USDA CARIBBEAN CLIMATE HUB for Tropical Forestry and Agriculture

2018 | May

International Institute of Tropical Forestry, Río Piedras, Puerto Rico

Caribbean Drought Workshop

Impacts, Resilience, and Recovery

Caribbean Drought Workshop Report:

Impacts, Resilience, and Recovery

This workshop was held in collaboration with the Southeast Climate Adaptation Science Center, North Carolina State University, the Integration & Application Network from the University of Maryland Center for Environmental Science, and the USDA Caribbean Climate Hub. This report was made possible by support from NRCS Caribbean.

The Southeast Climate Adaptation Science Center, formerly known as the Southeast Climate Science Center, is part of a federal network of eight Climate Adaptation Science Centers (CASCs) managed by the U.S. Geological Survey National Climate Adaptation Science Center (NCASC). The mission of NCASC and regional CASCs is to work with natural and cultural resource managers to gather the scientific information and build the tools needed to help fish, wildlife, and ecosystems adapt to the impacts of changing climate and land use. The CASCs and NCASC focus on the delivery of science, data, and decision-support tools that are practical and relevant to resource management. North Carolina State University acts as the host institution for the Southeast Climate Adaptation Science Center, providing organizational support to implement the CASC mission through capacity building, project management, communications, partnership development, and connections with scientific capabilities in the region. The mission is implemented through collaborative partnerships among USGS, natural resource management organizations, and academic institutions.

The Caribbean Climate Hub (CCH) is located in Río Piedras, Puerto Rico, and is one of ten Regional Hubs nationwide. This network of Climate Hubs works with the USDA to deliver science based knowledge and practical information to farmers, ranchers, and forest landowners that will help them to adapt to climate change and weather variability by coordinating with local and regional partners in federal and state agencies, universities, and the public. The mission of the CCH is to help society sustain and improve the viability of forestry and agricultural production, the availability and quality of soil and water resources, the viability and quality of rural lifestyles, and food security in light of climate variability and change. The goal of the CCH is to develop and deliver information related to climate, agriculture, and forestry for better planning and implementation of actions related to the mitigation of and adaptation to climate change in tropical working lands.

Contents

Synopsis

On May 30th and 31st, 2018, over 50 experts on drought, water management, ecology, and agriculture met to discuss the impacts the effects of drought in the Caribbean at the International Institute of Tropical Forestry in the Botanical Garden of Río Piedras, Puerto Rico. The purpose of the workshop was to synthesize the state of the science on drought impacts by sector in Puerto Rico and the U.S. Virgin Islands. Hosted by the USDA Caribbean Climate Hub, in collaboration with the USGS National Climate Adaptation Science Center (NCASC), the regional Climate Adaptation Science Centers (CASCs) and North Carolina State University, the two-day workshop welcomed around 55 representatives from agriculture, natural resources, water supply sectors and multiple levels of government. To synthesize the State of the Science on drought impacts by sector in Puerto Rico and the U.S. Virgin Islands, workshop participants collaborated to:

1. Identify lessons learned from past drought effects (e.g. 2015);
2. Highlight key similarities and differences in terms of impacts between the agricultural, ecosystem and water supply sectors;
3. Identify available data and information for drought monitoring and information gaps to support drought management; and
4. Discuss future drought scenarios and thresholds, and what projected future conditions will mean for managers.

The U.S. Caribbean Drought Workshop was a product of a network-wide initiative by the NCASC and CASCs that aimed to identify what we know about the impacts of drought on ecosystems across the U.S. and how managers can plan for these impacts and adapt to changing conditions. During the first workshops in the series, it became clear that islands such as Puerto Rico, the U.S. Virgin Islands, and the U.S. Affiliated Pacific Islands experience unique challenges related to drought. To delve further into this topic, NCASC developed two workshops on island drought in 2018, one in Puerto Rico and one in Hawai'i. The scope of these workshops covered the ecological impacts of drought and its impacts to agriculture, water supply and distribution, and other key sectors. The workshop brought together regional drought experts to identify key threats, challenges, and management solutions related to drought.

Cover page photos courtesy of Pablo E. Gutiérrez-Fonseca

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Thank you to all collaborators and participants!

Attendees

Abby Frazier, *USFS Pacific Southwest Research Station*
Adam Terando, *Southeast Climate Adaptation Science Center*
Amilcar Vélez Flores, *UPR Laboratorio de Climatología*
Aranzazu Lascurain, *Southeast Climate Adaptation Science Center*
Arthur Petersen, *Virgin Islands Department of Agriculture*
Bill Dennison, *University of Maryland Center for Environmental Science*
Brad Rippey, *USDA Office of the Chief Economist*
Brenda Torres, *San Juan Bay National Estuary Program*
Brent Murry, *US Fish and Wildlife Service*
Calwyn Morton, *University of the Virgin Islands*
Cari Furiness, *Southeast Climate Adaptation Science Center*
Charles González, *FEMA*
Christina Bandaragoda, *University of Washington*
Deborah Bathke, *National Drought Mitigation Center*
Dorothy Sifuentes, *USGS Caribbean and Florida Water Science Center*
Edwin Más, *USDA Natural Resources Conservation Service Caribbean Area*
Emily Fort, *National Climate Adaptation Science Center*
Ernesto Díaz, *Puerto Rico Departamento de Recursos Naturales y Ambientales*
Eva Holupchinski, *USDA Caribbean Climate Hub*
Evelyn Huertas, *Environmental Protection Agency*
Graciela Ramírez-Toro, *Inter American University of PR - Center for Environmental Education, Conservation & Research*
Greg Guanuel, *UVI - Caribbean Green Technology Center*
Gus Engman, *North Carolina Cooperative Fish and Wildlife Research Unit/ North Carolina State University*
Idania Rodríguez, *FEMA*
Jimmy Phuong, *University of Washington*
Jamie Curie, *University of Maryland Center for Environmental Science*
Jared Bowden, *North Carolina State University*
Jason Howard, *University of Maryland Center for Environmental Science*
Jess Zimmerman, *University of Puerto Rico / Luquillo Long Term Ecological Research*
Jonathan Putnam, *NPS*
José Castro, *USDA Natural Resources Conservation Service Caribbean Area*
Kate Malpeli, *National Climate Adaptation Science Center/ Southeast Climate Adaptation Science Center*
Kelly Smith, *National Drought Mitigation Center*
Kristin Wilson Grimes, *University of the Virgin Islands*
Leonela Torrado, *Puerto Rico Department of Natural and Environmental Resources*
Marianela Torres Rodriguez, *Puerto Rico DNER - Division of Monitoring and Water Planning*
Melody Hunter-Pillion, *North Carolina State University*
Miguel García-Bermúdez, *US Fish and Wildlife Service*
Myrna Comas Pagán
Nora Álvarez-Berríos, *USDA Caribbean Climate Hub*
Odalys Martínez, *National Weather Service*
Pablo Gutiérrez, *University of Puerto Rico/Luquillo Long Term Ecological Research*
Pablo Méndez, *UPR Environmental Health Department*
Pedro Ríos, *El Yunque National Forest*
Ryan Boyles, *Southeast Climate Adaptation Science Center*
Shawn Carter, *National Climate Adaptation Science Center*
Scott Peckham, *University of Colorado - Boulder*
Shelley Crausbay, *Conservation Science Partners*
Sigfredo Torres-González, *USGS Caribbean and Florida Water Science Center*
Soledad Gaztambide Arandes, *Para La Naturaleza*
Stanley Latesky, *University of the Virgin Islands*
Stuart Weiss, *University of the Virgin Islands - Agriculture Experiment Station (AES)*
Tamara Heartsill, *USFS - International Institute of Tropical Forestry*
Tana Wood, *USFS - International Institute of Tropical Forestry*
Vanessa Forbes, *Puerto Rico Department of Agriculture*
William Gould, *USDA Caribbean Climate Hub*

Agenda Day 1: Wednesday, May 30, 2018

IITF Conference Room, Jardín Botánico Sur, San Juan, Puerto Rico | 8:45 am - 5:00 pm

8:45 – 9:15 am

Workshop overview and introductions by Bill Dennison, UMCES IAN

9:15 – 9:30 am

Overview of the USDA Caribbean Climate Hub by Bill Gould, USDA Caribbean Climate Hub

9:30 – 9:45 am

Past drought in the U.S. Caribbean by Odalys Martínez, NOAA

9:45 – 10:00 am

Impacts to Agriculture (Puerto Rico) by José Castro and Edwin Más, NRCS

10:00 – 10:15 am

Impacts to Agriculture (USV) by Stuart Weiss, UVI

10:15 am – 11:15 am

Breakout session: Aim to identify key impacts of drought to agricultural sector.

11:15 am – 11:45 am

Plenary: Report back from breakout

11:45 am – 12:45 pm

Lunch

12:45 am – 1:00 pm

Impacts to ecosystems (PR) – forests by Jess Zimmerman, UPR/LTR and Tana Wood, USFS/LTER

1:00 pm – 1:15 pm

Impacts to ecosystems (PR) – aquatic by Pablo Gutiérrez, UPR/LTER

1:15 pm – 1:30 pm

Impacts to ecosystems (USVI) by Kristin Wilson Grimes, UVI

1:30 pm – 2:15 pm

Breakout session. Aim to identify key impacts of drought to ecosystem sector

2:15 pm – 2:45 pm

Plenary: Report back from breakout

2:45 pm – 3:00 pm

Impacts to water supply (USVI) by Kristin Wilson Grimes, UVI

3:00 pm – 3:15 pm

Impacts to water supply (PR) by Sigfredo Torres, USGS Caribbean Florida WCS

3:15 pm – 3:30 pm

Impacts to Heath and Society by Pablo Mendez, UPR Environmental Health Department

3:30 pm – 4:15 pm

Breakout session. Aim to identify key impacts of drought to water supply sector.

4:15 pm – 4:45 pm

Plenary: Report back from breakout

4:45 pm - 5:00 pm

Wrap-up by Bill Dennison, UMCES IAN

5:00 pm

Optional Happy Hour (100 X 35)

Agenda Day 2: Thursday, May 31, 2018

IITF Conference Room, Jardín Botánico Sur, San Juan, Puerto Rico | 8:45 am - 4:00 pm

8:45 – 9:15 am

Reflection on Day 1, goals for Day 2 by Bill Dennsion, UMCES IAN

9:15 – 9:30 am

Landscape scale analysis of drought and conservation practices by Nora Álvarez-Berríos, USDA Caribbean Climate Hub

9:30 – 10:15 am

2015 drought and drought committee by Marianela Torres, DNER

10:15 – 10:30 am

Break

10:30 – 11:00 am

Datasets for drought monitoring by Dorothy Sifuentes, USGS Caribbean Florida WCS and Stanley Latesky, UVI

11:00 am – 11:30 am

Breakout session: Data availability and data needs

11:30 am – 11:45 am

Plenary: Report back from breakout

11:45 am – 12:30 pm

Lunch

12:30 pm – 12:45 pm

Overview of U.S. Drought Monitor by Brad Rippey, USDA OCE

12:45 pm – 1:30 pm

Plenary: Next steps: How do we utilize this data to get routine, weekly input? What process should we follow? By Brad Rippey and Bill Gould

1:30 pm – 2:00 pm

Future drought scenarios by Jared Bowden, NCSU

2:00 pm – 3:00 pm

Breakout session. Given these potential future drought scenarios, what are some adaptation strategies that can be implemented now?

3:00 pm – 3:30 pm

Plenary: Report back from breakout

3:30 pm – 4:00 pm

Plenary: Report back from breakout

Presentation snapshots

During the workshop, experts on water resources, ecology, climate and natural resources presented the State of the Science on drought in the U.S. Caribbean. The next several pages include selected information from each presentation. Note: All PowerPoint presentations from the U.S. Caribbean Drought workshop are available in Google Drive: https://drive.google.com/open?id=1TP86Z6GHzEQmV2M2RKaBNhiA7mzNs87p

U.S. Caribbean Drought workshop overview – Bill Dennison described the origin of the drought workshops series and shared various effects of ecological drought across the U.S.

- In northern states runoff patterns have been affected by snow droughts
- In Great Plain states, agriculture has been affected by flash droughts
- Alaskan droughts are changing permafrost
- Island droughts often result in water shortages

Overview of the USDA Caribbean Climate Hub- William Gould provided a background on the role of the USDA Caribbean Climate Hub and the drought-related work they have been working on over the years.

- The spatial distribution of recent drought exposure in Puerto Rico
- Future suitability of coffee production in Puerto Rico based on precipitation changes
- Climate change outreach materials

Past drought in the U.S. Caribbean – Odalys Martínez-Sánchez described instances of past drought in the Caribbean.

- 95% of the Caribbean were affected by drought in late 2013 and early 2016
- At least 50% of the Caribbean affected by 1997/98 drought

A conservation perspective to reduce drought impacts on agriculture in PR – Myrna Comas, José Castro and Edwin Más described drought impacts to PR agriculture, economic losses caused by drought occurrence in 2015, and various management practices.

- Nearly $14 million in agricultural losses due to the 2015 drought
- Agricultural drought impacts: soil quality degradation, hydric stress and plant desiccation, tissue and fruit damage, increase in wildfires, reduced yields, increased energy costs

Environment, Climate, and Drought: Developing Resilient Agriculture in the USVI - Stuart Weiss and Robert Godfrey presented climatic and environmental information about St. Croix, USVI, and interesting photos of the impact of the 2015 drought. Recommendations for drought mitigation:

- Develop forage banks and hay production
- Use alternative grazing species
- Plant multi-purpose trees and shrubs

Drought impacts to tropical forested ecosystems – Jess Zimmerman and Tana Wood presented various studies that exemplified the effects of drought in tropical forests.

- Throughfall experiment
- Microbial pre-exposure to drought
- Above average litterfall in 2015

Drought impacts to stream ecosystems in Puerto Rico – Pablo Gutiérrez-Fonseca described two studies on drought impacts to stream ecosystems. Key results included:

- Introduced species dominant in periods of drought, while native species dominate periods of non-drought
- Diadromous native species affected by loss of stream/ocean connectivity in drought

Drought impacts in the U.S. Virgin Islands – Kristen Wilson Grimes summarized the climate and environmental characteristics of USVI islands and pointed out some of the local impacts of drought.

- In USVI, water conservation mandated by law
- Water delivery, desalinization plants
- Drought changing forest composition and causing water scarcity for local wildlife

Drought impacts to water supply in Puerto Rico- Sigfredo Torres-González provided a description of the climatic zones of Puerto Rico as well as an overview of local water resources.

- Decreasing groundwater withdrawal trend
- Total dissolved solids in South Coast Aquifer increasing
- Rainfall accumulation during hurricane Maria recharged South Coast Aquifer significantly

Can the Puerto Rico water systems in the future be more feasible, resilient, more sustainable and healthier? – Pablo Méndez-Lázaro shared his insights on the effects of drought on public health and well-being.

- Instances of drought can have an effect on mental health
- Power and resources are an important determinant of a region's ability to adapt to dry conditions
- Rainwater harvest and water recycling as recommended water management strategy

Drought in the U.S. Caribbean: Impacts to Infrastructure – Christina Bandaragoda used a conceptual diagram that she and Bill Dennison created to describe how lack of access, distribution and contamination of water can induce drought conditions.

- Power outages disable groundwater pumps, waste water treatment plants, drinking water plants
- Access to freshwater dependent on location and timing of oasis water trucks

Correlating drought conservation practices and drought vulnerability in a tropical agricultural system- Nora Álvarez-Berríos discussed her research on the spatial coincidence of accumulated drought occurrence in Puerto Rico and the implementation of NRCS EQIP practices.

- From 2000 – 2016, 92% of Puerto Rico experienced periods of drought conditions
- From 2014 – 2016, there were 31 consecutive weeks of extreme drought in certain regions
- There was a general mismatch between drought exposure and the implementation of drought-related conservation practices from 2000 - 2017

Puerto Rico 2014 – 2016 Drought – Marianela Torres Rodriguez presented on water policy in Puerto Rico and the sequential progression of the 2014 – 2016 drought

- Puerto Rico drought committee created to manage drought event
- Severe depletion of water resources in key reservoirs and aquifers at peak of 2015 drought
- Announcement of Salinas Aquifer Recharge Project

USGS Data portals for drought monitoring in Puerto Rico and the U.S. Virgin Islands – Dorothy Sifuentes provided the group with a tour of the USGS drought monitoring data on usgs.gov where resources are available on:

- National Water Information System
- Groundwater watch
- Streamflow data

- See U.S. Caribbean Drought Resources section of report for more information.

Drought monitoring in the U.S. Virgin Islands – Stanley Latesky shared microclimate and drought monitoring efforts in the USVI.

- Monitoring monthly and annual rainfall, water quality testing, wind speed, soil moisture, and other parameters
- Some monitoring stations lost to recent hurricanes
- Involved in efforts to extend USDM drought monitoring to USVI

Overview of the U.S. Drought Monitor - Brad Rippey described the data that is used to create the weekly U.S. Drought Monitor (USDM) maps for Puerto Rico and the available data in the USVI.

- USDM data used declare disaster areas and for the qualification of payments with the USDA's Livestock Forage Disaster Program
- Plans for experimental weekly monitoring for USVI
- To join the USVI drought monitoring listserv, please write to Brad (BRippey@oce.usda.gov) or Brian Fuchs (bfuchs2@unl.edu) of the National Drought Mitigation Center

Tracking Drought Impacts – Kelly Helm Smith shared drought monitoring efforts at the National Drought Mitigation Center.

- "Submit a report" option on NDMC website
- Drought impacts by sector
- Monitoring CoCoRaHS and drought-related media reports throughout 2017

Using climate models to improve our understanding of future drought risks in the U.S. Caribbean Storytelling using climate science and modeling – Jared Bowen described potential climate scenarios based on projected climate modeling (with a fun Disney twist).

- Puerto Rico & US Virgin Islands Dynamical Downscaled Climate Change Projections available at: https://doi.org/10.5066/F7GB23BW
- Complexities of island thermodynamics and land surface feedbacks
- Strategies: reduce local carbon footprint, use best practices, apply innovative and adaptive technology

Pasture management in USVI Photos taken the same day in different locations. Proper pasture management (L) versus poor management (R) Photos: Stuart Weiss

A Jersey cow drinks at Tai South Farm in Lajas, Puerto Rico. Photo: Caribbean Climate Hub

Breakout discussion notes

The following bullet points were compiled in several breakout discussion groups throughout the workshop and transcribed below to share with participants.

Drought impacts to agriculture

Group 1

- *Food security*
  - Decrease in fresh food available to social programs
  - Access to food during disasters and after (farm-to-school hospital, elderly)
  - Economics, economic disparity (vulnerable groups more affected)
  - Unemployment, poverty increase
  - Puts farms out of business, no recovery
  - Lease lands don't qualify for aid
  - No crop insurance, no safety net (USVI)
  - Food prices increase, output decrease, food quality decrease, increased exports
  - Public health – more canned food
- Competition for water (who has priority access? – policy (drinking, irrigation, tourism, irrigation, sanitation, commercial, etc.)
- *Animal ag*
  - Decrease in feed availability
  - Livestock death, lose pasture land
  - Decrease in herds (markets flooded, need price support)
  - Lose incentive to go into ag- lose capacity for farming, loss knowledge
- *Wildfire*
  - Lost grazing land, dry conditions increases fire risk (lost fences and grass, air quality decreases)
  - Government programs may not cover replacement costs (livestock containment)
- *Short / long term impacts*
  - Types of irrigation, rain fed pastures (no surface water USVI)
  - Reestablish infrastructure

Group 2

- Water supply for livestock and farm use can conflict with municipal need for water
- Balance need for sustainability (increased food independence) and drought / climate impacts – choice of crops (rice adequate?)
- Increase need for local / on farm storage
- PR food imports (80%)
- VI food imports (99%)
- Plantains, root vegetables, pineapples, coffee, mangoes

- Most farms polyculture and small – good thing?
- Location for crops is critical – grow right food at right location
- See downscaled models
- How will climate change impact $ viability of some crops that require long term investments?
- Diversity in types of crops might make farmer more resilient but? scarcity of island for food?
    - Plantains and bananas can grow fast after disasters
- How to manage livestock in PR and VI?
    - Herd? Sustainably
    - Type of livestock
    - Pasture management
    - Culture change for food preference?
- Think positive outcomes/ suggestions!

Group 3

- *Short term (short term must be defined)*
    - Anticipatory info
    - Bush fire
    - Crop yield reduction
    - Disruption of seasonality
    - Crop selection
    - Lack of data / education and outreach
    - Dry pasture = fire
- *Long term (long term must be defined)*
    - Soil water shortage
    - Salinity greater
    - Food security – cross sectional coordination
    - Duration of drought
    - *Note*
    - Rainfed ag – cost prohibited to use irrigation
- *Solutions*
    - Early warning system for preparation- based on agricultural drought, not just meteorological drought
    - ID hybrids for drought (cultivars) – seed classification and labeling

Group 4

- Show people and map (inset)
- Write out U.S. Virgin Islands
- Explain shaded boxes and make circle images of largest commodity in USVI and PR, respectively
- (graphic showing local production, cultural impact and the economic value, sovereignty and resilience)
- Culturally appropriate visuals
    - E.g. coffee, plantains, mountains, coastline (show island with water), different livestock (chickens, goats, and brown cows).
- Graphic to show future drought impacts
- Numbers not enough, show present vs. reality with temperature change
- More layman language
    - E.g. "What is agricultural drought?"
- Plants lose 3X more water than South Florida
- Visual of local production vs. import for different parts of Caribbean
- Mention of cultural attachment to ag production
- Check warming statistics for US Caribbean (2.5 degrees F)

Group 5

- *Short term*
    - Animal loss
    - cattle
    - heat stress
    - overgrazing
    - Milk quality for human consumption
    - Beef quality
    - Hay shortage
    - Water shortage
    - Difficult for farmers to wash crops / sanitation
    - Produce characteristics
    - Size (significant decrease)
    - Quality
- *Long term*
    - Hay shortage
    - Increase pricing / seed
    - Increased Ag. Pricing
    - Seed
    - Fertilizer
    - Erosion
    - Water table
    - Well water management
    - Salinity intrusion
    - Overgrazing
    - Decrease in feed plants
    - Increase in scrub
    - Water quality
    - Cistern / catchment
    - Loss of mature trees
    - Wildfires
    - Pollinators in urban areas
    - Residents kill pollinators
    - Clear-cutting
    - Run-off / silt
    - Erosion
    - Lack of filtration
    - Loss of pollinators
    - Due to non-education of public about their impact on pollinators and pollinators importance in food production

Group 6

- What is goal / sustainable local ag?
- Increase to 40% in 16 years
- Limits: land, water, technology
- More efficient water storage and distribution
- Need a seed bank – production and biodiversity
- Resistant to pests, temperatures, salinity
- Also for farm breeds
- Consumption: plantains
- Increase salinity: due to groundwater pumpage, drought and climate
- Soil and groundwater
- Canals
- Short term more vulnerable to pests
- Conflict in water use- Ag vs. people
- Short and long term: H20 and land for agriculture due to salinity
- Long term
- Cost of food productions – unaffordable
- Migration of ag labor
- Waste management- water needed for it

Streamflow in Puerto Rico representative of two periods (L) 2008 2013 versus (R) 2014 2016. Photo credit: Pablo Gutierrez Fonseca

Drought impacts to ecosystems

Group 1

- Ecosystem services
  - Coastal protection (resilience to storm damage, habitat)
  - Water quality (filtration, pH, salinity, temp, nutrients, increase concentration of contaminants / sanitation)
- Feedbacks to climate - (loss of veg changes microclimate, albedo, temp, RH)
- Sedimentation
- Ecotourism (swimming holes, hiking, fishing)
- Decrease in biodiversity, species composition shifts, habitat loss
- Increase in invasive species
- Forest livelihood / fisheries
- Cultural losses
- Decrease pollination
- Soil microbes – nutrient dynamics
- Water storage
- Flood mitigation
- Salinity – impacts on oysters, tourism biobays
- Species migration
- Species migrations
- Ungulates change forage patterns (deer)
- Bird migrations (local, continental)
- Food chain
- Disease and pathogens increase
- Insect pest increase
- Add reservoirs (man –made lakes) to aquatic (separate coastal? Coral, mangroves)
- Climate change feedbacks, human stressors

Group 2

- From US Drought Monitor perspective, ecological drought is underrepresented
- Anecdotal evidence, but not statistical
- More long-term studies needed
- Need historical perspective / context
- At most a few years of data on islands with centuries of recorded human history
- Identity forms of resilience in ecosystem
- Naturally occurring adaptive strategies
- Exotic species vs. native species
- Invasive species have advantage in natural disasters? (eg. Drought)
- Ecology can get tangled with human / invasive interactions
- From a public perspective, change document focus to less wordy, more informative, more relatable
- What could happen instead of what is happening
- What is more important: human impact (e.g. land use changes? Or climate change
- Coqui: cultural importance

Group 3

- Ecosystems should come up first
- Language of report is too elaborate
- Need to incorporate ecosystem protection laws in decision makes processes including agricultural at a local scale
- Relate ecosystem protection with tourism (cultural use & values: coquí, rivers, biobays)
- Benefit of canopies
- Issue of invasive flora and fauna
- Fragmented ecosystems by spreading urban areas
- Modify buffer zones along streams and coastal ecosystems

Group 4

- Need ridge to reef (spatial orientation)
- Short term
  - Mangroves
  - Ecosystems services (define and describe importance and benefits)
- Compounding stressors
- Land use change / legacy impacts
- Already operating at reduced capacity
- Coral reef / near shore ecosystems
- Invasives
- Saltwater intrusion into freshwater wetlands

(L to R) Brent Murray, Charles Gonzalez, Dorothy Sifuentes, Edwin Mas and others discuss drought impacts. Photo credit: Caribbean Climate Hub

- Highlight interesting changes over time
- Tourism + ecotourism
- Ecosystem service, most important source of income
- Make culturally relevant
- E.g. species examples (coqui, etc)
- Lose resilience
- E.g. storm / hurricane protection
- USVI no long term data
- Data gaps separate sections
- Investigate how ecosystems respond to drought
- Potential job loss
- Ecosystems as educational tool – job growth

Group 5

- *Short term*
  - "What is ecological drought"
  - birds lose nesting area
  - Loss of amphibian species
  - Increase in invasive reptile population
- *Long term*
  - Loss of larger trees
  - Loss of wetland ecosystem
  - Mass erosion
  - Permanent loss of ecosystems
- Aquatic
  - *Short term*- Permanent loss creveshi (crawfish indigenous to VI)
  - Long term- Loss of coral, leading to loss of habitat for fish
  - Increase in overall water temp
  - Loss of possible revenue for fishing and hotel industry
  - Increase in aquatic algae
  - Water hyacinth blooms: can choke out fish and other species

Group 6

- Reword definition – in "rice and beans"
- Differences – mainland PR vs. Vieques and Culebra
- Mention impact on pollinators
- Ceti as food – cultural significance, economic
- Livelihood River Shrimp
- Competition between human and ecosystem uses and ag
- Rio Grande de Arecibo, Añasco
- Mangroves – lack of storm protection, economic effects
- Tourism, sport fishing
- Potential sediment increase in acute precipitation event
- Hyper salinity (evaporation, intrusion)
- Vulnerability + predation (word difficult to make out on poster) all along the system
- Add section on "Decision points + call to action"
- "Try to learn something about everything and everything about something. " -Thomas Henry Hux

Data gaps for U.S. Caribbean Drought

Group 1

- Money – specific RFAs for drought monitoring
- Both data access and acquisition
- Partnerships
- Variable missing / under-monitored (fill spatial and temporal gaps)
- Soil moisture / temp
- Weather stations (USVI)
- ET, Rnet (SW +LW), RH, temp, RF, wind speed, direction
- Groundwater monitoring
- Ecological monitoring
- Farmer app for irrigation scheduling and planning (eg. Florida)
- What data need to inform irrigation this?
- Translation of data to actionable products
- Extension agents…

- Decision support tools (DST) – coproduction
- Access – data portals, education, outreach
- Real-time, easy access
- Recovering post-disaster, communication

Group 2

- Data needs
- Trophic interactions
- Hydrologic monitoring tool with predictive abilities
- Refine network
- Need more stations on undammed / unregulated streams (unregulated headwater streams)
- Plan de Agua
- Need technical support to automate drought monitoring
- Start now! For work in 20 years
- Can we model histories / normal?
- Forest / reserve drought impact monitoring tool
- Train DRNA / agencies / NGOs before next drought
- Inventory illegal / informal water extraction
- Legal framework for environment flows

Group 3

- Data needs
- Drought early warning signs / indicators
- Temperature / wind
- Precipitation
- Groundwater levels
- Resiliency / trade off (costs, values)
- Understanding of thresholds for ecosystems / crops / humans
- Potential evapotranspiration, spatial distribution
- Compliance law – policy to support data needs and drought management / forecast
- Drought mitigation plan

Group 4

- General comments
- High quality hydrological and meteorological monitoring (specifically USVI)
- Long term ecological (LTER) needed in USVI
- Analysis of how well remotely sensed products are able to fill in data gaps
- Natural disasters: archive data in advance, during and after
- Difficulty resolving microclimate difference
- Solution: more experimental analysis
- More analysis of long-scale teleconnections impact on US Caribbean (Sahara dust)
- **Group 5**
- Soil analysis (historical)
- Aquifer recharge
- Soil nutrient availability
- Historical precipitation data
- Chart more understandable for common people
- Public knowledge (how much do they know)
- Well data (number of wells in use and rate of water consumption)
- High resolution re-analysis data for VI

Group 6

- Identify data gaps- this is a data gap
- Types of data needed:
- Atmospheric, hydrologic, ag, ecosystems
- Data portals – thematic?

Aerial view of St. John, USVI. Photo credit: News of St. John (Link)

Group 1

- n/a

Group 2

- There's plenty of water in PR for humans- ag?
- Little conservation practices various scales
- Lots of water loss in distribution systems (57% loss)
- People dependent on wells manage water better than those dependent on municipal supply – why? Lessons?
- Lack knowledge water supply: aquifers, springs and WCP (?)
- Fish kill – present in reservoir systems
- Solutions
- Revise land use practices to minimize sediment in dams and ponds, (probably dredging?)
- Fixing / invest in water distribution infrastructure
- Implement water conservation strategies at home (cistern efficient toilet)
- Decentralized distribution systems – isolated communities have cistern systems
- Education campaign for water conservation practices
- Balancing management of aquifers and reservoirs (probably already happening)
- Finalize emergency drought plan
- Small, affordable filtration systems to drink well-water
- Grey water reuse

Group 3

- Zonification of urban / economic sectors.
- Find funding solutions
- Increase water storage in lakes, and consider the tradeoff
- Improve the energy model of the water distribution system
- Increase ag best practices & reduce inconsistencies among state / fed policies / incentives
- PR: more rainwater harvesting / change building code – conservation (residential) measures

Group 4

- Plant trees, conservation cover, agroforestry (shade coffee)(seagrapes + mangroves (green infrastructure co-benefit)
- Conservation tillage, no-till
- Fast-growing food source for fauna (legumes, moringas N-fixing)
- Irrigation scheduling based on evaporation
- Include USVI in drought monitor
- More reservoirs (tradeoffs) not dams
- Understand current water use practices, understand cultural differences between islands
- Better understand distribution, map infrastructure including illegal / unmanaged withdrawals
- Overall systems assessment
- Increase aquifer recharge
- Improve water management
- Utilize wastewater, promote greywater re-use
- Write water management plans (USVI)
- Encourage university monitoring
- Leverage NSF connections

Group 5

- Incorporate more water catchments
- Plant more native species that are drought resistant
- More education for public
- Repair water distribution infrastructure (old pipes)
- Develop new irrigation techniques
- Be aware of best techniques and technology that improve water conservation
- No matter where it comes from
- Use recycled water (wastewater)
- Incorporate more drought resistant livestock (goats, rabbits)

Group 6

- Communities to decision-makers and money / power
- Monkey only dances when you pay him
- Modernize (make resilient) water infrastructure – interconnections for water supply
- Increase water storage (dredging res., infrastructure, watershed protection, ground water storage)
- Develop science-based management and tools at appropriate S+T scales (eg. Watershed budgets)
- Inventory of water users
- Tools, outreach, implement for various sectors (residential, community, agricultural, industrial) for BMPs
- Evaluate benefits of ecosystem services (include money) and effects of land use practices
- Create listserv of diverse expertise for capacity building / sharing information (potential host: PRsciencetrust.org

Caribbean drought resources

Water Resources of the Caribbean

Website: https://pr.water.usgs.gov/
Managed by: USGS, Caribbean Water Science Center
About: The Caribbean Water Science Center (CWSC) is one of 48 Water Science Centers in the Water Resources Discipline of the U.S. Geological Survey (USGS). The Water Science Center's mission is to collect, analyze and disseminate the impartial hydrologic data and information needed to wisely manage water resources for the people of the United States and in Puerto Rico.
Data available on:

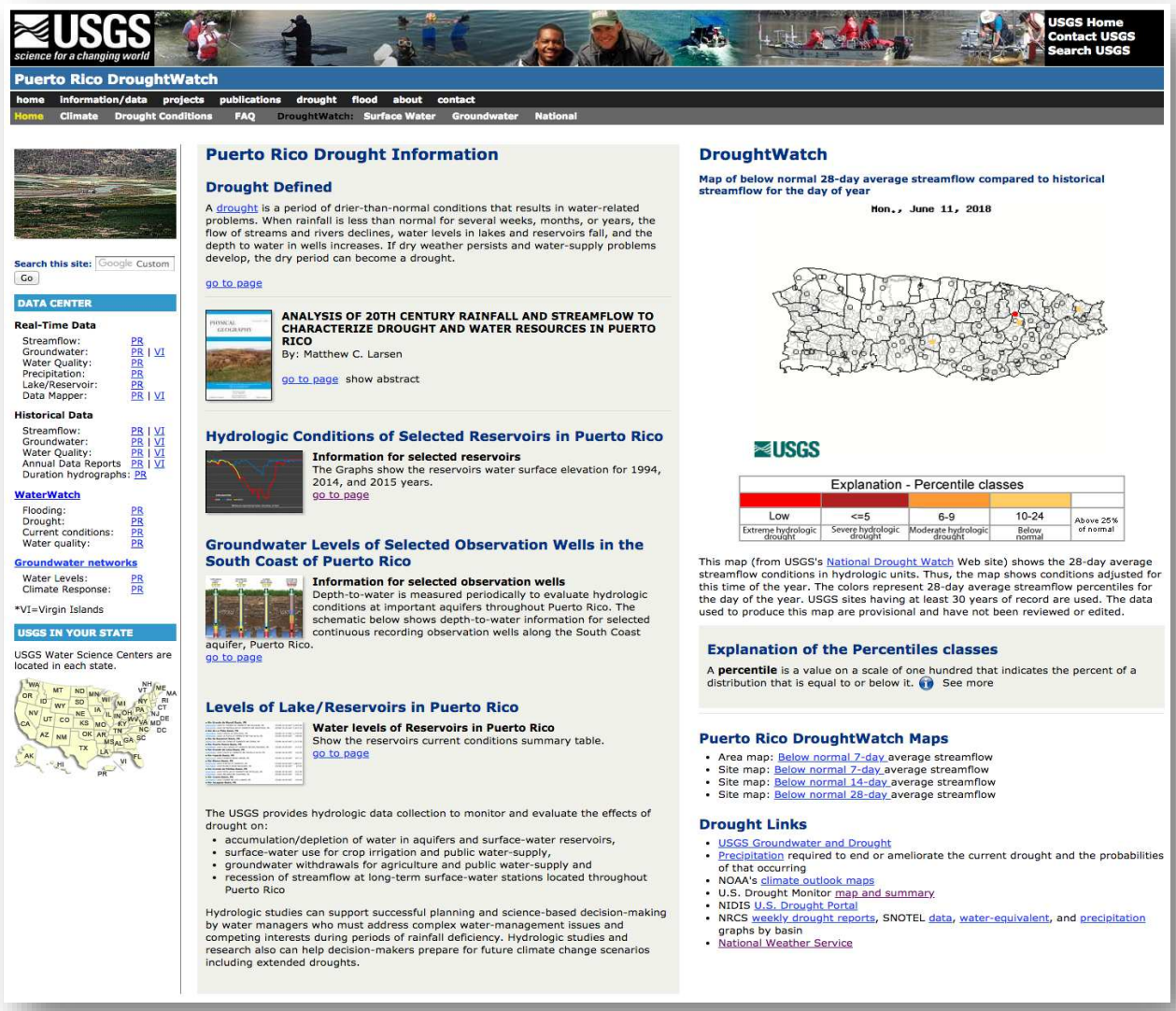
- Streamflow, reservoir, and lake data
- Ground-water data
- Continuous and discrete water-quality data
- Water-use data
- Geographic Information System (GIS) data

Puerto Rico Drought Watch

Website: https://pr.water.usgs.gov/drought/
Managed by: USGS, Caribbean Water Science Center
About: The Puerto Rico Drought Watch page is a collection of information relevant to drought in Puerto Rico.

Data available on:

- Reservoir levels
- Groundwater levels
- Below normal streamflow



Puerto Rico Agricultural Water Management

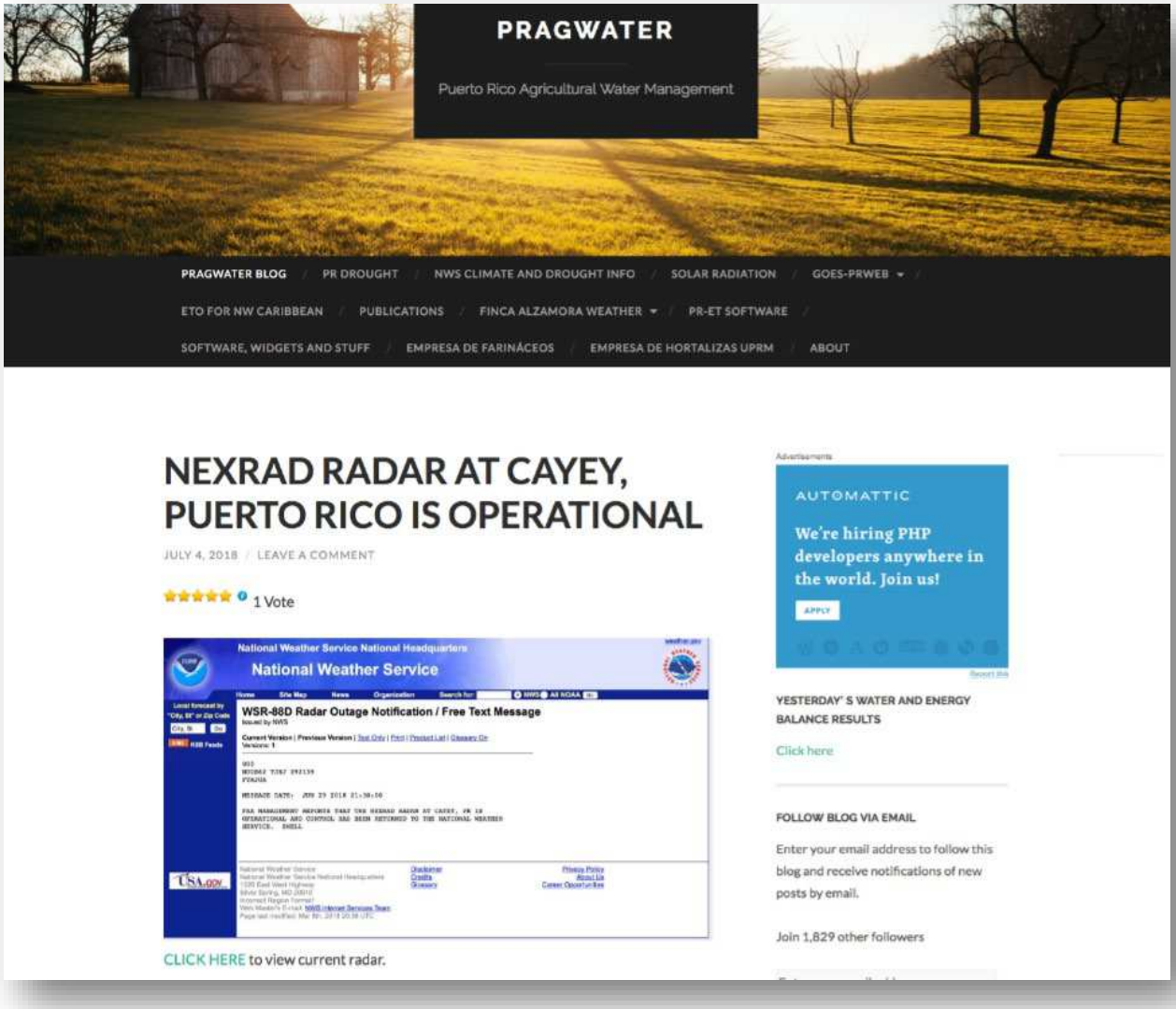
Website: http://pragwater.com

Managed by: Eric Harmsen, Ph.D. Department of Agriculture and Biosystems Engineering, University of Puerto Rico- Mayagüez

About: Collection of data relating to Puerto Rico and Caribbean agricultural water management

Data available on:

- Daily reference evapotranspiration for Puerto Rico, USVI, Hispaniola, Jamaica and Cuba
- NWS climate and drought info
- Hourly and daily solar radiation



United States Drought Monitor

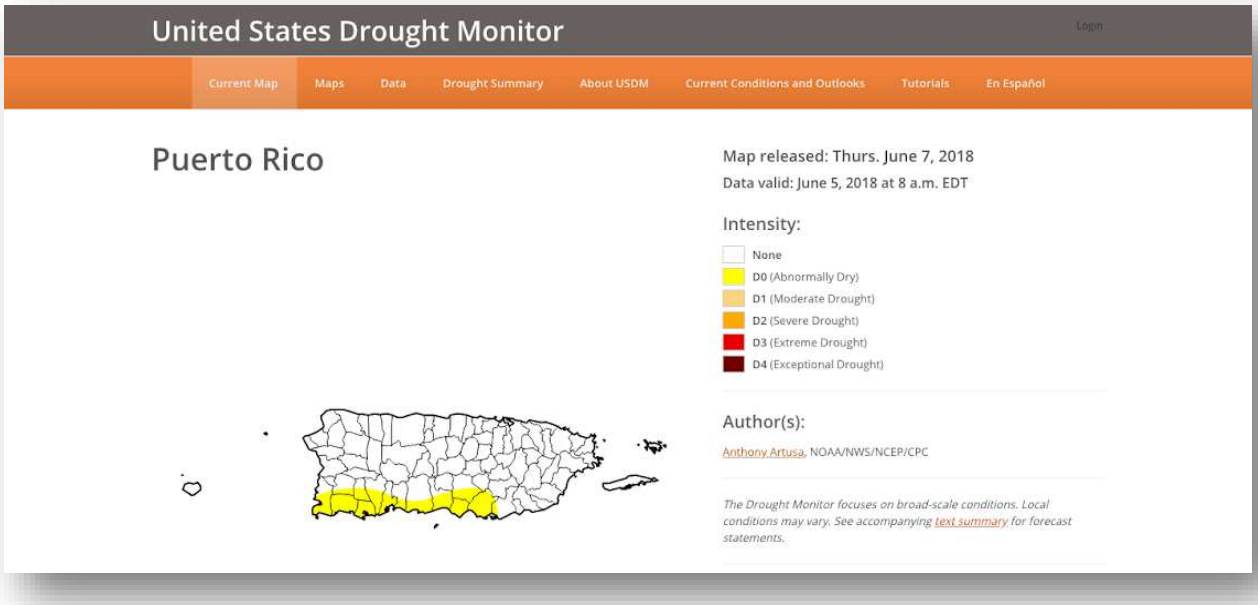
Website: http://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?PR

Managed by: the National Oceanic and Atmospheric Administration, the U.S. Department of Agriculture, and the National Drought Mitigation Center at the University of Nebraska-Lincoln

About: The U.S. Drought Monitor is used by policymakers and media in discussions of drought and in allocations of drought relief. The U.S. Department of Agriculture's Farm Service Agency uses the U.S. Drought Monitor to distribute relief through the Livestock Forage Disaster Program, the Livestock Assistance Grant Program, and the Non-Fat Dry Milk Program. The Internal Revenue Service also uses the U.S. Drought Monitor to determine the replacement period for livestock sold because of drought. As part of its response to the drought of 2012, the U.S. Department of Agriculture streamlined the process for secretarial disaster declarations, making declarations nearly automatic for a county shown in severe drought on the U.S. Drought Monitor for eight consecutive weeks.

Data available on:

- Puerto Rico drought time series
- GIS data on spatial coverage of drought



Results and products

Factsheets - Drought impacts in the U.S. Caribbean
In an effort to summarize drought impacts in the U.S. Caribbean, several factsheets are currently in development on the following topics:

- Agriculture
  - Crops
  - Livestock
- Ecosystems
  - Tropical forests
  - Streams
  - Estuaries
- Water supply
- Future climate

Collection of oral history of island drought
NC State University and the National Climate Adaptation Science Center carried out recorded interviews during the drought workshop with select participants. The interviewees described the societal and cultural impacts of island drought, and the unique challenges island regions face in periods of drought.

Experimental Drought Monitoring for USVI

A listserv for USVI drought monitoring was created after the U.S. Caribbean Drought Workshop. The listserv, managed by Brad Rippey and Brain Fuchs of the U.S. Drought Monitor, is the focal point of discussions regarding the expansion of the U.S. Drought Monitor to the USVI. To join the listserv contact:

Brad Rippey (BRippey@oce.usda.gov)

Brian Fuchs (bfuchs2@unl.edu)