Data-Driven Discovery at the U.S.-Mexico Border

The National Academy of Sciences

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Funded by:

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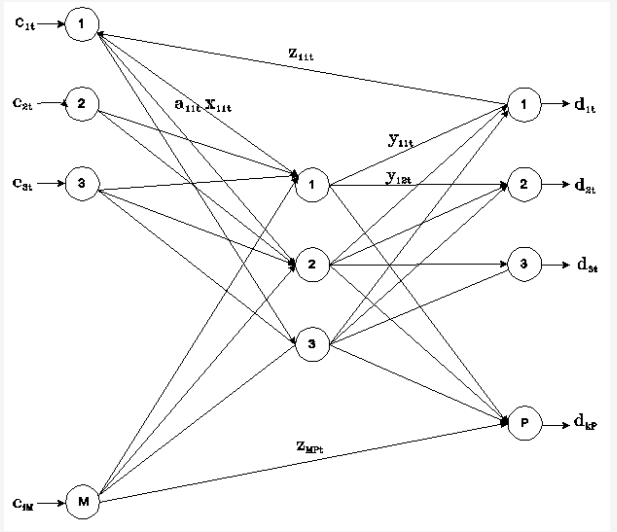
UTSA ROADRUNNERS

The Transformation of Production

Cross-Border Production System

- Several types of products are manufactured in the border area.
- The border area is considered a region where manufacturing and supply chain are the driving force for the economy.
- Important assets such as…

  - ✓ Skilled Workers
  - ✓ Transportation Infrastructure
  - ✓ Logistics Services
  - ✓ A strong presence in several manufacturing industries
  - ✓ Key educational institutions

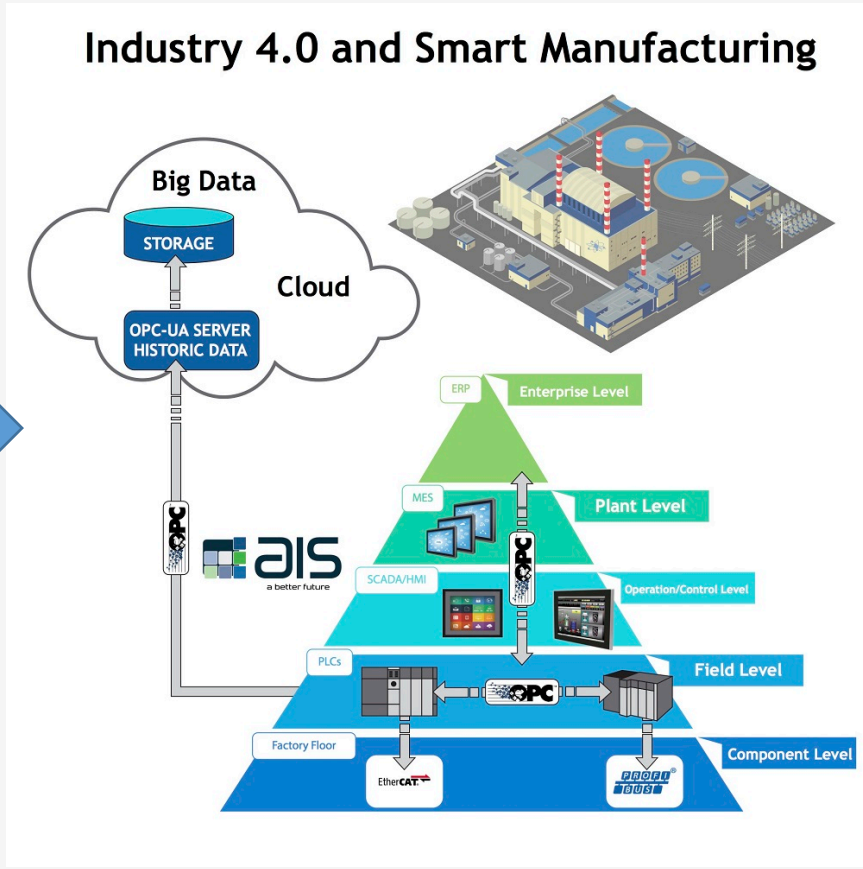


Challenges For Border Industries

Border industries…

- Are susceptible to political and social forces at both the local and national level and are subject to regulatory issues that are multi-national and not always well-coordinated.

Industrial operations transition to integrally connected smart systems

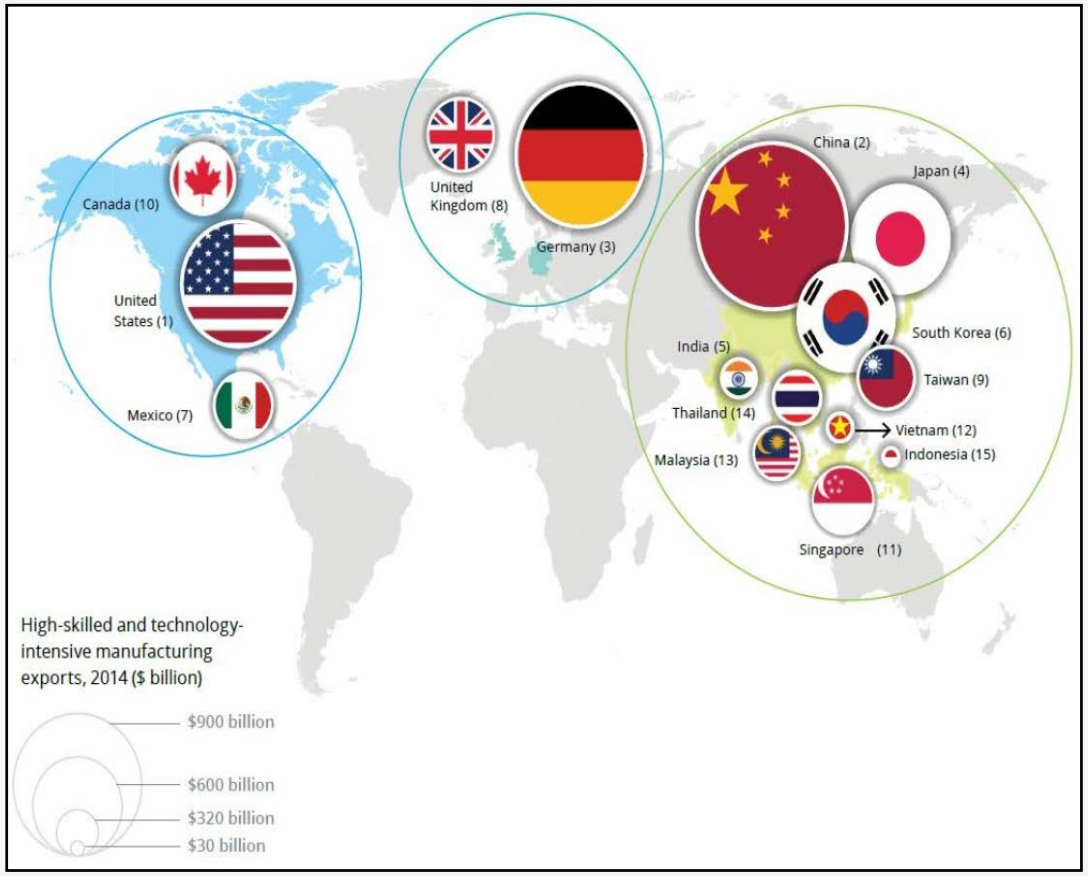


Industry 4.0: Global Competition

Industry 4.0

- Cyber-Physical Systems (CPS)
- Internet of Things (IoT)
- Internet of Services (IoS)
- Robotics and sensors
- Big Data
- Cloud manufacturing
- Augmented reality
- SCADA

Integration of machines, production modules and products that can exchange information independently, trigger actions and control each other, allowing an intelligent manufacturing environment.



1. The U.S.-Mexico Border

- **Mexico and the United States are neighbors who depend on each other economically and culturally.**
- **The border is nearly 2,000 miles (3,200km) long**
- **The border between the two is said to be the busiest border in the world.**
  - **Almost 1 million people cross it every day.**

Texas' Ports of Entry

Texas has 29 official ports of entry that serve as critical gateways to global trade.

Three of Texas' ports are among the 10 most utilized in the nation.

- **Each port, whether an airport, land port or seaport, serves many domestic and international economic activities across multiple industries**

Ports of entry within the state of Texas accounted for nearly $740 billion in international trade in 2018.

Out of the $740 billion Texas' total international trade, $408 billion (55.2 percent), traveled across the state's border crossings with Mexico.

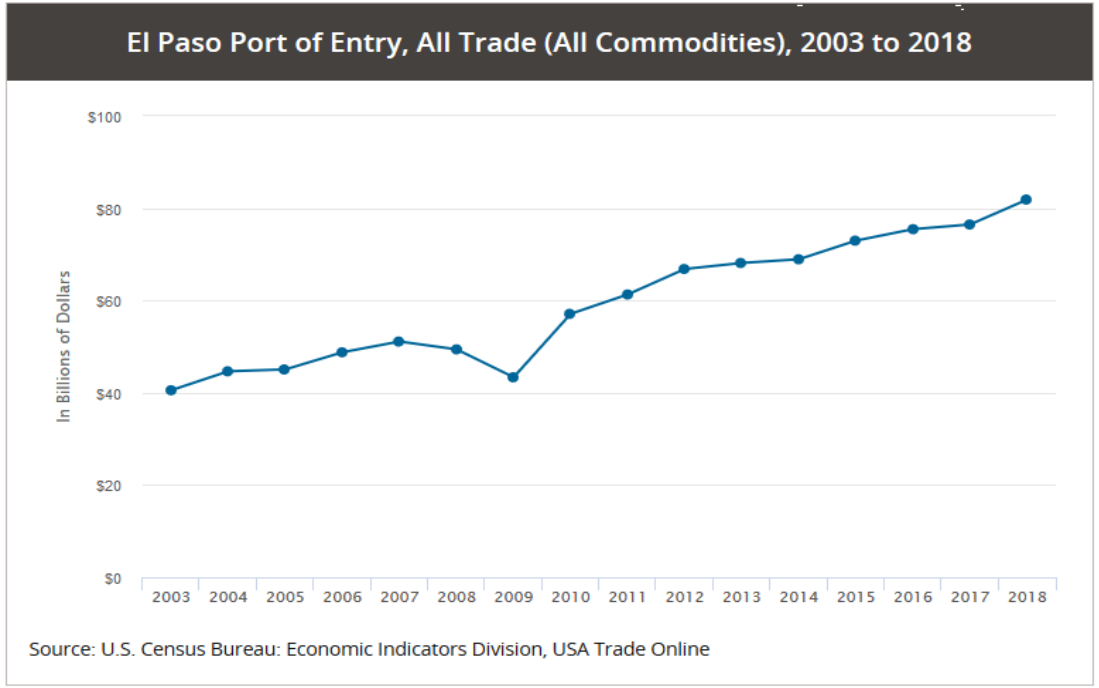
The El Paso port of entry accounted for 20.1 percent of land port trade, or about $81.9 billion.[1]

https://gov.texas.gov/uploads/files/business/portsofentry-map.pdf

Port of Entry: El Paso Impact to the Texas Economy

In 2018, the El Paso port of entry handled northbound border-crossing traffic of about:

- **811,000 trucks, more than 12 million cars (with 22 million passengers) and more than 7 million pedestrians.**
- **Shipping activity through this port accounted for $81.9 billion in trade in 2018.**

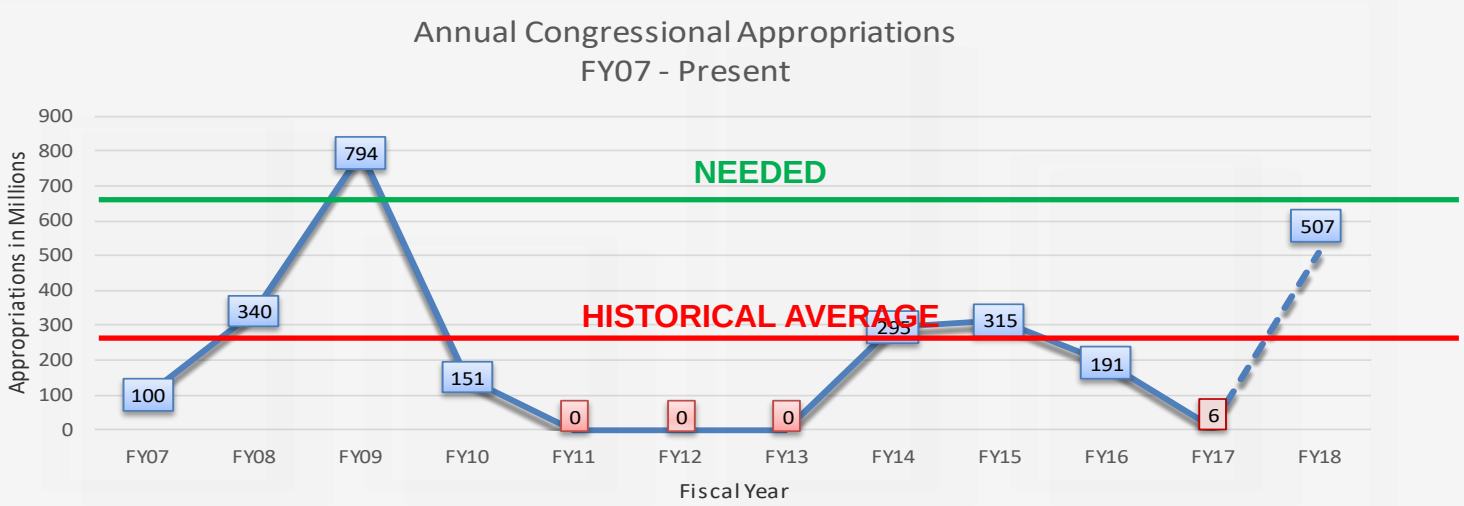


2. Major Challenges

Commonalities but also discrepancies on both sides

- Economy
- Infrastructure
- Data
- Policies and Goals

Cross-border Mobility Challenges



- Infrastructure
- Process Improvement

3. Different types of cross-border flows

- **People**
- **Produce**
- **Products**
- **Energy**
- **Health**
- **Etc…**

Moving through different modes of transportation

4. Stakeholder participation and commitment for cross-border mobility

- **Government**
- **Industry**
- **Agencies**
- **NGOs**
- **Academia**

- **Public Policy (Development and Adoption)**

5. Data-Driven Cross-Border Intelligent Mobility

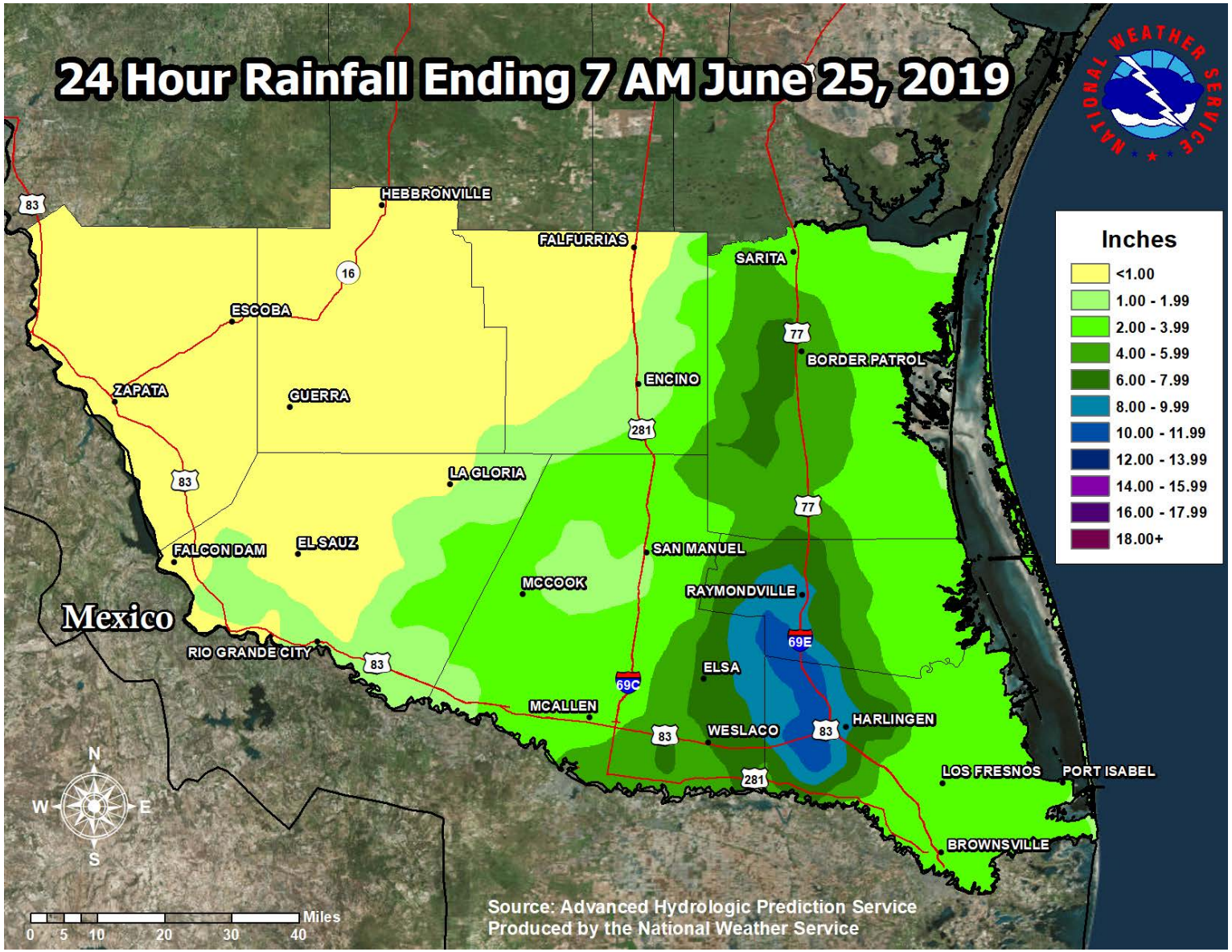
- Complex Systems
- Data as the enabling substrate
- System-of-Systems Approach (system dynamics)
- Modeling and Simulation – IoT, Digital Twin
- Sustainability (Economic, Environmental, Social)
- Data-driven decision making (data analytics, artificial intelligence, cybersecurity)
- Public-Private-Academia partnerships
- Commercialization pathways
- **Convergence and Team Research**

The border region between the U.S. and Mexico is a dynamic point of exchange and a point of intersection

Harmonizing multiple stakeholders

Finding common goals and shared solutions for the benefit of our border regions and society

Health and Well-Being


24 Hour Rainfall Ending 7 AM June 25, 2019
NATIONAL WEATHER SERVICE
Inches
<1.00
1.00 - 1.99
2.00 - 3.99
4.00 - 5.99
6.00 - 7.99
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10.00 - 11.99
12.00 - 13.99
14.00 - 15.99
16.00 - 17.99
18.00+
HEBBRONVILLE
FALFURRIAS
SARITA
ESCOBA
BORDER PATROL
ENCINO
ZAPATA
GUERRA
LA GLORIA
FALCON DAM
EL SAUZ
SAN MANUEL
MCCOOK
RAYMONDVILLE
Mexico
RIO GRANDE CITY
ELSA
MCALLEN
WESLACO
HARLINGEN
LOS FRESNOS
PORT ISABEL
BROWNSVILLE
83
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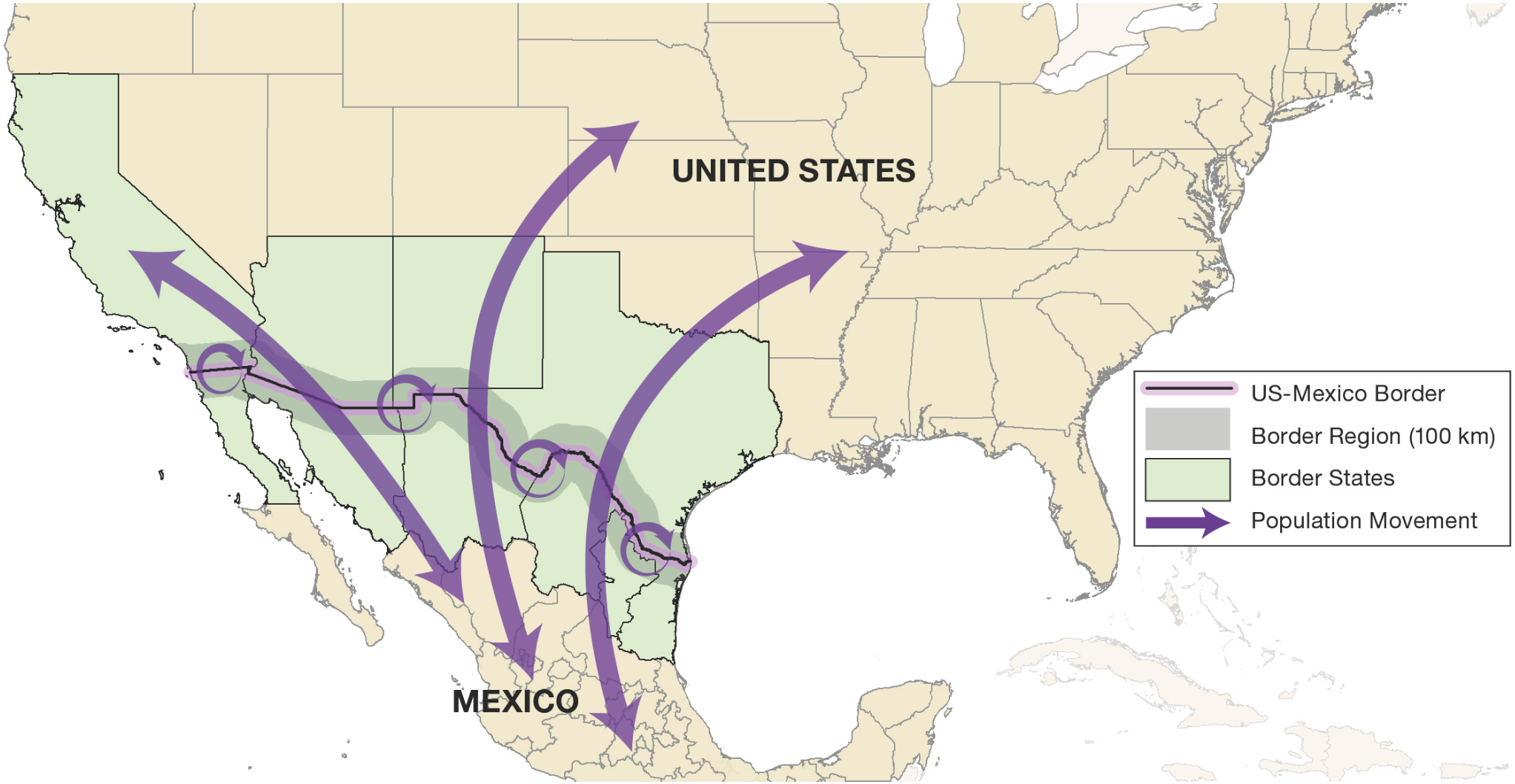
Source: Advanced Hydrologic Prediction Service
Produced by the National Weather Service


UNITED STATES
MEXICO
US-Mexico Border
Border Region (100 km)
Border States
Population Movement

US-MX Border communities: Transborder Mobility and Access

United States-Mexico Border

El Paso, Texas-Cd. Juarez, Chihuahua Border

Colonias

In California, 13 of most destructive 20 fires happened over the last two decades!

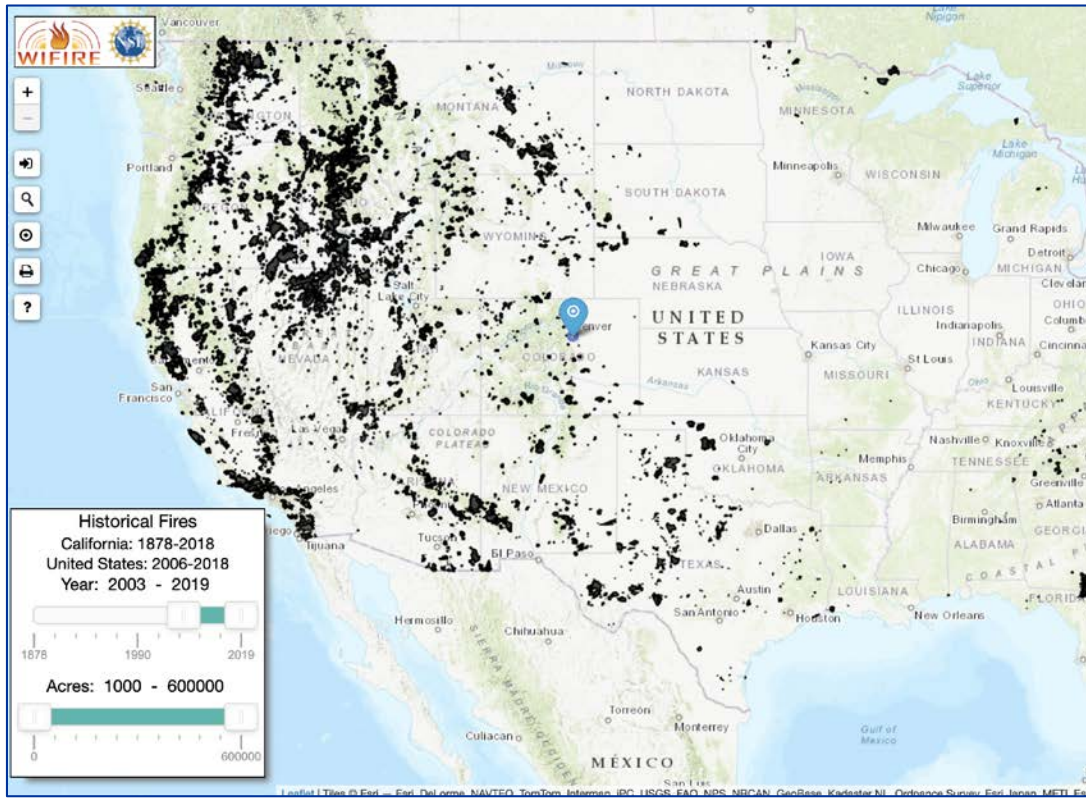


Image Source: https://firemap.sdsc.edu/

Top 20 Most Destructive California Wildfires

	FIRE NAME *(CAUSE)*	DATE	COUNTY	ACRES	*STRUCTURES*	DEATHS
1	**CAMP FIRE** *(Powerlines)*	November 2018	Butte County	153,336	**18,804**	85
2	**TUBBS** *(Electrical)*	October 2017	Napa & Sonoma	36,807	**5,636**	22
3	**TUNNEL - Oakland Hills** *(Rekindle)*	October 1991	Alameda	1,600	**2,900**	25
4	**CEDAR** *(Human Related)*	October 2003	San Diego	273,246	**2,820**	15
5	**VALLEY** *(Electrical)*	September 2015	Lake, Napa & Sonoma	76,067	**1,955**	4
6	**WITCH** *(Powerlines)*	October 2007	San Diego	197,990	**1,650**	2
7	**WOOLSEY** (Under Investigation)	November 2018	Ventura	96,949	**1,643**	3
8	**CARR** *(Human Related)*	July 2018	Shasta County, Trinity County	229,651	**1,614**	8
9	**NUNS** *(Powerline)*	October 2017	Sonoma	54,382	**1,355**	3
10	**THOMAS** *(Powerline)*	December 2017	Ventura & Santa Barbara	281,893	**1,063**	2
11	**OLD** *(Human Related)*	October 2003	San Bernardino	91,281	**1,003**	6
12	**JONES** *(Undetermined)*	October 1999	Shasta	26,200	**954**	1
13	**BUTTE** *(Powerlines)*	September 2015	Amador & Calaveras	70,868	**921**	2
14	**ATLAS** *(Powerline)*	October 2017	Napa & Solano	51,624	**783**	6
15	**PAINT** *(Arson)*	June 1990	Santa Barbara	4,900	**641**	1
16	**FOUNTAIN** *(Arson)*	August 1992	Shasta	63,960	**636**	0
17	**SAYRE** *(Misc.)*	November 2008	Los Angeles	11,262	**604**	0
18	**CITY OF BERKELEY** *(Powerlines)*	September 1923	Alameda	130	**584**	0
19	**HARRIS** *(Undetermined)*	October 2007	San Diego	90,440	**548**	8
20	**REDWOOD VALLEY** *(Powerline)*	October 2017	Mendocino	36,523	**546**	9

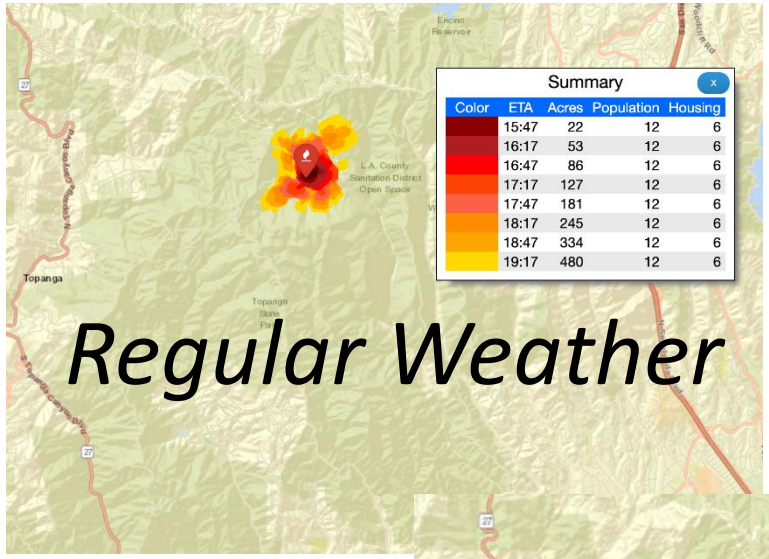
***"Structures" include homes, outbuildings (barns, garages, sheds, etc) and commercial properties destroyed.
***This list does not include fire jurisdiction. These are the Top 20 regardless of whether they were state, federal, or local responsibility.

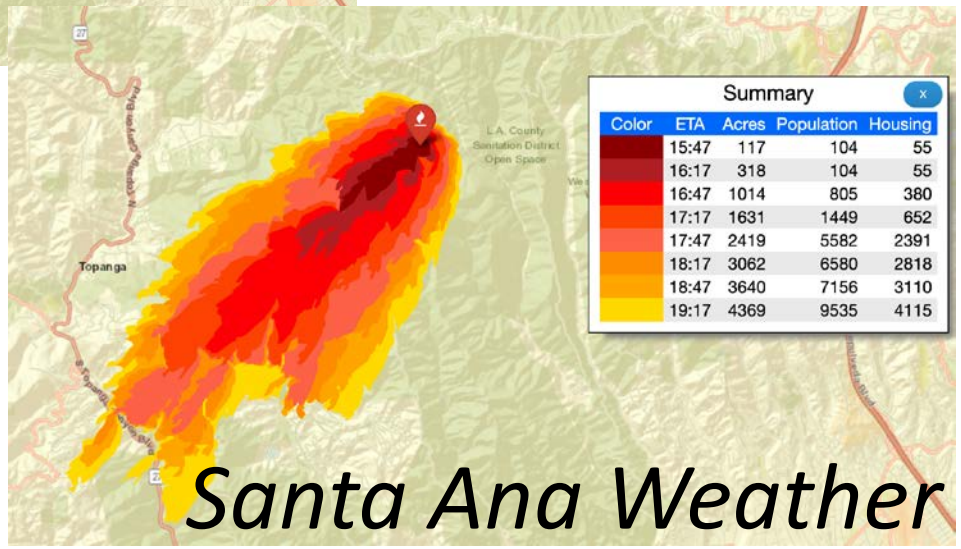
CAL FIRE

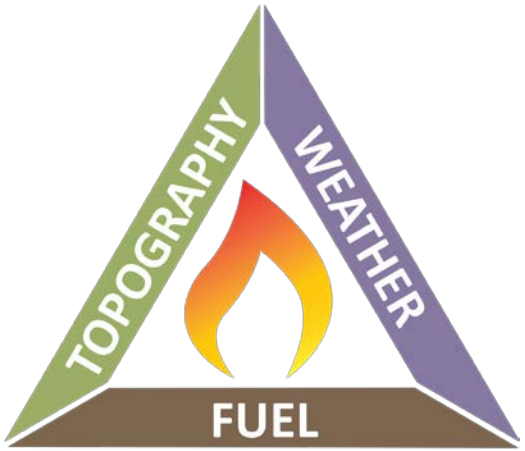
8/08/2019

Source: https://www.fire.ca.gov/media/5511/top20_destruction.pdf

Fire Behavior Depends on Changing Weather and Fuel





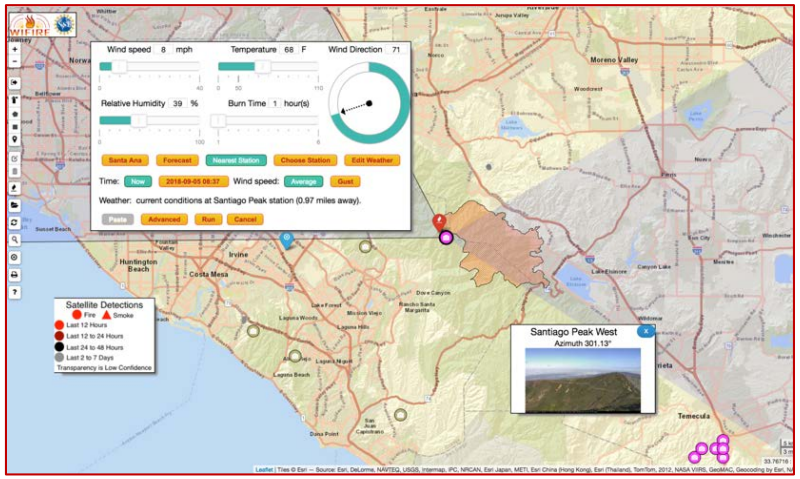


Fire Behavior Triangle

NEED

An **intelligent** and **integrated** infrastructure to catalog, curate, exchange, analyze and communicate data at scale.

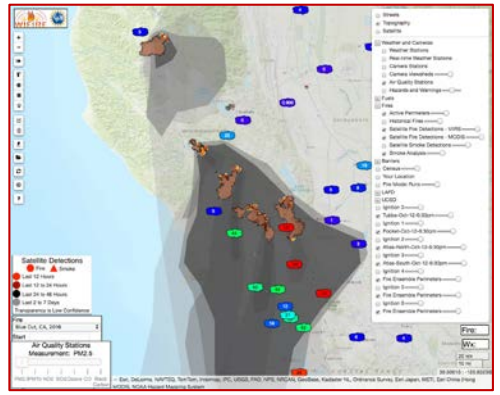
WIFIRE



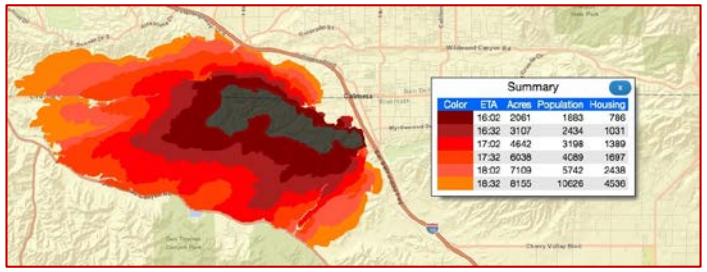
INNOVATION

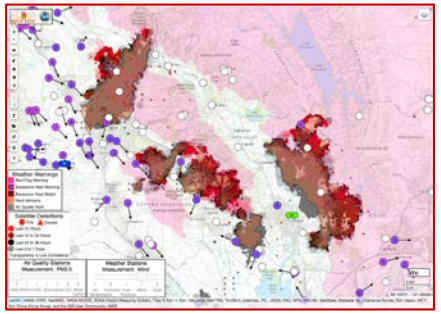
Combine Data Science and Fire Science
to Use “Big Data” for Dynamic Fire Modeling at Scale

NSF



wifire.ucsd.edu





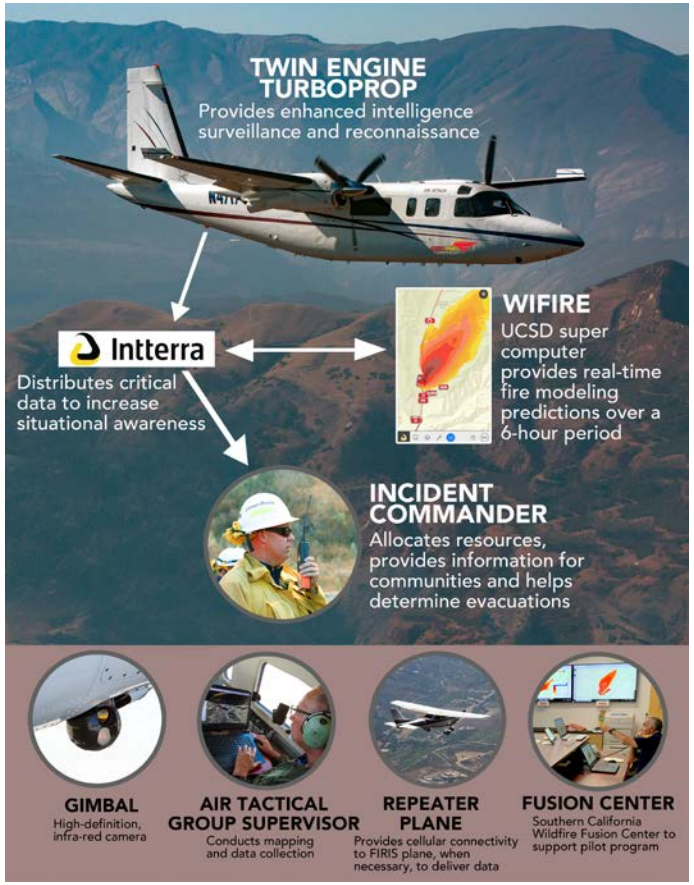
Year 2015: LAFD Collaboration

firemap.sdsc.edu

WIFIRE'S FIREMAP CONNECTS DATA AND SCIENCE TO OPERATIONAL USE, BEFORE, DURING AND AFTER A WILDFIRE.

FALL 2019 - FIRIS

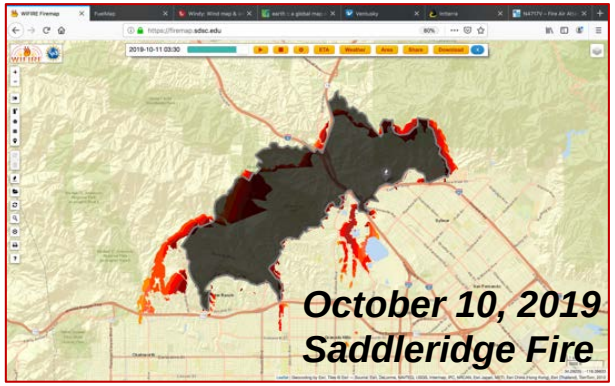
Fire Integrated Real-time Intelligence System

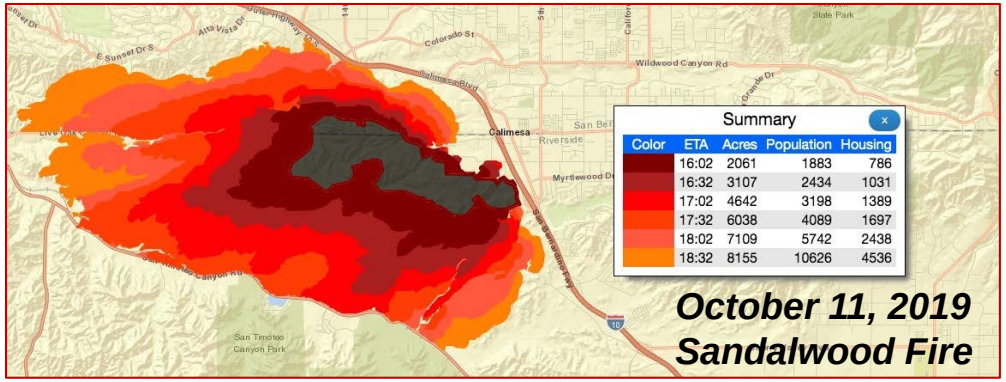


Intterra

WIFIRE

Response to 60+ fires in five months



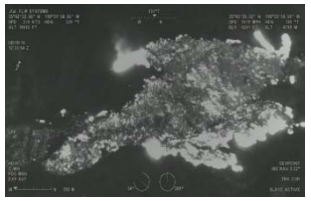


WIFIRE IN FIRIS PILOT PROGRAM

*Collect **real-time data** for modeling*

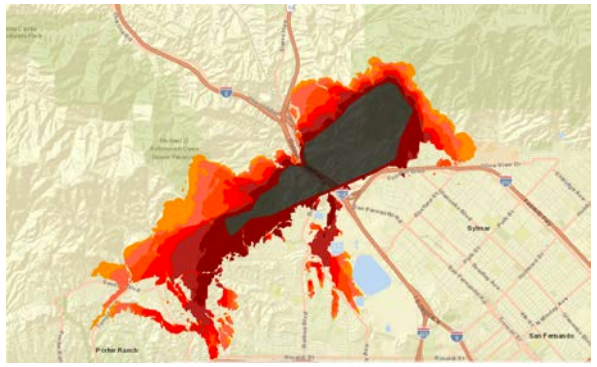
WIFIRE

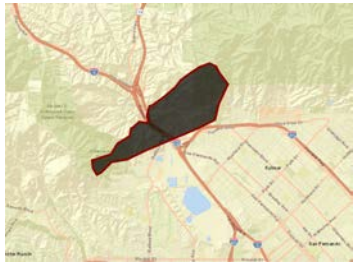
Faster and more accurate fire behavior modeling and situational awareness



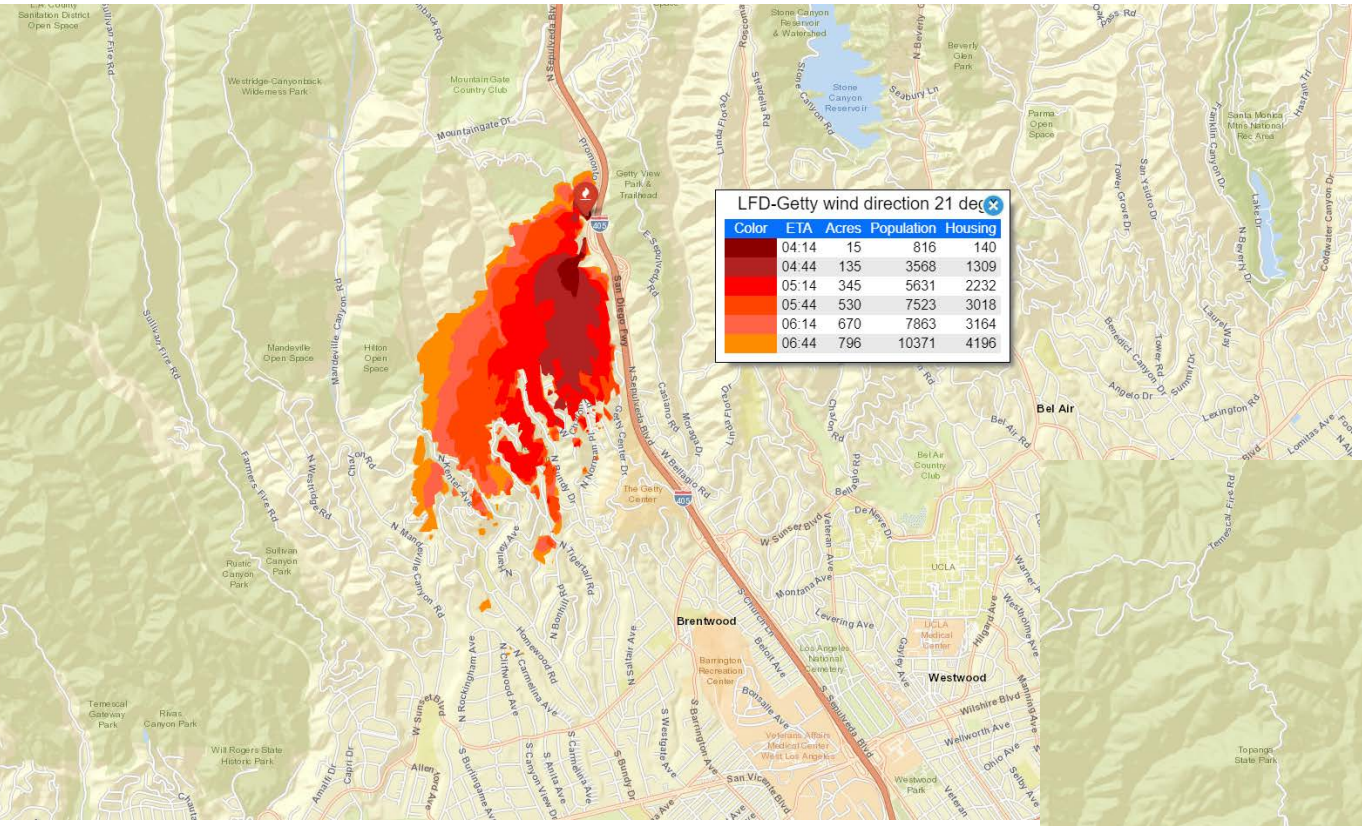
WIFIRE

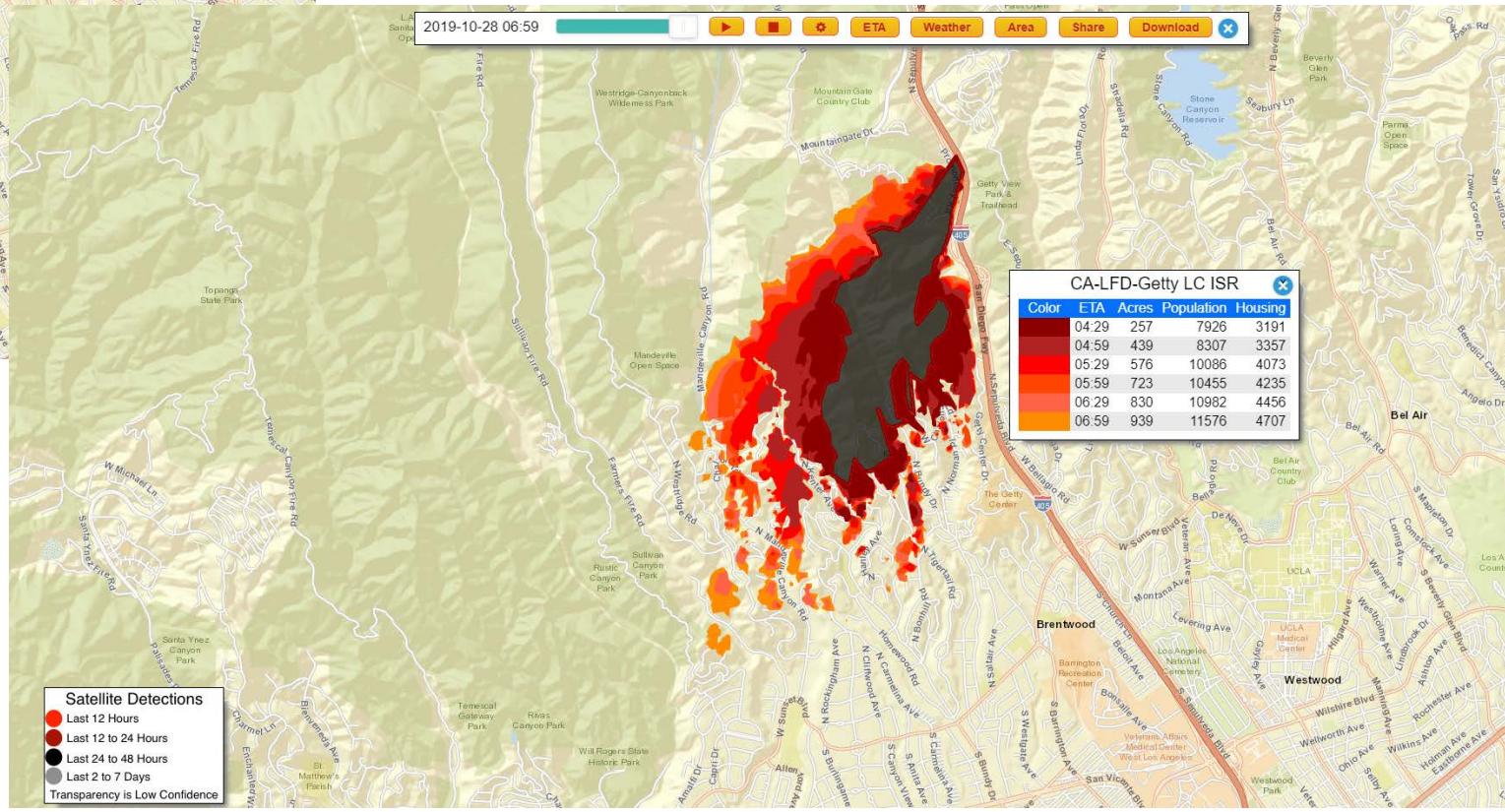
Continuous data processing and fire modeling





Getty Fire in Los Angeles





WIFIRE LAB – BUILDING THE FUTURE TOGETHER

WIFIRE

wifire.ucsd.edu

Mission: Research and development towards infrastructure, services and tools for AI-integrated fire science.

SDSC
SAN DIEGO SUPERCOMPUTER CENTER

QUALCOMM INSTITUTE

UC San Diego
Jacobs School of Engineering

Our Partners

Academic

University of Maryland · HPWREN · ALERTWildfire · SAGE Cyberinfrastructure for AI at the Edge, sagecontinuum.org

Public Agencies

Los Angeles Fire Department · Orange County Fire Authority California · County of Los Angeles Fire Department · San Diego Fire Rescue · Ventura County Fire Department Fire & Rescue · Public Utilities Commission State of California

Industry

GEOLINKS · CENIC · Southern California Edison · SDGE A Sempra Energy utility · planet. · General Atomics · Courtney Aviation · Intterra · SALO

Regional Sustainability

Urban-Rural Resilience

Flood in Ambos Nogales on July 12, 2008
KOLD News 13

Flood in Ambos Nogales on July 12, 2008
Tucson.com

Flood in Nogales, Sonora on August 23, 2018
Photo: Matt Brode

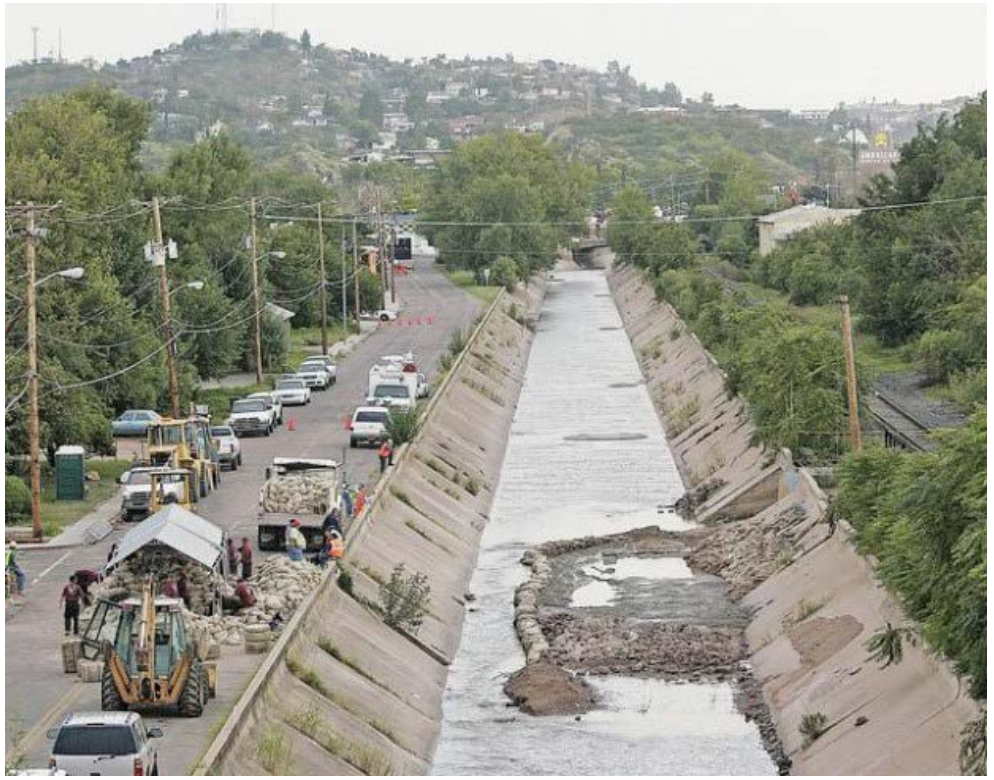
Urban-Rural Resilience

Damage to the sewage system in Nogales, Sonora after July 2008 flood

2009 reconstruction of the sewage system in Nogales, Sonora

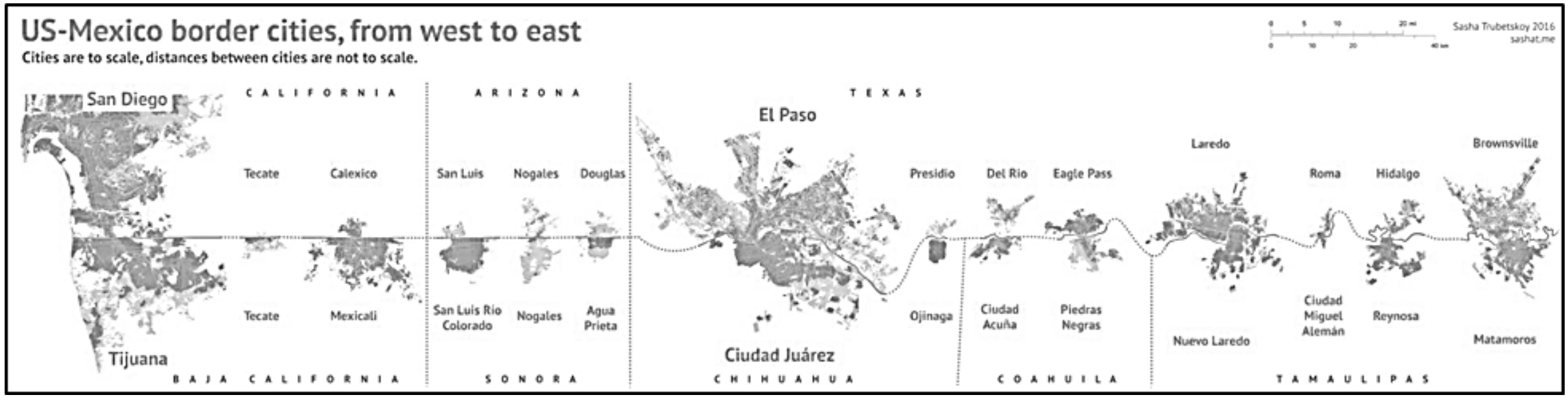
Urban-Rural Resilience

Flooding in Nogales, August 22, 2018
Arizona Daily Star

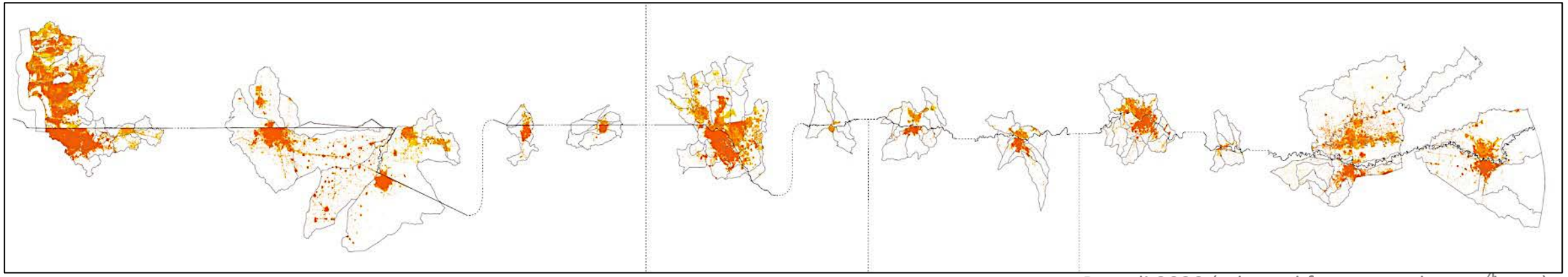


Raw sewage spills in Nogales, AZ in Aug. 28, 2007
Arizona Daily Star

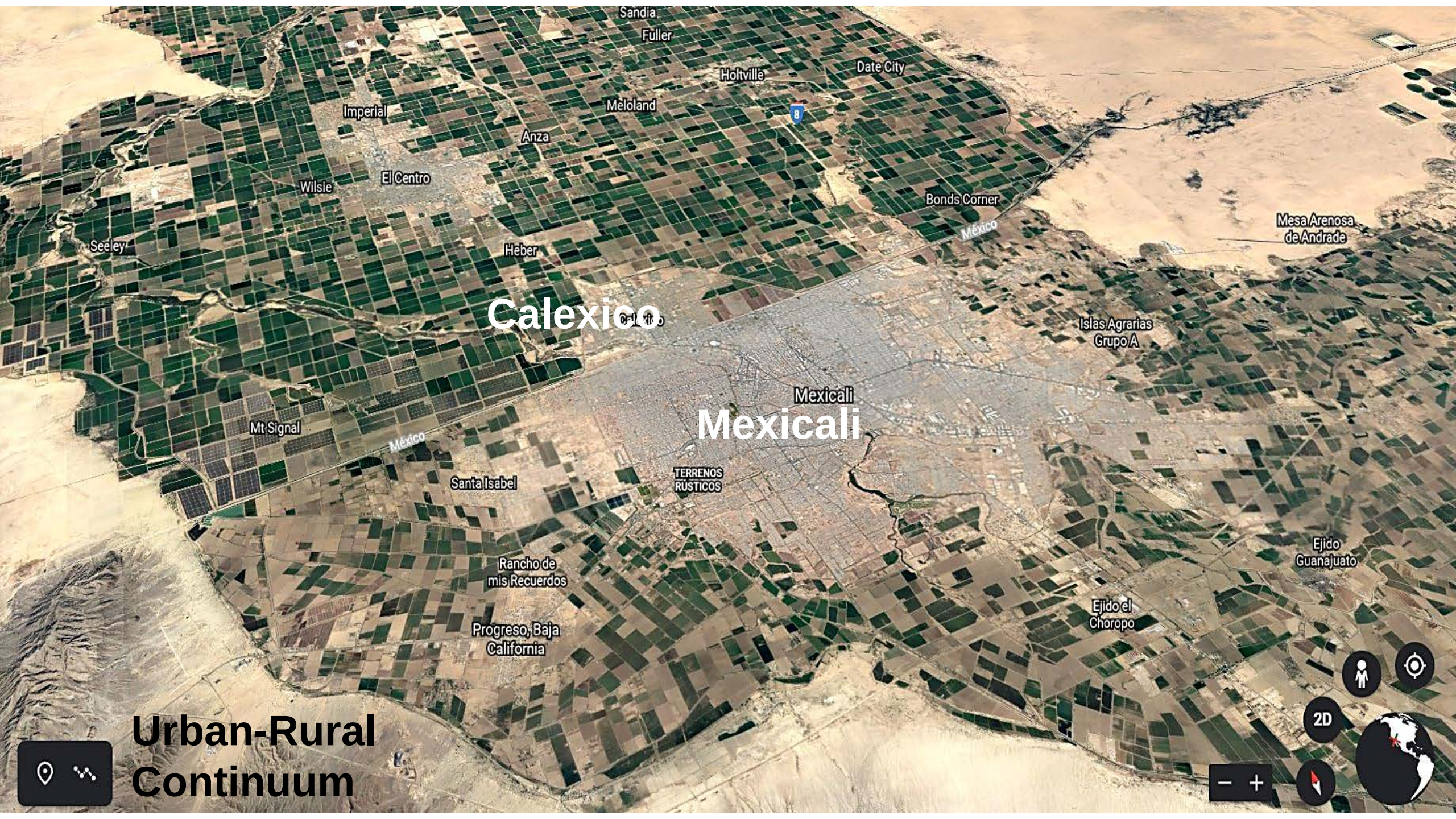
Sister Cities along the US-Mex Border



Mexico's urban pileups 2016. (https://sashat.me/2016/12/14/mexicos-urban-pileup_).



Pezzoli 2020 (adapted from map shown above)

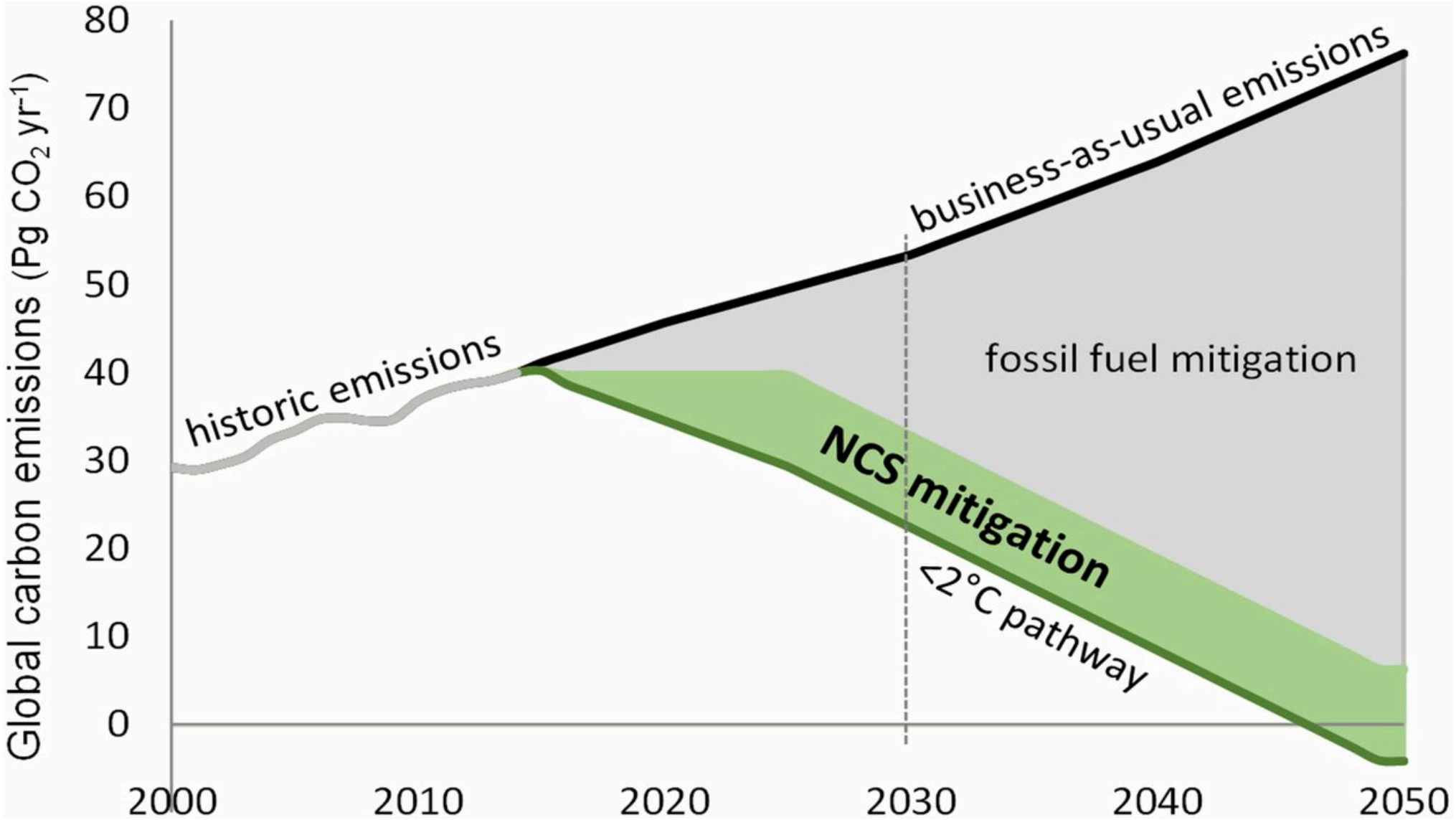

Sandia
Fuller
Holtville
Date City
Meloland
Imperial
Anza
Wilsie
El Centro
Seeley
Heber
Bonds Corner
México
Mesa Arenosa de Andrade
Calexico
Islas Agrarias Grupo A
Mexicali
Mexicali
Mt Signal
México
Santa Isabel
TERRENOS RÚSTICOS
Rancho de mis Recuerdos
Progreso, Baja California
Ejido Guanajuato
Ejido el Choropo
2D
Urban-Rural Continuum

Grey Infrastructure

Green Infrastructure

A map of a city (left) shows a neighborhood's gray infrastructure including buildings and roads. High-resolution satellite imagery (right) adds a green infrastructure data layer (trees and other vegetation). Green Infrastructure Center 2018

Vacant lots Chollas Creek

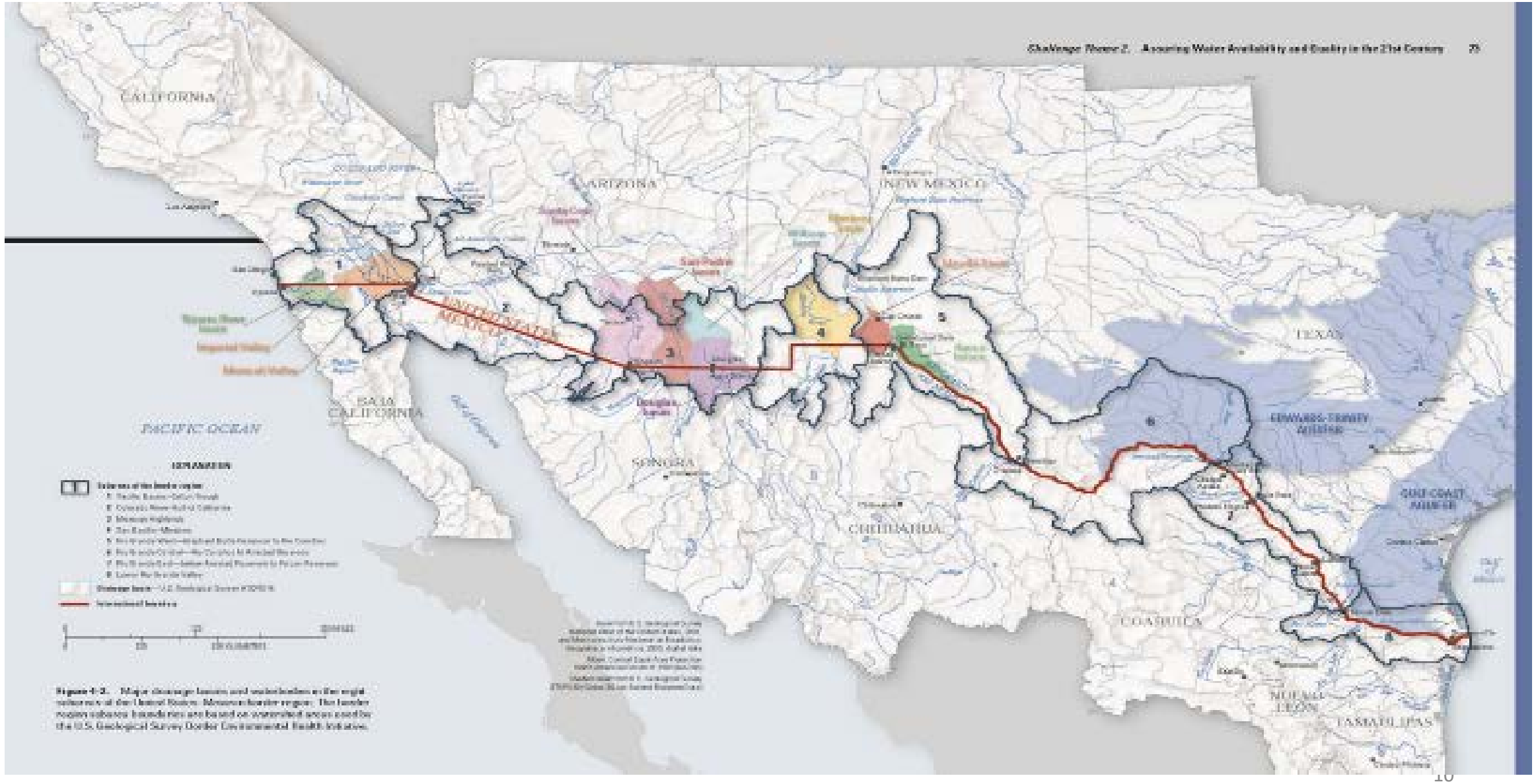


©2017 by National Academy of Sciences

Figure 20.3.1 Contribution of natural climate solutions (NCS) to stabilizing warming to below 2 °C. Reproduced from Bronson W. Griscom et al. PNAS 2017;114:44:11645-11650

Transboundary Watershed and Aquifer Resources

Aquifer Resources in the US-Mex Border



Groundwater depletion on the border

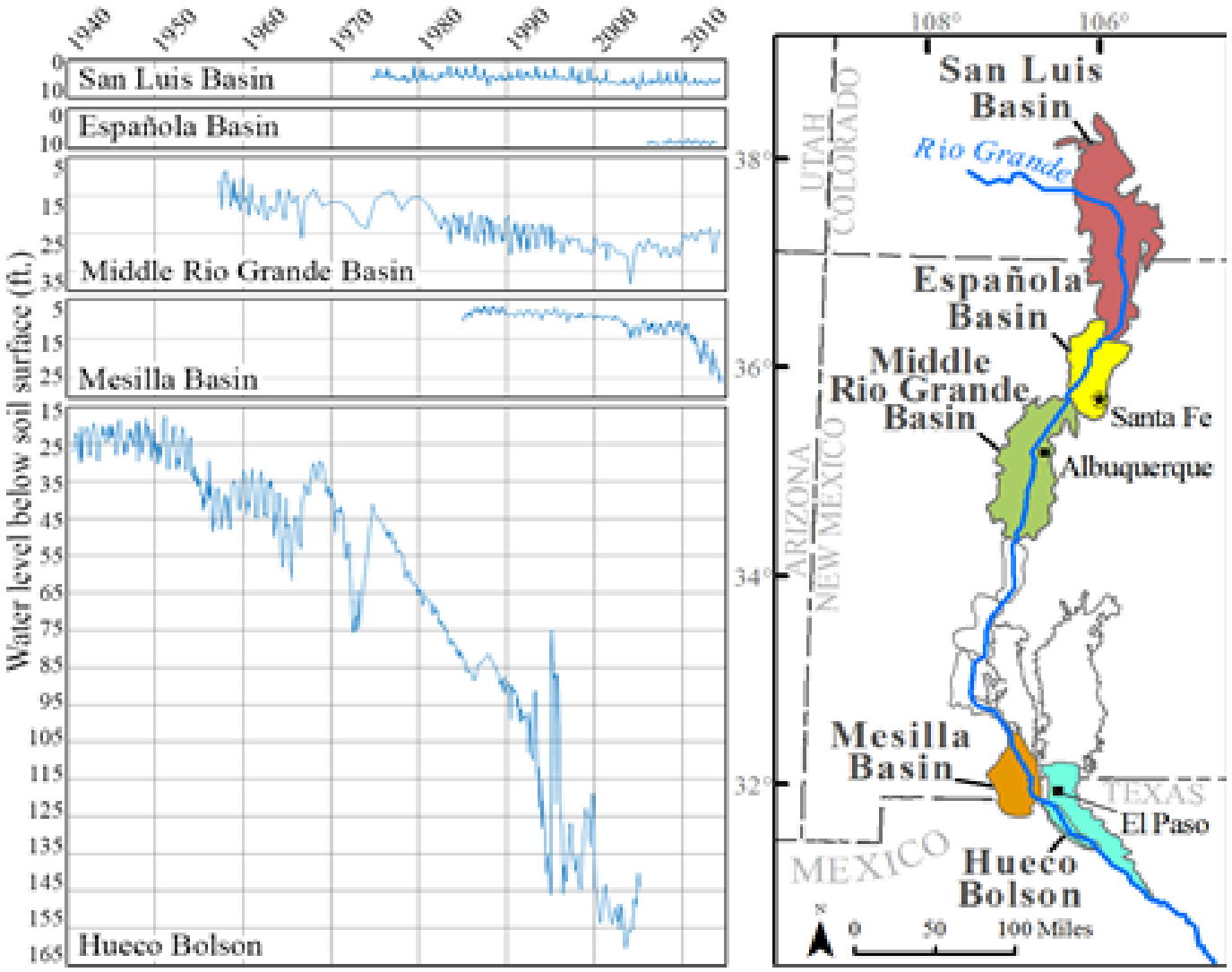


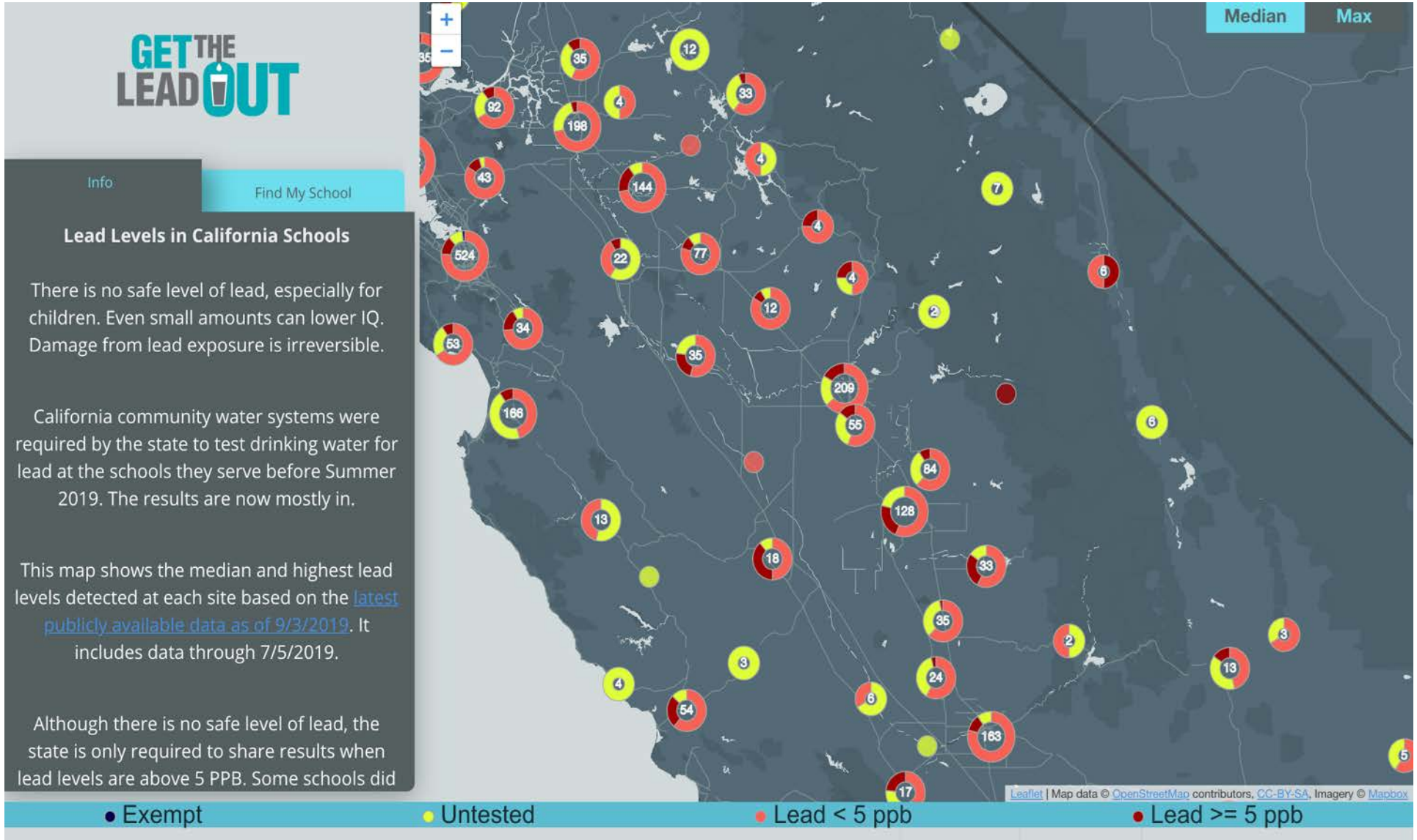
Figure 1. Groundwater levels in selected groundwater basins along the Rio Grande, showing precipitous declines downstream where pumping exceeds recharge from surface water (USGS 2016; Ochoa et al. 2013).

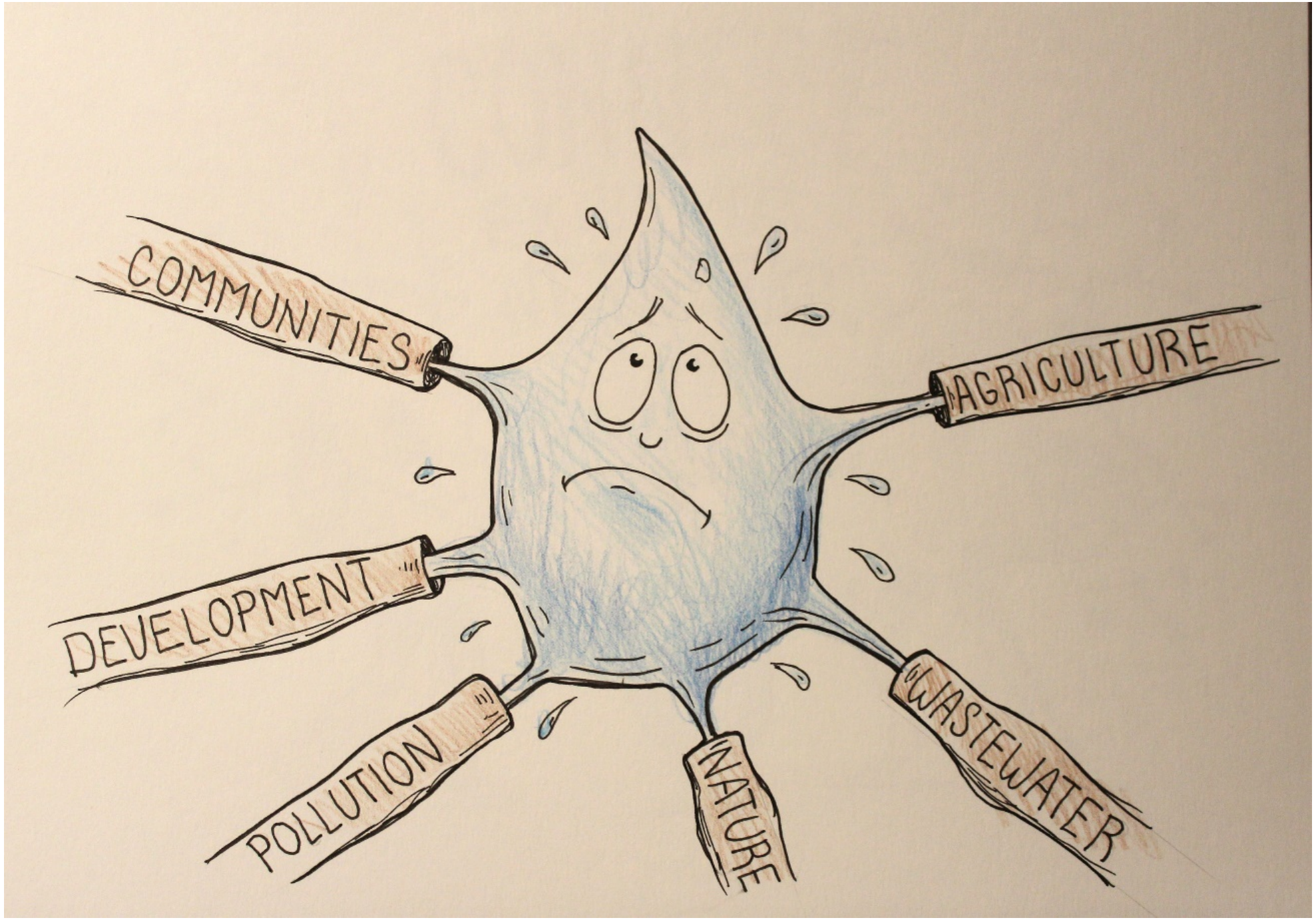
The California Water Data Challenge

#CAWaterDataChallenge | waterchallenge.data.ca.gov

CALPIRG

GET THE LEAD OUT




COMMUNITIES
AGRICULTURE
DEVELOPMENT
POLLUTION
NATURE
WASTEWATER

8 Principles for Managing a Commons (Ostrom)

1. Define clear group boundaries.
2. Match rules governing use of common goods to local needs and conditions.
3. Ensure that those affected by the rules can participate in modifying the rules.
4. Make sure the rule-making rights of community members are respected by outside authorities.
5. Develop a system, carried out by community members, for monitoring members' behavior.
6. Use graduated sanctions for rule violators.
7. Provide accessible, low-cost means for dispute resolution.
8. Build responsibility for governing the common resource in nested tiers from the lowest level up to the entire interconnected system.

Sources: Stakeholder Alignment Collaborative, Consortia: A Complement and Alternative to Market-Based Economic Systems, Economist

Maderas del Carmen
Photo: KIALOA PADDLES

The Future of Work at the U.S.-Mexico Border

NORTHEAST BIG DATA INNOVATION HUB

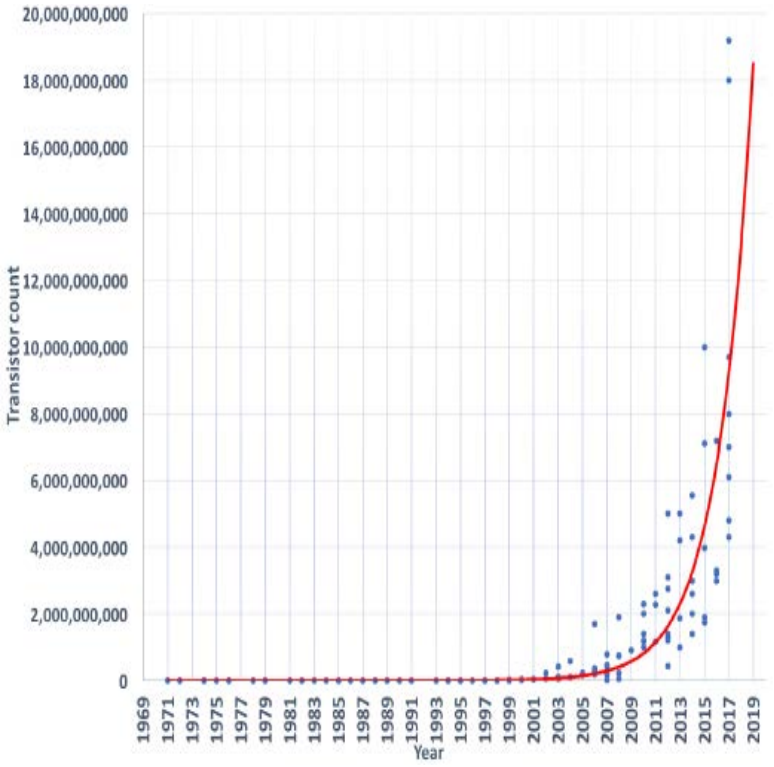
Data Literacy and the Future of Work

Catherine Cramer, Northeast Big Data Innovation Hub

Data-Driven Discovery at the U.S.-Mexico Border
National Academy of Sciences
Washington, DC
February 6, 2020

NEBigDataHub.org | @NEBigDataHub
#BDHubs #NEBigData

How Data Saved Science

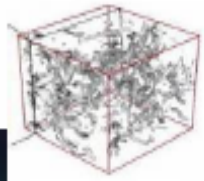


Moore's Law:
Computing capacity is expected to double every 2 years

Emergence of a Fourth Research Paradigm

1. Thousand years ago – **Experimental Science**
   - Description of natural phenomena
2. Last few hundred years – **Theoretical Science**
   - Newton's Laws, Maxwell's Equations...
3. Last few decades – **Computational Science**
   - Simulation of complex phenomena
4. Today – **Data-Intensive Science**
   - Scientists overwhelmed with data sets from many different sources
     - Data captured by instruments
     - Data generated by simulations
     - Data generated by sensor networks

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{4\pi G\rho}{3} - K\frac{c^2}{a^2}$$



- eScience is the set of tools and technologies to support data federation and collaboration
  - For analysis and data mining
  - For data visualization and exploration
  - For scholarly communication and dissemination

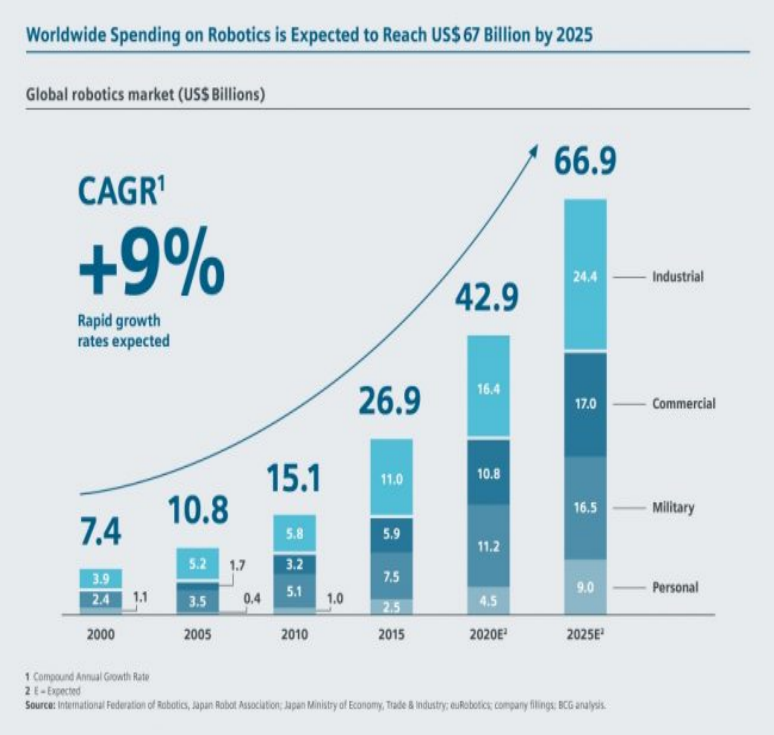
(With thanks to Jim Gray)

(Graph, EDC, 2019; Descriptive slide,: Microsoft, 2009)

Smart Cities and the New Infrastructure

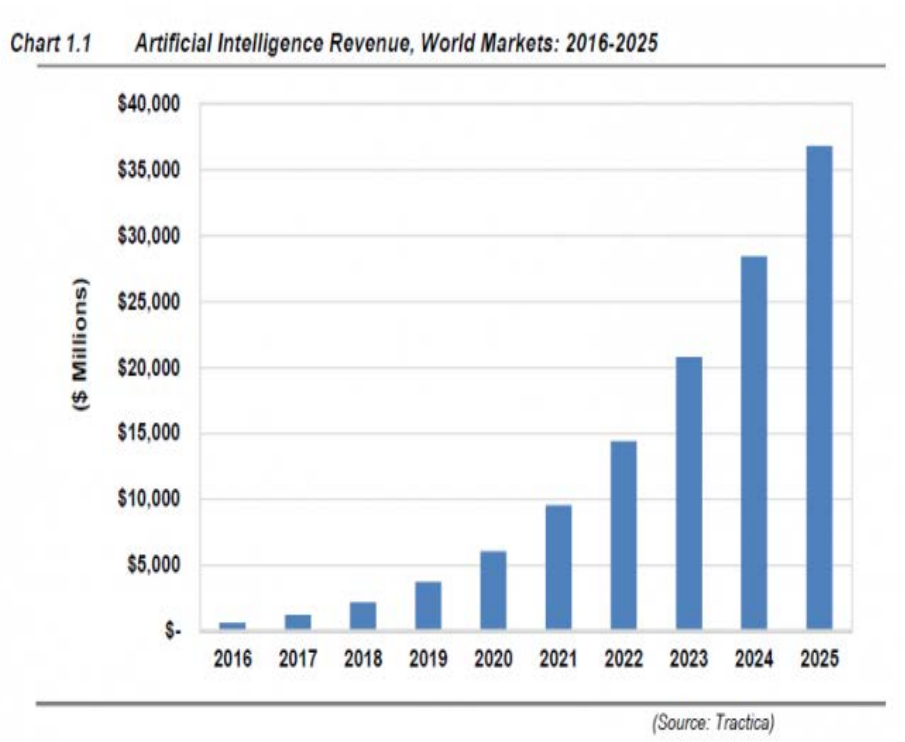
- Sensors
- Automation
- Control systems
- Surveillance
- Data analytics
- A.I.

Robotics, Machine Learning and AI



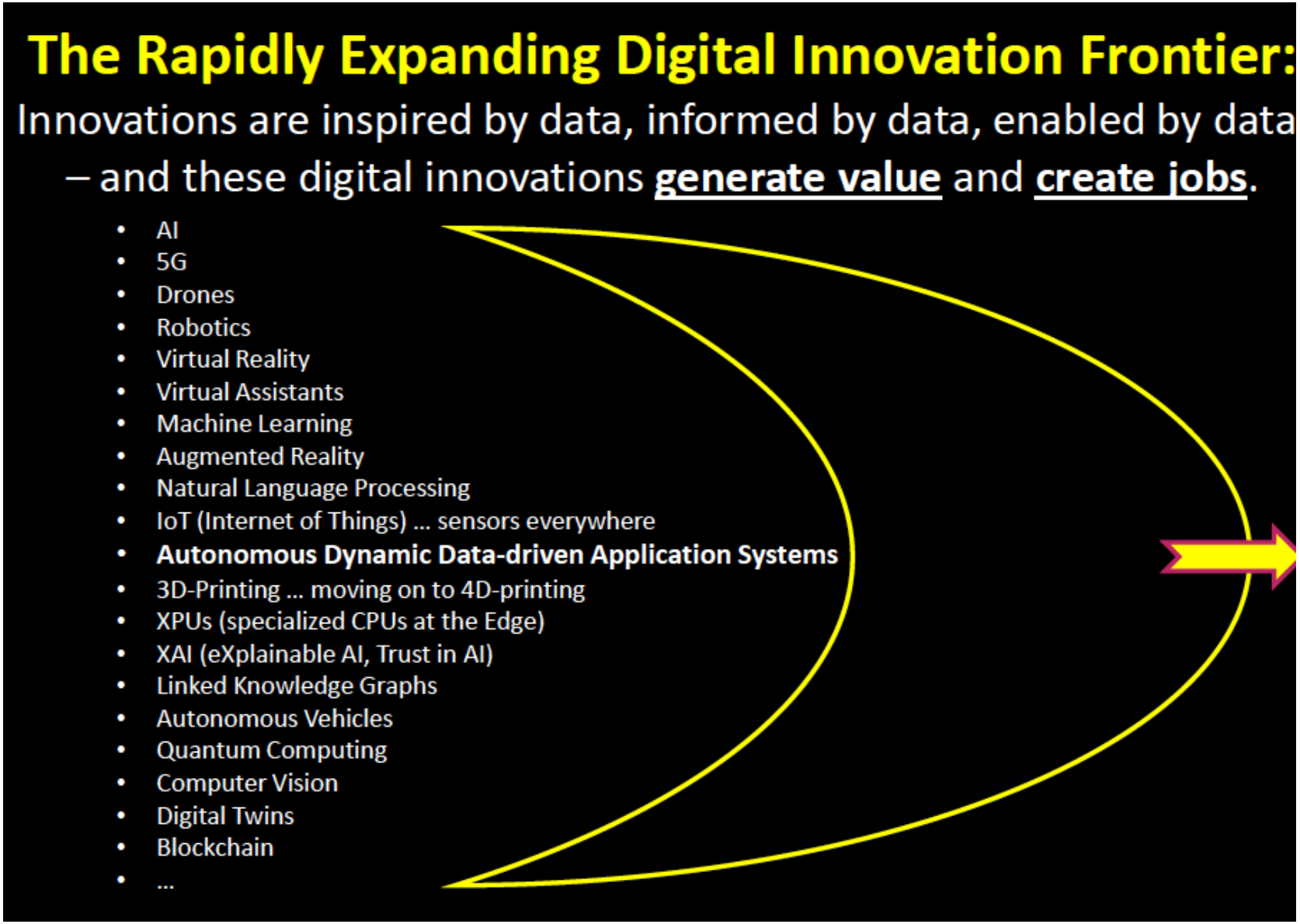
Spending on Robotics

Spending on AI



The Rapidly Expanding Digital Innovation Frontier:

Innovations are inspired by data, informed by data, enabled by data – and these digital innovations **generate value** and **create jobs**.



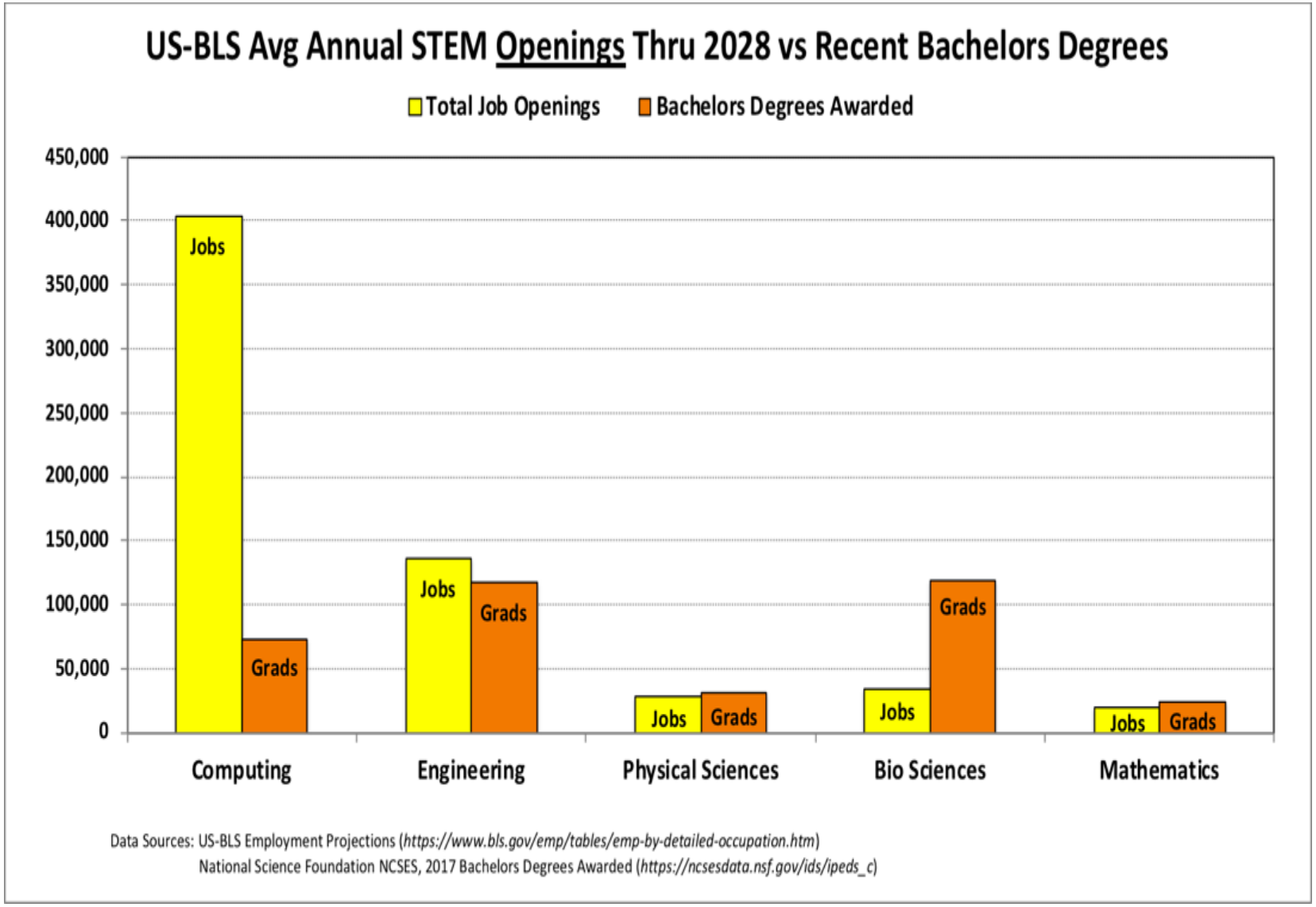
Thanks Kirk Borne, BAH

What motivated NSF Computing education workforce development efforts?

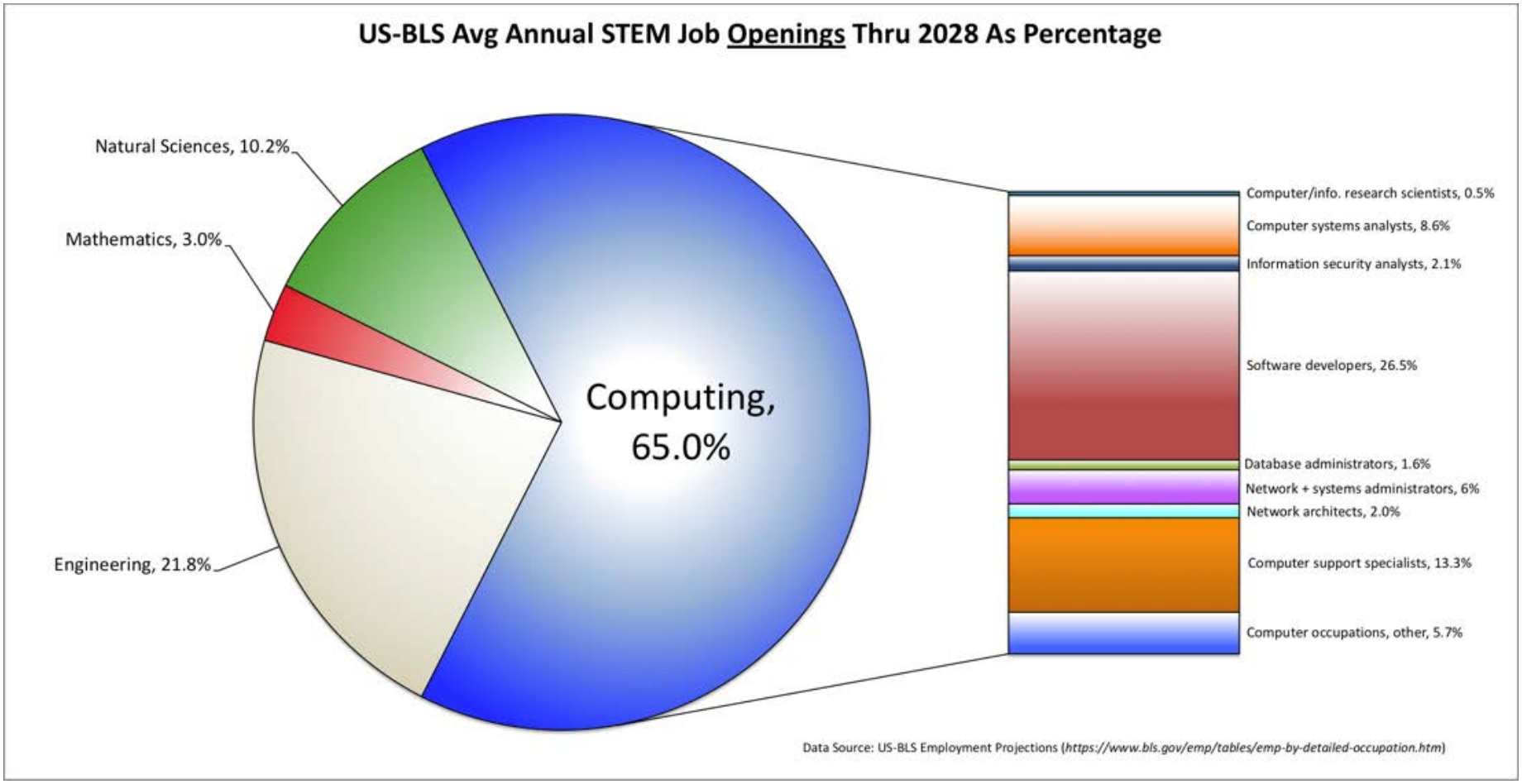
- → Underproduction of degrees
- → Underrepresentation
- → Lack of a presence in K-12

Thanks Jeff Forbes, NSF

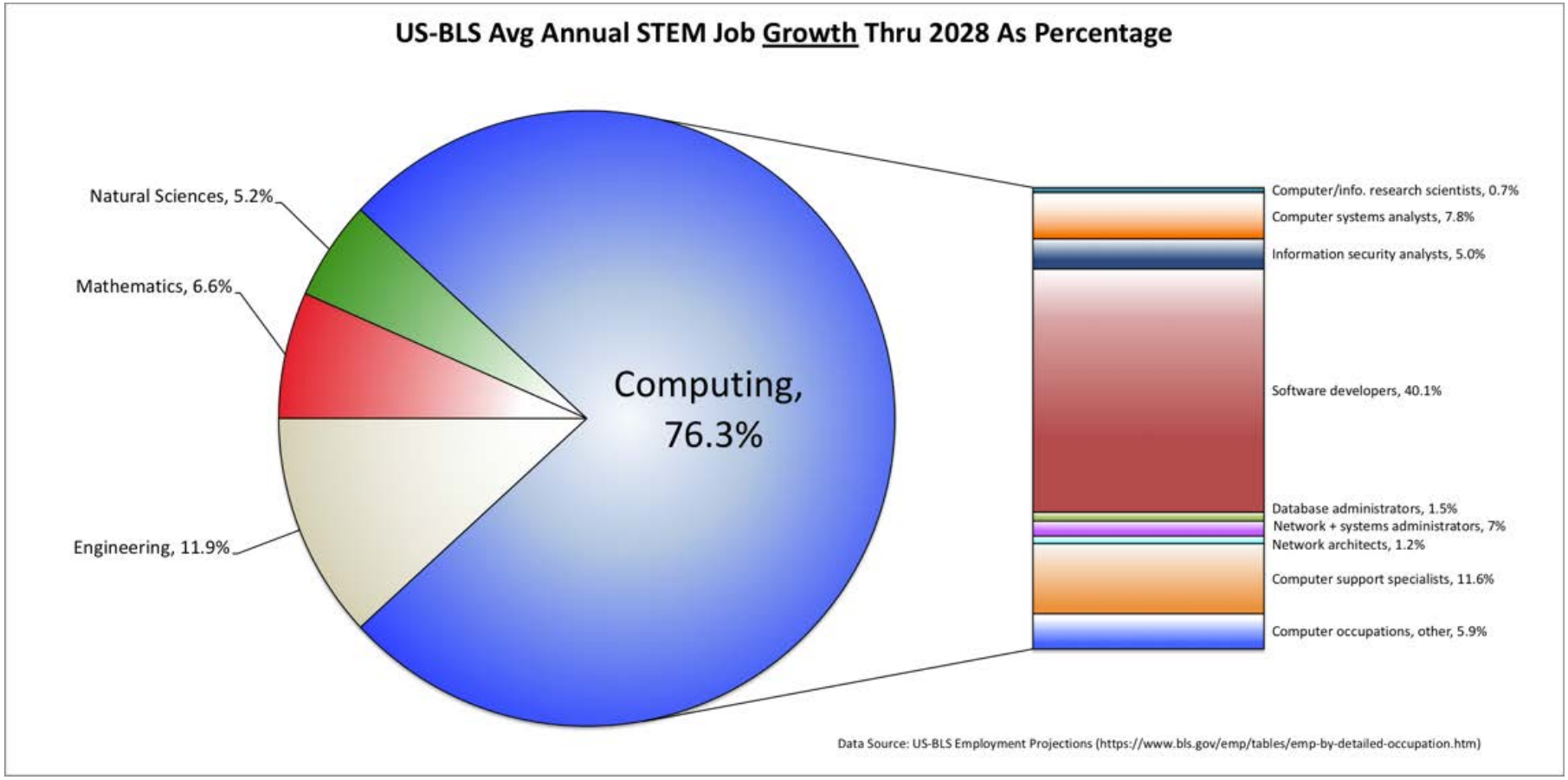
Where the jobs are…



Where the jobs are II



Where the jobs are III



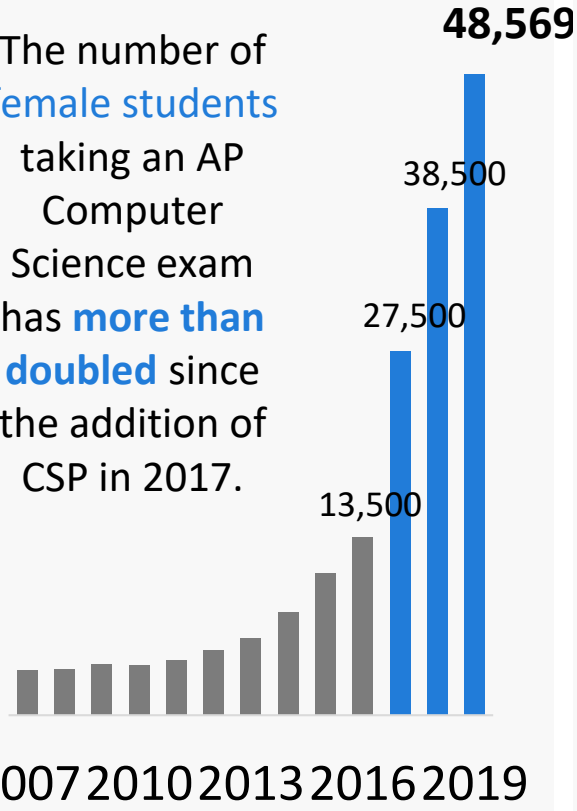
CSforALL

A National movement to provide ALL K-12 students with the opportunity to learn CS both in and out of school

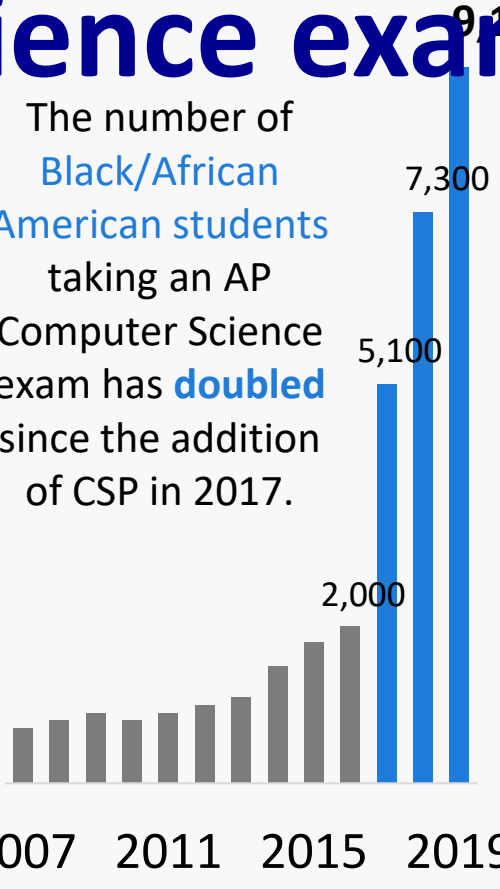
Federal leadership engagement with CS education

Students taking AP® computer science exams

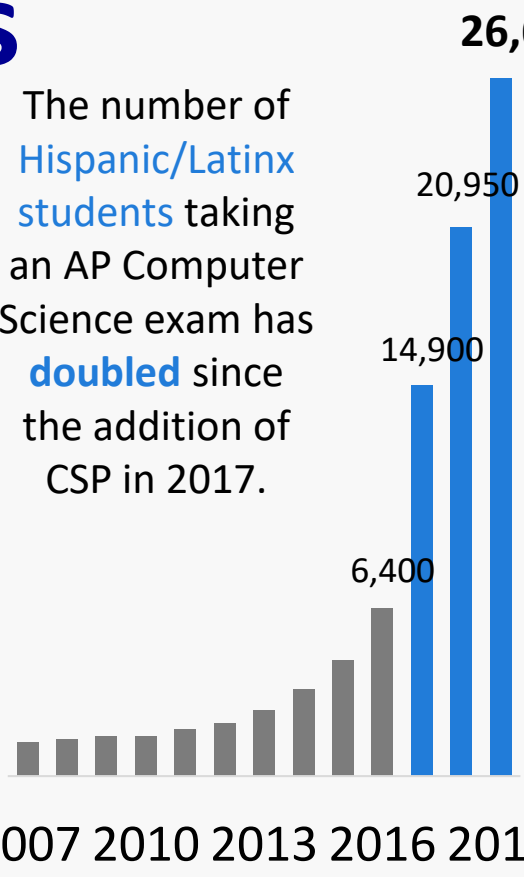
The number of female students taking an AP Computer Science exam has **more than doubled** since the addition of CSP in 2017.



The number of Black/African American students taking an AP Computer Science exam has **doubled** since the addition of CSP in 2017.



The number of Hispanic/Latinx students taking an AP Computer Science exam has **doubled** since the addition of CSP in 2017.



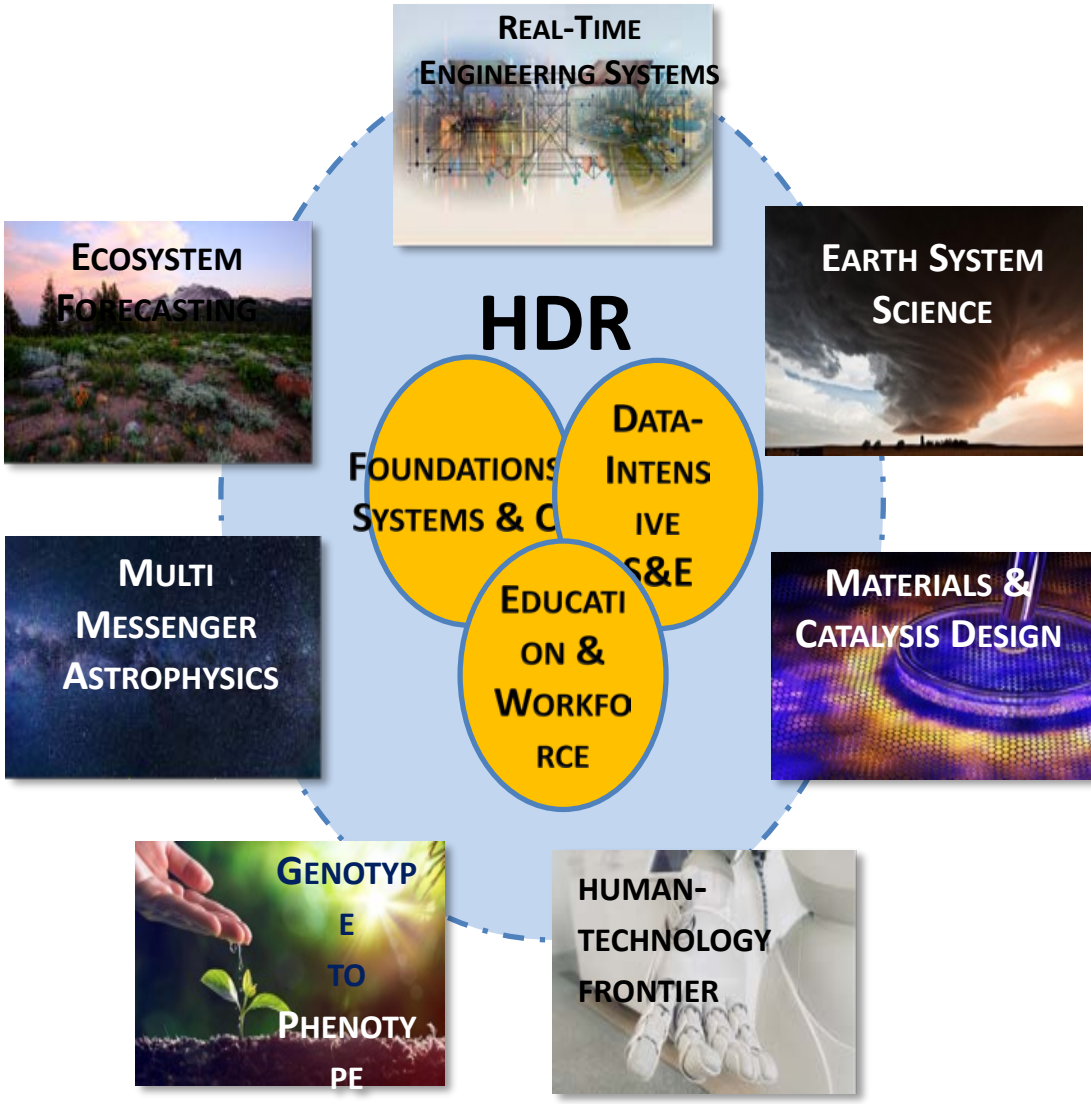
	2007	…	2016	2017	2018	2019
Women	18%	…	23%	27%	28%	29%
Underrepresented Minorities	12%	…	15%	20%	21%	22%

A new generation of CS College students

Representative Course	Increase in Majors	Increase in Non-majors
Intro to Major	152%	**177%**
Mid-Level	152%	**251%**
Upper-Level	165%	143%

HARNESSING THE DATA REVOLUTION: VISION

HDR will enable new modes of data-driven discovery that will allow fundamental questions to be asked and answered at the frontiers of science and engineering



Big Data Hubs
Data Science for All Initiative
(DS4All)

- Community of practice

- Data literacy essential principles

(Data literacy=ability to read, work with, analyze and argue with data.)

- Needs of multiple sectors

Skills Needed by 21st Century STEM Workforce (including those already on the job)

- Interact with large amounts of data.
- Facility with visual metaphors.
- See patterns in complex data.
- The ability to understand the changing role of models.
- Exploratory and inductive skills
- Wide range of differing environments and processes.

Skills Needed by 21st Century STEM Workforce (including those already on the job)

- Students and workers need to be prepared for this new reality
- Unavailable to most students and to those already in the workforce

Skills Needed by 21st Century STEM Workforce (including those already on the job)

- Students and workers need to be prepared for this new reality
- Unavailable to most students and to those already in the workforce
- And most certainly unavailable to underrepresented and underserved populations. (INCLUDES)

Big Data for Little Kids

- *Structure:* 7-week workshop, meeting once per week for 1.5 hours
- *Theme:* Use data to help you design a new exhibit for the Hall of Science.
- *Families:* Each iteration involved 7-10 local families
- *Languages:* Facilitators spoke English, Spanish, Mandarin

Humans+Machines

+

Formal and Informal Education Needs

All citizens in the 21st century should be data literate by the time they graduate from high school.

Include all stakeholders especially teachers.

Partial support by the U.S. National Science Foundation under Grants No. 1027752, 1509079 and 1139478.

Data-Driven Discovery at the U.S.-Mexico Border

The National Academy of Sciences

February 6, 2020

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UC San Diego

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