Breaking out of the Silo: Training a new breed of "Geoengiscists"

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3-6-2013

COLORADOSCHOOLOFMINES
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Integration of Geoscience and Engineering...

Education:
B.S. Geology, University of Wisconsin-Eau Claire, Eau Claire, WI.
M.S. Hydrology and Water Resources Eng., Univ. Arizona, Tucson, AZ.
Ph.D. Hydrology and Water Resources Eng., Univ. Arizona, Tucson, AZ.

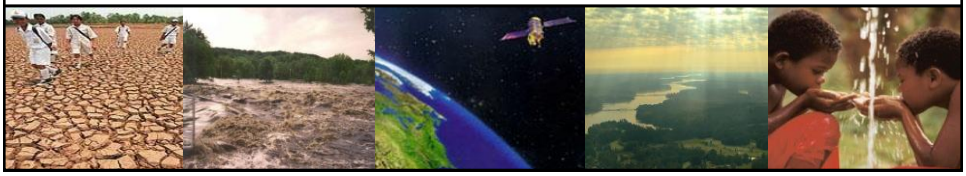
Research:
- Hazards (wildfires, floods, heat waves)
- Urbanization
- Climate change
- Tools – Modeling, remote sensing, natural laboratories

Teaching:
- Hydrologic Modeling (Grad and Undergrad levels)
- Lab and Field Courses (Undergrad)
  - watershed-scale, hydrologic field methods
  - system design (CEE/ABET)
- Snow Hydrology (Grad/Undergrad)
- Remote Sensing (Grad)

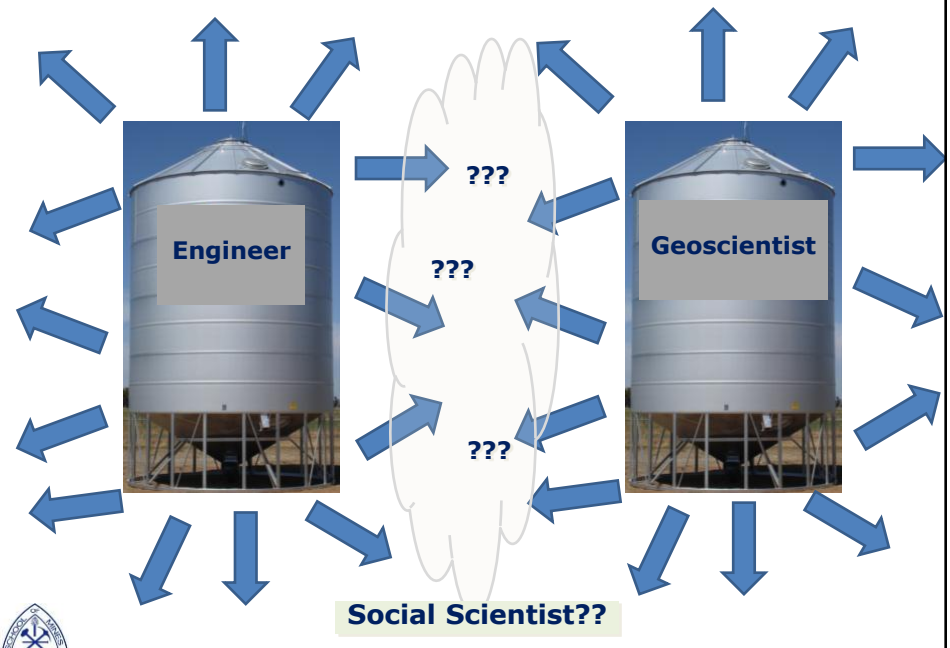
Integration of Geoscience and Engineering…

Outline:

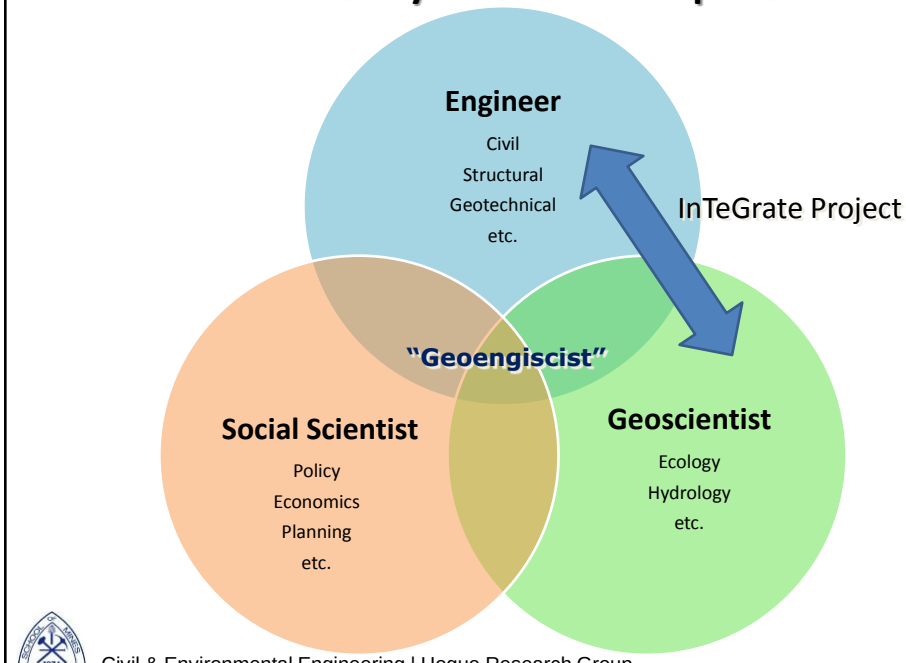
- Traditional and New Models
- What can bring us together
  i.e. our local to global problems
- My attempts and experiences
- Closing thoughts



Old Model: One Directional - "If I build it, they will use it"



New Model: Synthesis of Disciplines



Civil & Environmental Engineering | Hogue Research Group

WHY do we need to Integrate Disciplines?

Today's Issues are COMPLEX…

USAF Studies 'Disaggregated' Weather Satellite Concept
Aviation Week & Space Technology - 03/05/2013
Pentagon officials have espoused the lofty goal of "disaggregating" massive satellites—breaking their capabilities up into smaller but more numerous spacecraft—as a way to save millions of dollars in the costly military satellite arena.

Sequestration could shut off or delay climate and weather data
E&E Publishing, LLC - 03/05/2013

Prepare for severe weather, urge NOAA and FEMA
NOAA/NWS - 03/05/2013
Be a Force of Nature: know your risk, take action, be an example.

Mystery black-box method used to make "all new" Australian "hottest" ever records
Free Republic - 03/04/2013
There were not many long term sites (in black dots) in the centre of Australia in 1930. This summer the Bureau of Meteorology (BOM) invented a whole new metric to measure average national heat, which might be all very well except no-one (other than the BOM) seems to know what it is.

NASA Transfers Operational Control Of Environmental Satellite
14 News - 03/04/2013
/PRNewswire-USNewswire/ -- The Suomi National Polar-orbiting Partnership (NPP) satellite, a partnership between NASA and the National Oceanic and Atmospheric Administration (NOAA), was transitioned to NOAA operational organization control Feb.

Florida Hurricane Season - Overview for Travelers
About.com - Autos - 03/04/2013
Every year, families are tempted to seek beaches and bargains in Florida (and Mexico and the Caribbean) during that long stretch of [illegible] which is officially Hurricane Season.

Space Weather Monitoring and Forecasting
Geology.com - 03/04/2013
Republished from January 2010 press releases by NOAA website. The Dangers of Space Weather Economies around the world have become increasingly vulnerable to the ever-changing nature of the sun.

Next Generation Weather Satellite Could Offer Earlier Warnings
Red Orbit - 03/03/2013
[Watch the Video: Talking Tornadoes with Tim Samaras] Alan McStravick for redOrbit.com – Your Universe Online On December 26, 2004, we learned of the importance that early warning systems can play in preventing loss of life when the great Indonesian tsunami caught locals and vacationers alike by

Climate change dates back to dawn of first farmers
The Advertiser (AP) - 03/02/2013
Chopping down trees with flint axes, planting peas and shearing sheep - those all sound like the prosaic duties of the earliest farmers. But those same Stone Age sodbusters were likely changing our planet's climate, researchers are now suggesting, long before the greenhouse gas emissions of the [illegible]

Utah leaders to blame for effects of pollution
The Salt Lake Tribune - 03/03/2013
By brian maench For : The Salt Lake Tribune For long stretches this winter, Utah cities were No. 1 in the country for air pollution, an "honor" broadcast internationally by every major news outlet on TV, radio, in print and online.

GAO Warns Climate Change Could Drain Federal Budget
About.com - 03/02/2013
And Disaster Subsidy Problems Won't Help

Extreme weather makeover: Has abnormal become the new normal?
Kansas City - 03/02/2013
Those drought-damaged evergreens outside? Regional climatologists say to expect more in the years ahead. And the surreal mounds of snow now hiding shrubs that barely survived summer's heat? Get used to that, too.

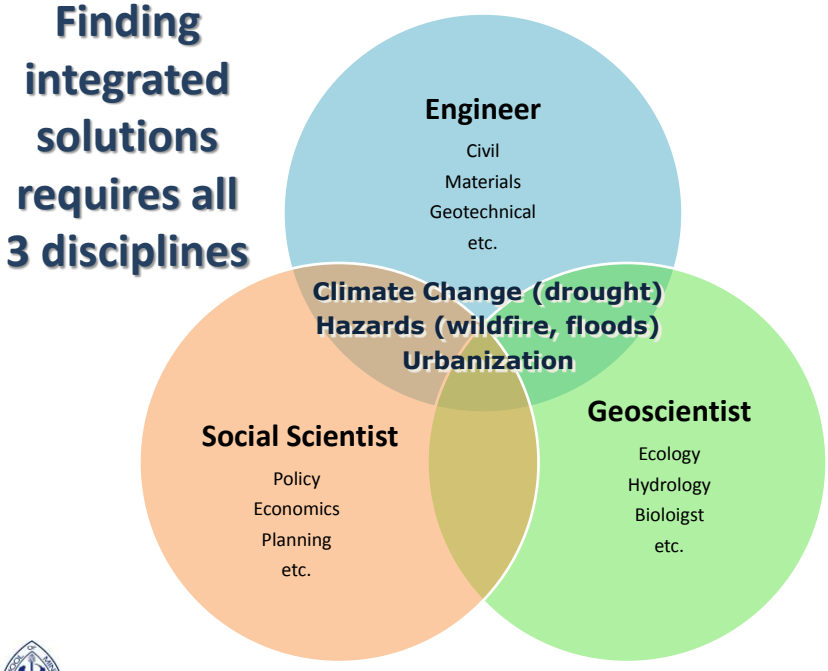
Remarkable Summer in Australia Is Its Hottest On Record
Climate Central - 03/01/2013
Australia: It's so hot right now. Or rather, it was so hot this summer, that the country set a record for its hottest summer since recordkeeping began there in 1910, the country's Bureau of Meteorology (BOM) announced Friday.

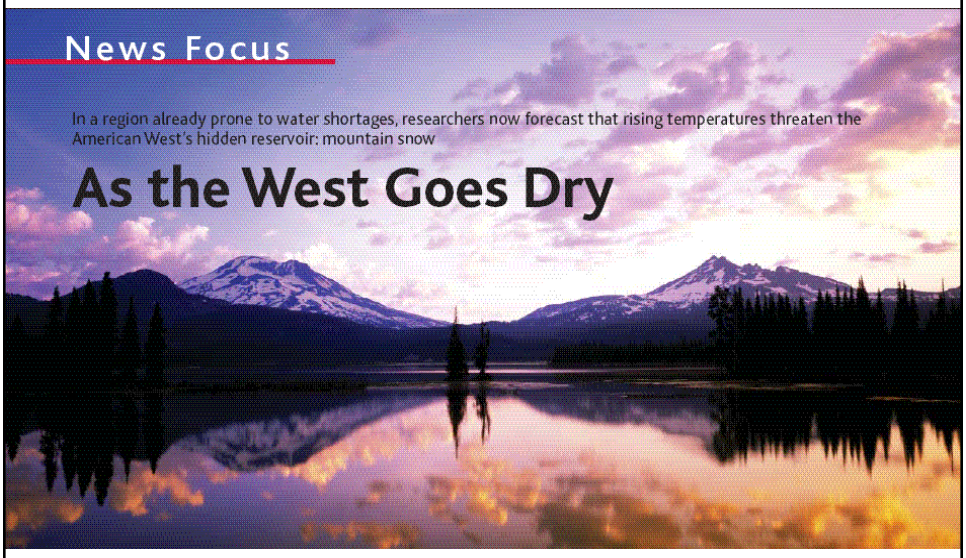
California Water: From Arctic Skies to Sierra Nevada Snow
KQED Public Media for Northern CA - 03/01/2013
It's March 1, which means Northern California is past its driest January-February period on record. Of course, the long-range forecast looks dry, too. So our question, as state water officials report on a Sierra snowpack that has fallen far short of normal for this time of year: "Where's our rain?"

NASA sees Declining Vegetation in Eastern U. S. Forests
Before It's News - 03/01/2013
(Before It's News) MOUNTAIN VIEW, Calif. — NASA scientists report that warmer temperatures and changes in precipitation locally and regionally have altered the growth of large forest areas in the eastern United States over the past 10 years.

New satellites may lead to earlier tornado warnings
Summit County Citizens Voice - 03/01/2013
Tracking lightning inside clouds helps predict tornado formation By Summit Voice SUMMIT COUNTY — New satellite technology that can detect lightning inside clouds and track cloud formation may help weather forecasters develop earlier warnings for severe weather, especially tornadoes.

Finding integrated solutions requires all 3 disciplines

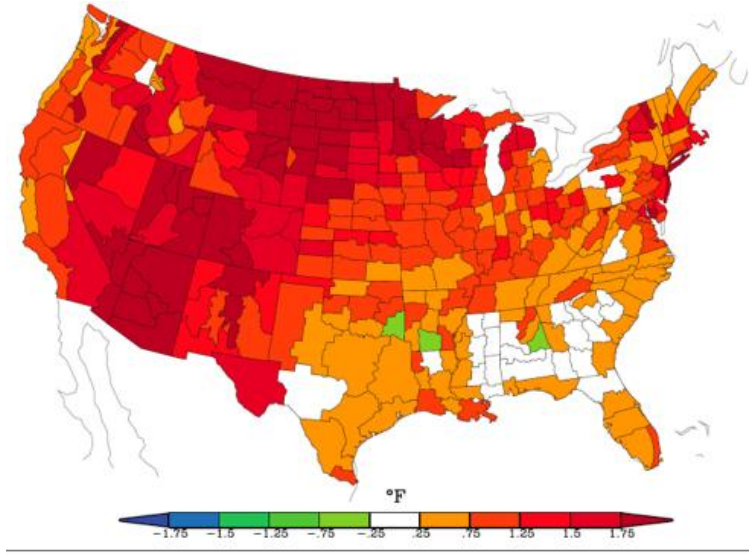




20 FEBRUARY 2004 VOL 303 SCIENCE www.sciencemag.org

Service, 2003

Annual Temperature Changes Across the US



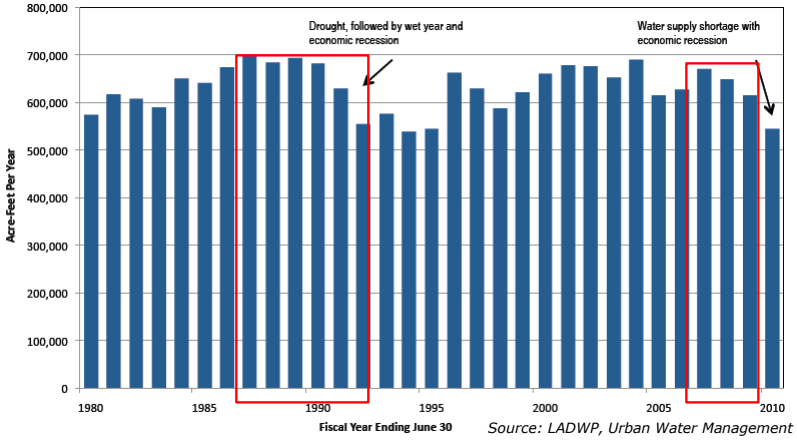
Average temperatures in 2000 - 2007 compared to averages for 1901 - 2000. Source: Dr. Martin Hoerling, National Oceanic and Atmospheric Administration.

Potential impacts from warming

- Declining Snowpack (water supply)
- Altered Streamflow Regimes
- Sea-level Rise (contaminated aquifers)
- Increased Agricultural Demand
- Decreased Soil Moisture
- Increasing Drought
- Landscape Changes
- Increasing Fire Frequency

Los Angeles Water Supply: City Efforts to Reduce Water Consumption

Concerns over drought, reduced snowpack (climate change), catastrophic system failure (earthquakes, levee breach, etc.)

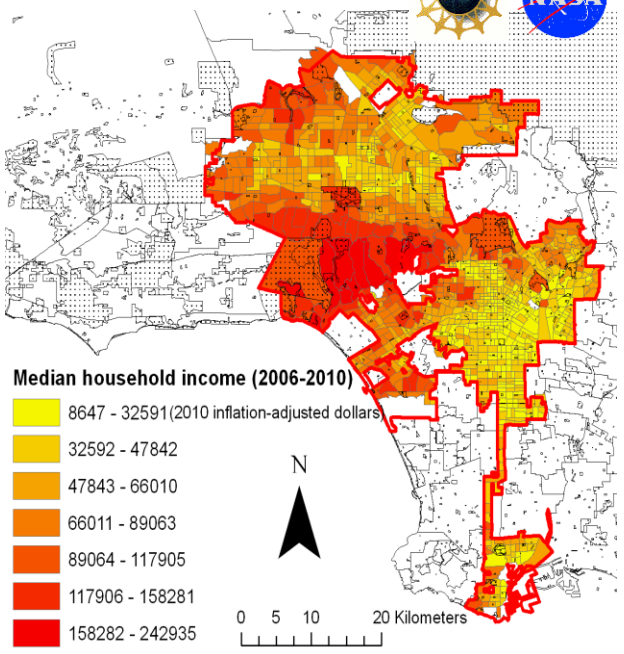


Source: LADWP, Urban Water Management Plan, 2010

- Dependence on MWD imported water increases during drought periods: 1976-1977, 1987-1992, 2007-2009.
- Decrease in water use back to 1980s water demand level despite an additional 1.1 million inhabitants in the City of Los Angeles between 1980 to 2010.

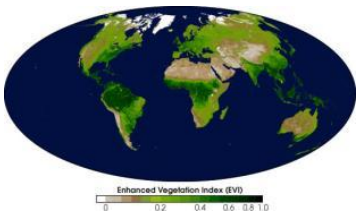
Income Patterns for Los Angeles (social science)

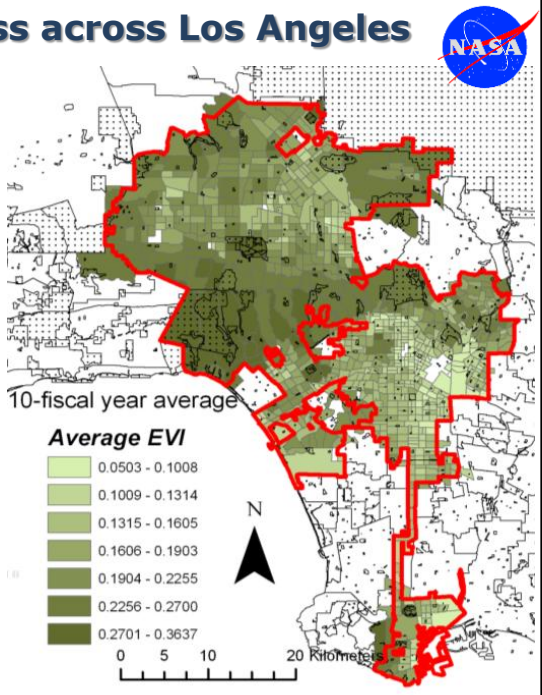
- 2006-2010 US Census estimates at the Tract Level
- Income patterns mimic landscape patterns (large yards, non-native plants, well-watered)



Landscape Greenness across Los Angeles (ecology)

- 10-year average EVI from NASA MODIS Satellites
- **Enhanced Vegetation Index (EVI)** measures the concentration of green leaf vegetation at 250m resolution every 8 days.





Water Consumption (engineering)

Who uses the water?

Income is the key driver in water consumption across LA and is strongly correlated to landscape patterns.

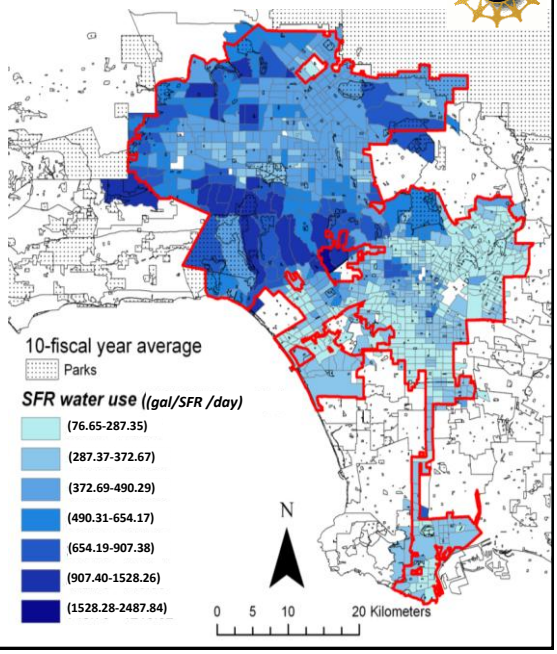
Lower income customers are sensitive to price and volume thresholds (they stay within their allocations)

Social equity needs to be considered in pricing and volume structure. We can not raise price on all users!

Engineering, biophysical and social science team!

Los Angeles Department of Water & Power

Household water use data from LADWP



June 2012 Waldo Canyon Fire – Colorado Springs

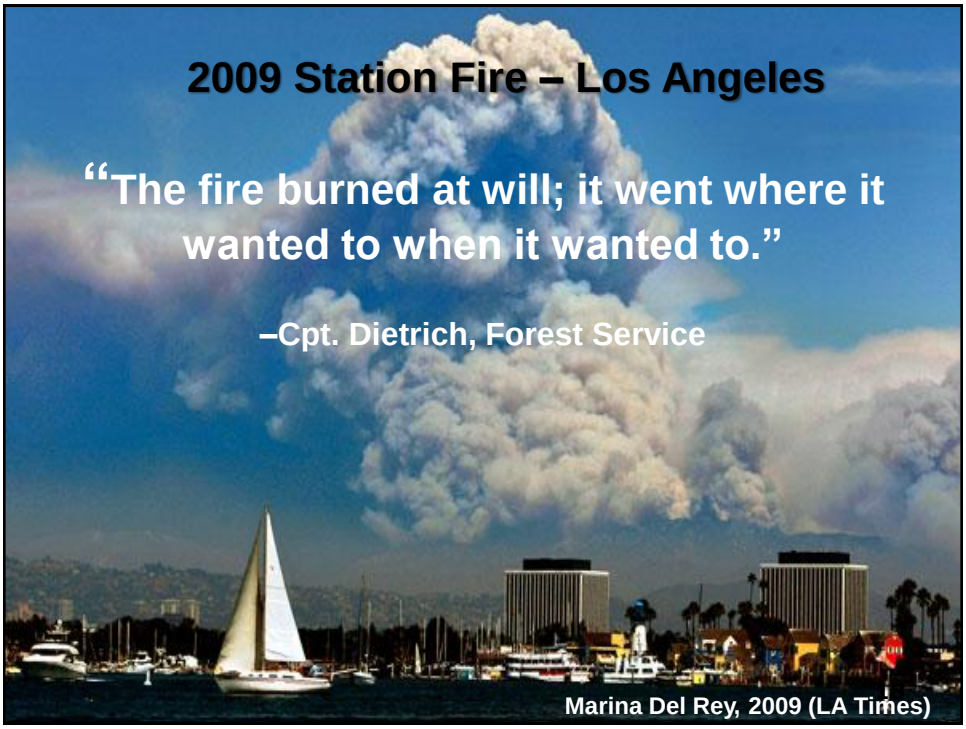
- Pikes National Forest,
- El Paso County
- >18,000 acres
- 360 homes destroyed

Major watersheds affected: West Monument Creek, Lower Monument Creek, Headwaters Fountain Creek, Cascade Creek, Garden of the Gods

2009 Station Fire – Los Angeles

"The fire burned at will; it went where it wanted to when it wanted to."

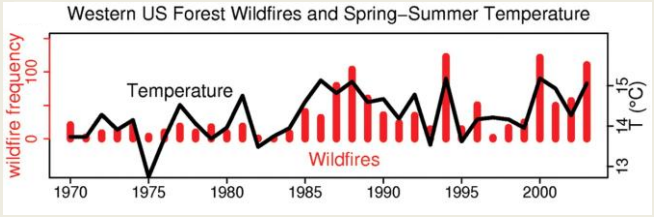
–Cpt. Dietrich, Forest Service



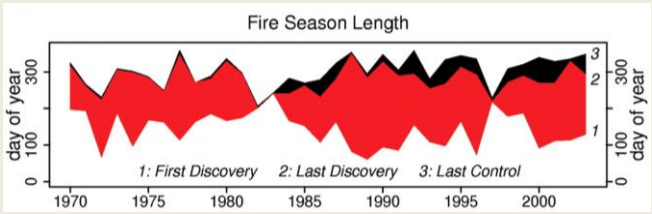
Marina Del Rey, 2009 (LA Times)

Recent Trends in Wildfires

Westerling et al., 2006



- Increase in large-wildfire frequency
- Warmer temperatures and earlier spring melt → increased wildfire activity



Longer fire durations (2 to 3) and longer fire seasons (1 to 3) since mid-1980's

Physical/Chemical Changes

Acute loss of vegetation, decreased soil cohesion, ash layer deposition, hydrophobic layer formation

Hydrologic Consequences

Decreased: infiltration, ET demand, water quality

Increased: erosion, overland flow, flooding, sediment laden and debris flow occurrence, dry season flow

Impacts…

Mitigation…

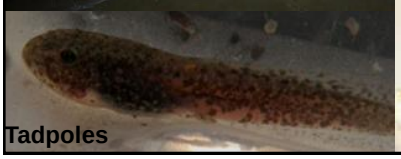
Environmental Concerns


Melted metal

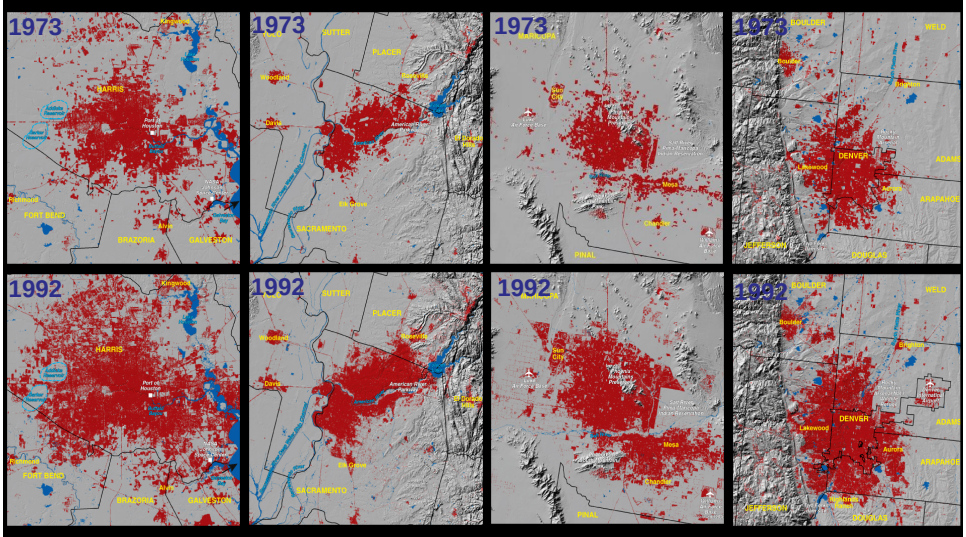

Foam


Endangered frogs

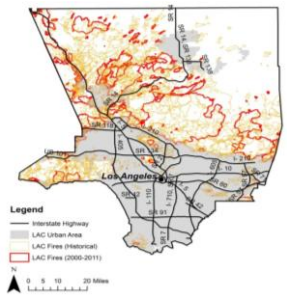

Water Quality

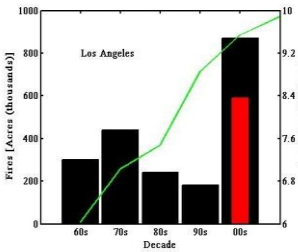

Tadpoles

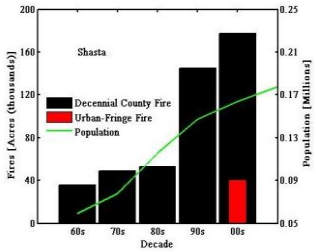
Wildland Urban Interface (WUI) expansion



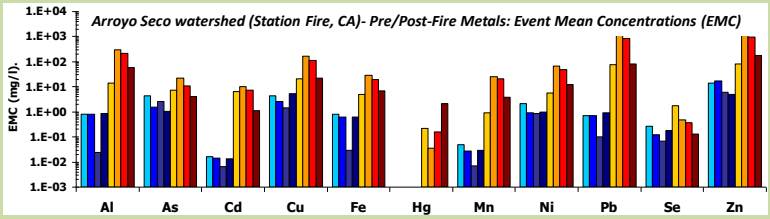
Wildfires at the Wildland-Urban Interface (WUI)







Hogue and Kinoshita, 2013



- Significant increases in concentrations of most trace metals over entire season
- 100 fold increase in TSS, Cd & Pb concentrations
- WHY?? Storage of pollutants since before Clean Air Act (1970)
- IMPACT?? Downstream ecosystems and water supply (spreading basins for LA)

Burke et al., 2012

Human – Hazard Interactions

- Need to predict short- and long-term cumulative effects of land-surface, hydrologic, and ecologic hazards
- Need for integration of fire science with policy at the urban-fringe
- Need to understand and communicate societal risks to communities at the urban-fringe from catastrophic fires

Training our Students

What are our Education Goals?

- **Coursework** - Solid math, science, engineering curriculum. Communication courses. Integration of policy courses?
- **Technical Skills** – Design courses, field experience, modeling, other relevant tools (remote sensing, lab, programming, etc.)
- **Interdisciplinary Research** – Undergraduate research experience, independent projects, design courses that can integrate disciplines
- **Outreach** – Exposure to other communities and audiences. Development of communication skills

Pressure for reduced credit hours at Universities
Need for creative curriculum design

Example #1:
UCLA CEE Course: Hydrologic Analysis and Design

ABET Design and Lab Credit

- **Culmination course for CEE Undergraduate students with hydrology and water resources emphasis (3rd course in series)**
- **2 hour lecture / 4 hour laboratory**
- **2-3 field trips during 10-week course**

Ex. #1: CEE Hydrologic Analysis and Design

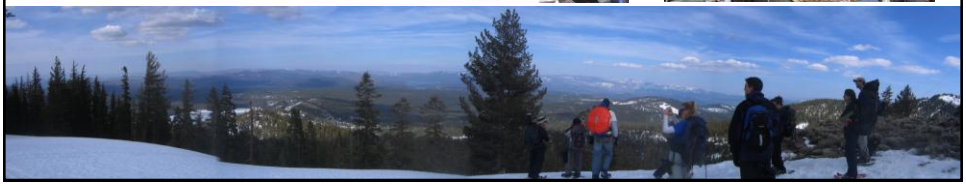
- **Integrated study of local watershed**
- **Data collection from local, state, national agencies**
  - **timeseries and statistical analysis**
- **Field observations and measurements**
  - **methologies, uncertainty assessment**
- **Model design - "industry models"**
  - **use collected data**
  - **calibration/validation for current conditions**
  - **scenario development (i.e. landcover change)**
  - **hydrologic response/behavior**
  - **mitigation considerations**
- **Individual weekly lab reports (weeks 1-6)**
- **Final team Project Report (week 10)**

Example #2:
UCLA CEE Course: Hydrology of Mountain Watersheds

ABET Lab Credit

- Undergraduate field-based course focused on catchment processes in snow-dominated and mountainous regions.
- Data collection (agency and field), remote sensing, snow modeling, team report. Extended field trip to Sierra Nevada Mts.



Example #3: Engaging Undergraduates in Research

Independent Study (credit); Partnered with PhD students

Audrey Lee, UCLA (Winter 2011)
CEE 199: Watershed Fire Analysis: Atmospheric and Hydrologic Characteristics Over the Arroyo Seco, City Creek, and Devil Canyon Watersheds"
Nathan Griffin, UCLA (Fall 2011 and Winter 2012)
CEE 199: "Wildcat5 Rainwater Hydrology Model Evaluation"
"Post-fire modeling tools: Part 1: Review and application of the WEPP's ERMiT and Part 2: Review of the AGWA2/Kineros2 Model"
Karen Chu, UCLA (Fall 2011 and Winter 2012)
CEE 199: "Post-fire Remote Sensing Application in Arroyo Seco and City Creek"
David Steger, CSM (Spring 2013)
ESGN 499 (Independent Study): "Hydrologic Remote Sensing for Sagehen Basin"




Example #4: Outreach Programs - NSF GK-12 Science and Engineering of the Environment of LA (SEE-LA)

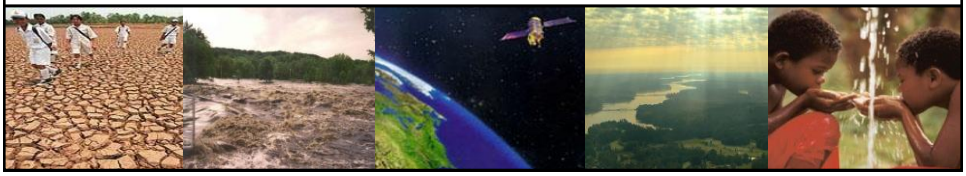
Five-year, $3 million NSF GK-12 Graduate Teaching Fellows in K-12 Education (GK-12) grant aimed at the professional development of Science Technology Engineering and Mathematics (STEM) graduate students at UCLA.
PI: T. S. Hogue Program Manager: S. Kappus (previous J. Daniel)
Co-PIs: M. Moldwin (U. Michigan), P. Nonacs (UCLA)

- Fourth year of program
- Supported 35 graduate students at UCLA (Engineering, Physical & Life Sciences)
  16 from HSSEAS (7 this year)
- Graduate students (Fellows) act as "Scientists-in-Residence" in L.A. schools
- Advance science curriculum, develop lessons, mentor students, etc. -- overarching goal is to improve communication skills




Concluding Remarks

- Natural and anthropogenic disturbance increasing across western US: climate, drought, urbanization, wildfire, etc.
- Need to **synthesize** solutions across disciplines within a **diverse study body**:
  - **Understand process: geoscience, biophysical science, etc.**
  - **Design solutions: engineering concepts/practice**
  - **Understand human interactions and impacts of solutions: social science**



Workshop Goals - My Two Cents…

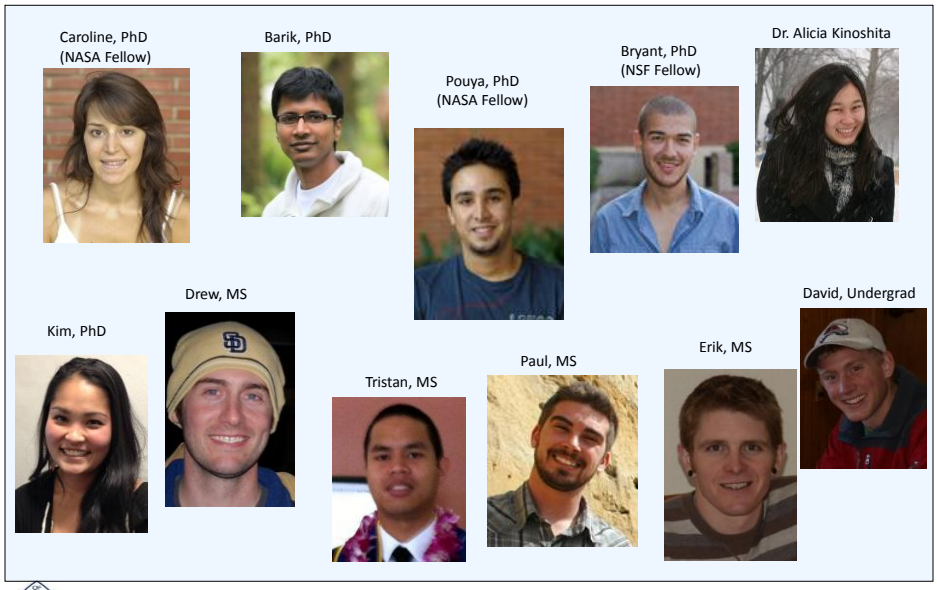
- **Current best practices in integrating geoscience and engineering education, such as addressing the need for sustainable engineering**
  - Examples from faculty, workshop participants, other campuses, etc.
  - Learn by doing
  - White papers, literature?
- **Geoscience education needs of engineers, engineering education needs of geoscientists, and new approaches to meet those needs,**
  - Break down those silos!
  - Get engineers in the field and lab, expose them to observations, physical process
  - Expose geoscientists to design and engineering concepts and practice
  - Integrate policy and social implications whenever possible

Workshop Goals - My Two Cents…

- **Barriers to increased geoscience education in engineering; ways to encourage increased diversity in engineering related to geoscience**
  - Faculty need to be comfortable getting out of the silo. Team taught and/or cross-campus courses will help
  - Need buy-in from department heads and deans. Use your constituent groups (alumni, industry) What do they want in our graduates?? ABET process may help
  - Design projects run by departments and suitable faculty (develop integrated geoscience and engineering projects)
- **Potential topics for new interdisciplinary courses or course modules and materials that could be integrated into existing engineering courses, and faculty interested in developing them**
  - Focus on environmental issues that are relevant and need interdisciplinary solutions – climate, water, earthquakes, floods, urbanization impacts, wildfires, green infrastructure, etc.
  - Team teaching with related (series) modules
  - Incentivize! McBride program (CSM) , Fiat Lux (UCLA), other examples??

    BUT – needs administration buy-in (use your advisory groups!)

Thank You to the Hogue Research Group!!



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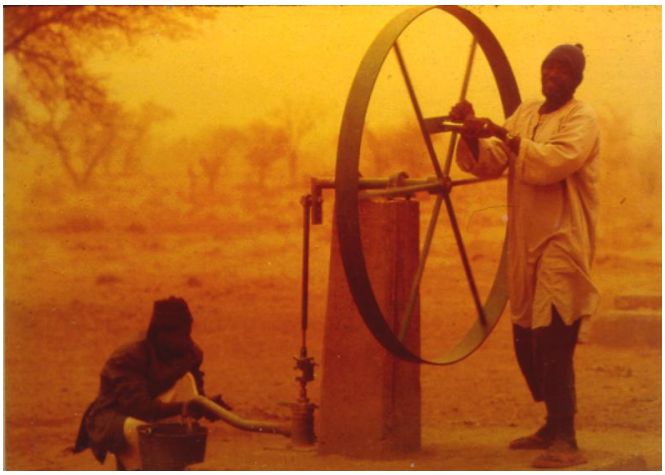

When the wells run dry, we know the worth of water

Benjamin Franklin [1746]