holcombe GW, Korte JJ, Lindberg-Livingston A, Degitz SJ (2011). "Effects of 4-tert-octylphenol on Xenous tropicalis in a long term exposure." Aquat Toxicol 103(3-4): 159-69.

In-house breeding

Well Water System

- 1300 sq. ft. aquatic
- 2 husbandry rooms
- 1 diluter room
- 1 procedure room
- 150 20L zebrafish tanks
  - up to 6000, 40 per tank
- 3 150G blue gill
  - up to 1050, 350 per tank
- 1 150G frog tanks
  - up to 20 adults per tank

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# What we are looking for

- Novel rapid toxicity tests for Toxic Industrial Chemicals
  - Answers within 1 hour
- Novel Coliform Bacteria tests
  - Currently Approved Capability Production Document (Army Acquisition jargon)
  - EPA Alternative Test Procedure passage
  - $
- Commercial partners looking to further develop in-house technologies

# What we can provide

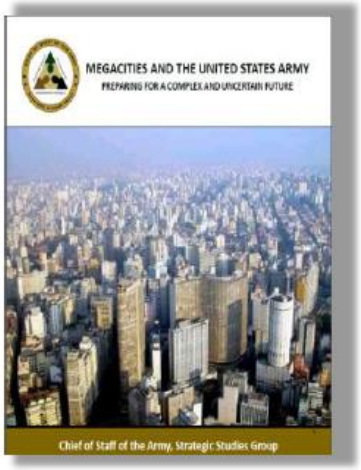
- Testing of source and drinking water samples for the presence or absence of:
  - Metals, pesticides, volatile organic chemicals (VOC's), degreasers, etc.

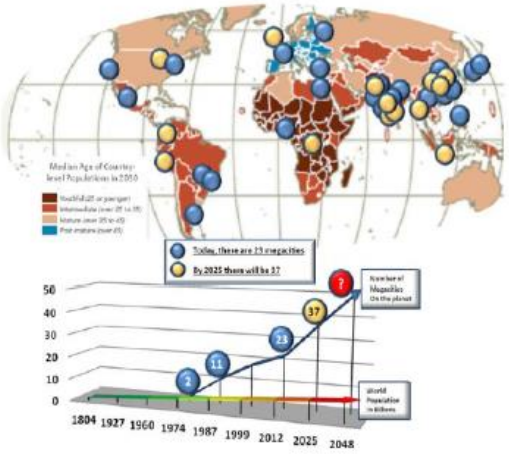
- Personnel and facilities for testing

- Coliform Bacteria $ available provided technology meets or has potential to meet key performance parameters
  - Coli-Lert gives presence/absence in 18 hrs
  - Gold Standard?

# Future Operating Environment

## Force 2025 and Beyond




*"Failing to prepare for military operations in dangerous megacities could leave a future president without the means to do something that he or she considers to be in the national interest."*

- Steven Metz, *Strategic Horizons: How the U.S. Military Might Get Involved in a Megacity*

"To ignore megacities is to ignore the future"

- What environmental health threats should we prepare for now?
- What new capabilities, concepts, and doctrine will be required to protect service members?

- World's population in urban areas will rise to 60% by 2030
- Megacities are locations with high levels of TICs, TIMs and ENMs

Tools are needed for:
- Medical surveillance
- Diagnosis of health effects
- Countermeasures

**These tools would enable Armed Forces to operate with confidence and thrive in uncertain and dangerous environments**

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