Drought Monitoring and Planning:
Case Studies from the United States





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Caribbean Drought Training Workshop, Kingston, Jamaica, May 22-24, 2012

Tailored Drought Planning

- **Steps based on experience and lessons learned**
  - ***Wilhite's 10 Step Planning Process***
- **Each entity will undergo it's own unique process based on goals, time, resources, etc.**
- **Case studies highlight these differences**

Step 1	Creating Political Momentum and Authority
Step 2	Strategic Planning and Coordination
Step 3	Fostering Involvement and Common Understanding
Step 4	Investigating Drought Monitoring, Risk and Management Options
Step 5	Writing a Drought Plan
Step 6	Implementing a Drought Plan

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Case Studies: United States

- **United States drought planning**
  - o State of Nebraska ***(on your flash drive)***
  - o Hualapai Tribe, Arizona
  - o State of Hawaii
    - o Micronesia
    - o Caribbean?

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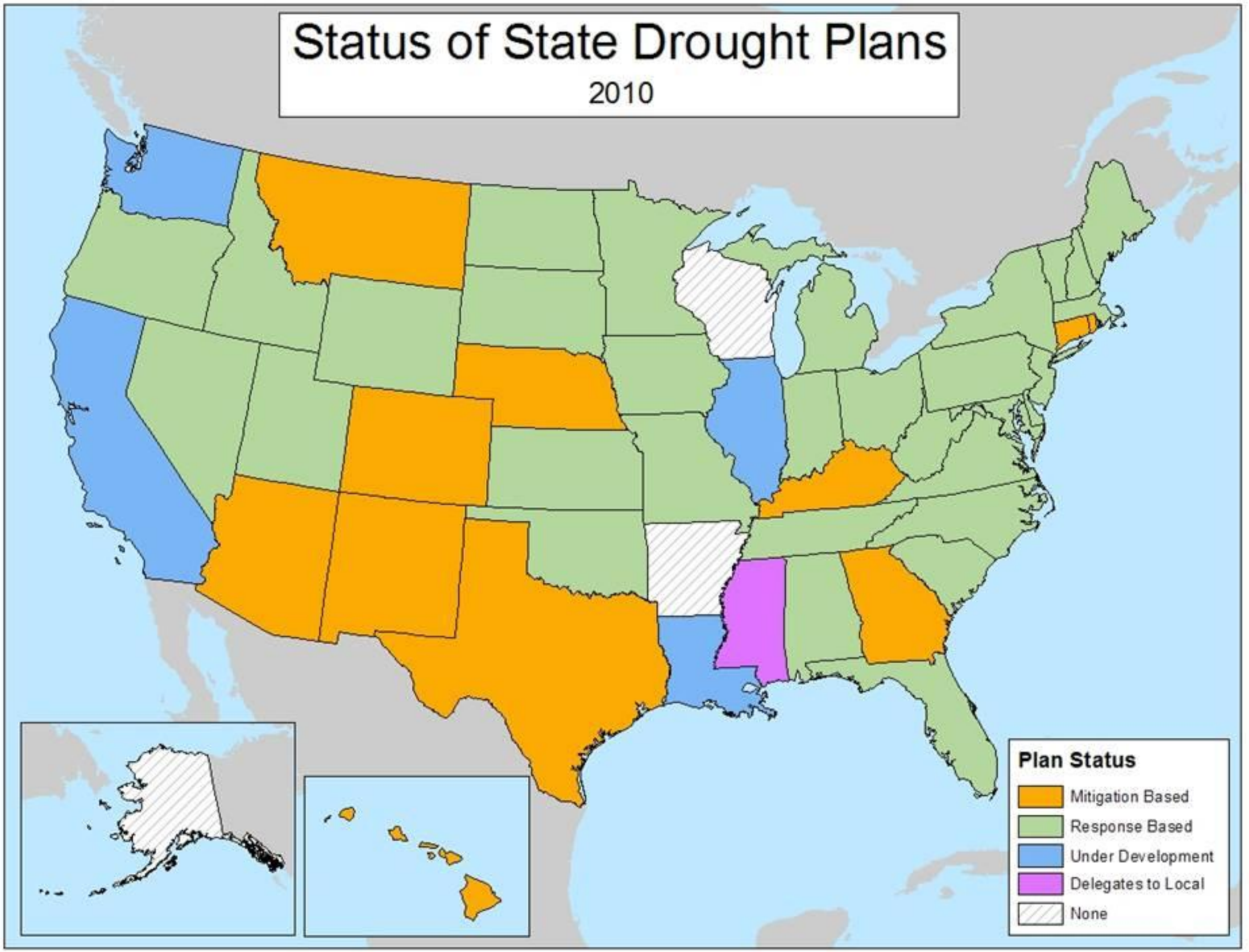

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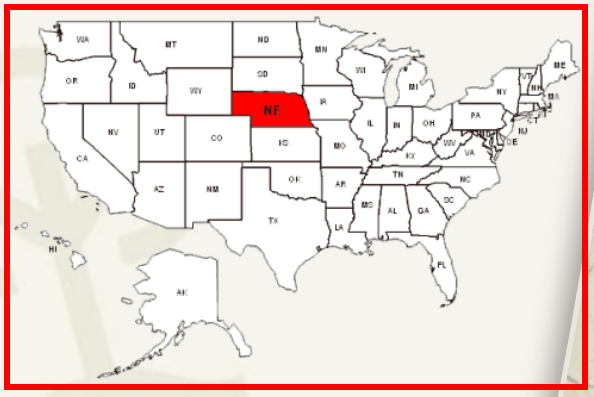
State Drought Planning: Nebraska

Economy:

- **Agriculture** (corn, wheat, soybeans, and cattle), **tourism**, **industry, energy production**



Nebraska Drought Planning

- 1986, 1990, 2000 Drought Plans

Governor mandate: update plan to include mitigation

NE Climate Assessment and Response Committee:

- Policy Research Office
- Department of Agriculture
- Department of Natural Resources
- Health and Human Services
- Emergency Management Agency
- University Cooperative Extension Service
- State Conservation and Survey Division
- Nebraska Livestock Producer
- Nebraska Crop Producer
- Others as the Governor deems necessary

Monitor, Research, and Plan for Climatic Emergencies

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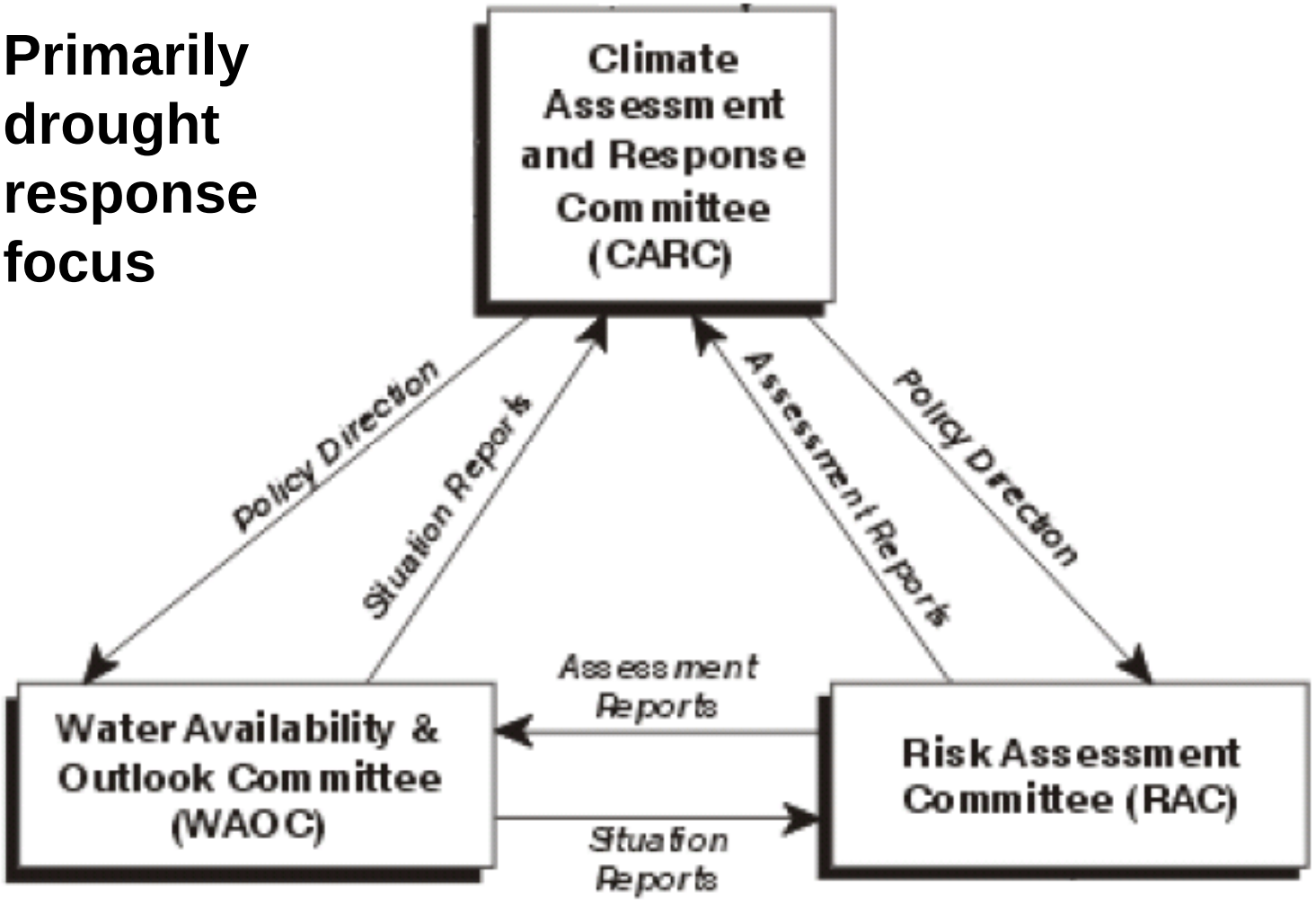
Primarily drought response focus



Monitoring

Assess Impacts
(during drought)

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Nebraska Drought Planning Process

Working Groups: any interested person/agency

Participants: 32 public and private entities

Established Subcommittees:

- Agriculture, Natural Resources, and Wildlife
- Municipal Water Supply, Health, and Energy

Ex) Nebraska Municipal Water Supply, Health, and Energy Subcommittee

Drought Impact Ranking

1. Municipal water supply shortages
2. Rural water district mechanical problems
3. Private well water quantity and quality problems
4. Excessive irrigation pumping/aquifer conflicts
5. Mental anguish
6. Industrial users drawing down aquifers
7. Health problems from blowing dust
8. Temperature extremes/increased electrical usage

Ex) NE Municipal Water, Health, and Energy

Impact:

- Municipal water supply shortages

Potential Actions:

- develop a list of "problem systems"
- emphasize water conservation
- work with utility companies to distribute information
- develop programs on the use of wastewater
- emphasize drought mitigation and response plans

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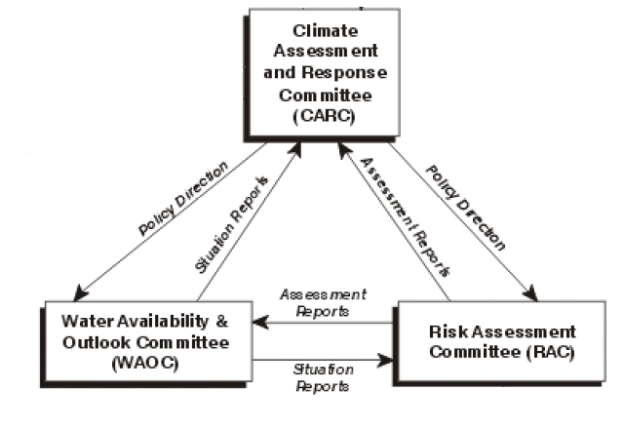
Nebraska Drought Monitoring



Water Availability and Outlook Committee (WAOC)

Nebraska State Climatologist (Chair)
National Drought Mitigation Center, UNL
Conservation and Survey Division, UNL
Cooperative Extension Service, UNL
Department of Natural Resources, State of Nebraska
Natural Resources Conservation Service, USDA
National Weather Service, NOAA
U.S. Geological Survey, DOI
Bureau of Reclamation, DOI

Monitor conditions on regular basis, meet three times per year, and report to CARC during their meetings

- precipitation, temperature, soil moisture, stream flow, groundwater, reservoir and lake levels, and snowpack

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The Objectives of the WAOC are:

1. To work with CARC to define drought for various applications and develop triggers that will initiate and terminate mitigation and response programs and actions;

2. To inventory current observation networks and make recommendations on the expansion or improvement of those networks;

3. To develop a comprehensive monitoring system for drought that incorporates current and emerging technologies to monitor all principal components of the hydrological system;

4. To identify, in collaboration with CARC, drought management areas of the state that reflect various levels of vulnerability to drought conditions; and

5. To recommend potential mitigation and response actions to CARC.

Step 1 — Creating Political Momentum and Authority

- ✓ *NDMC urging/mandated by the governor*

Step 2 — Strategic Planning and Coordination

- ✓ CARC and *sub-committee formation*

Step 3 — Fostering Involvement and Common Understanding

- ✓ *One public meeting - limited*

Step 4 — Investigating Drought Monitoring, Risk and Management Options

- ✓ *Little assessment; no triggers*

Step 5 — Writing a Drought Plan

- ✓ *Wrote a drought plan*

Step 6 — Implementing a Drought Plan

- ✓ *No responsible agencies; little action*

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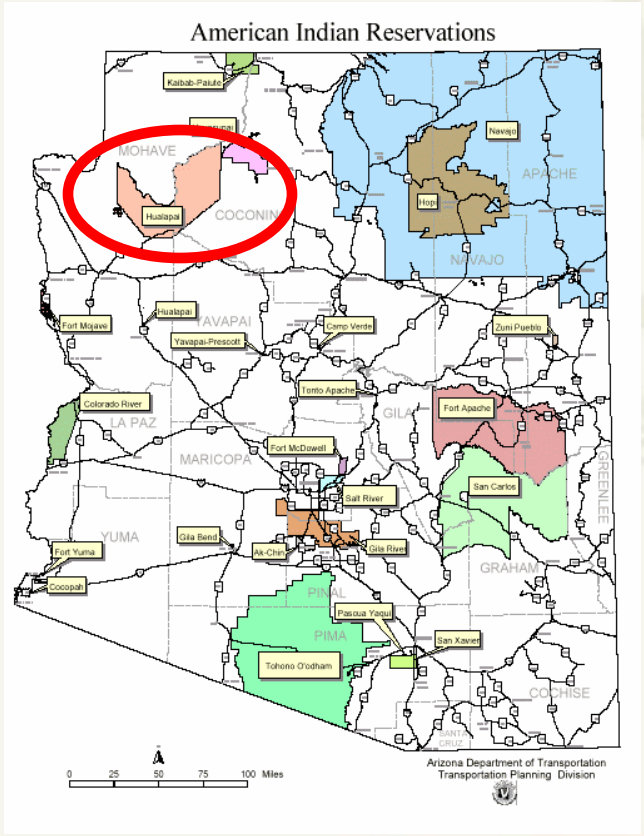
Tribal Drought Planning

The Hualapai Nation



HUALAPAI RESERVATION BACKGROUND

Location: NW Arizona

Size: 1 million acres; 108 miles of the Colorado River in Grand Canyon

Habitats: ponderosa pine forests, pinyon-juniper woodlands to dry desert scrub.

Economy: **Tourism** (river rafting, Grand Canyon tours), **cattle ranching**, **timber sales**, **big game hunting** (bighorn sheep, elk, antelope)

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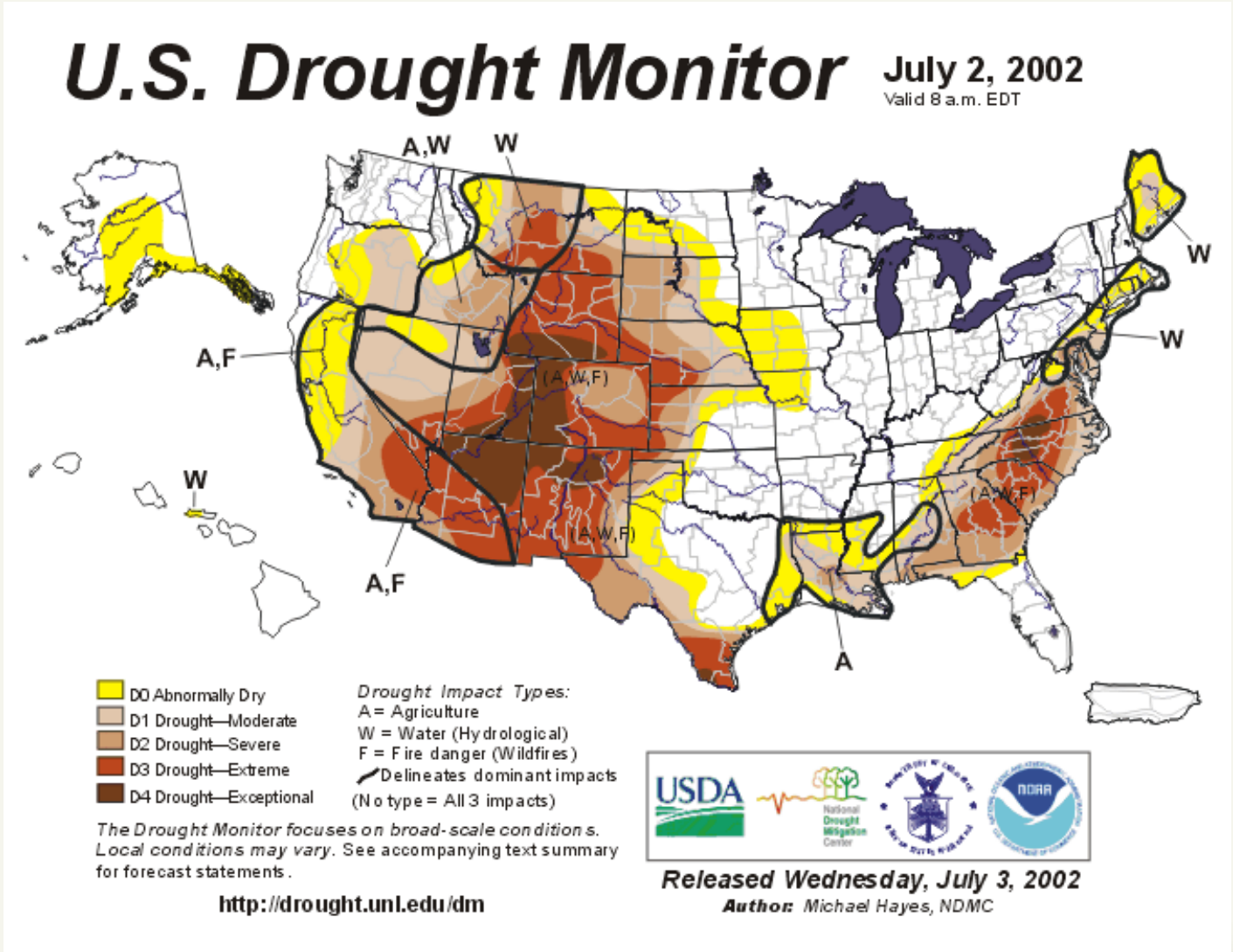
Drought Planning Focusing Event: Drought



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Drought Impacts:

- ***water shortages***
- increased ***wildfires***
- road closures - fire threat
- forage reduction
- ***invasive species***
- heavy ***culling of cattle***
- supplemental hay and ***water hauling***
- wildlife and cattle ***deaths***
- increase in wildlife ***disease***
- loss in quality of trophy bighorn sheep and elk
- reduction in hunting permits
- loss of wetlands and riparian habitat
- wind ***erosion*** and visibility problems
- river ***rafting business losses***

Drought planning funding through US Bureau of Reclamation

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Established Drought Task Force (2003)

- Agriculture Program
- Range Water Program
- Water Resources Program
- Cattle Districts
- Public Works Department
- Planning Department
- Wildlife, Fisheries, and Parks Program
- Natural Resources Department
- Forestry Program
- Hualapai Tribal Council

Project Leadership:

- **One coordinator – problem, too much work**
- **Expanded leadership and held community meetings**
  - Educated people about drought and the process
  - Fostered "buy-in" to the project
  - Gained information for the document
- **Iterative review among relevant tribal officials**
- **Fostered input on drought monitoring options, impacts and vulnerabilities**

Table 3. Drought triggering criteria across drought categories.

Drought Stage	Characteristics
Normal	PDSI between -0.9 and +5.0, Six month SPI positive.
Alert (mild drought)	PDSI is between -1.0 and -1.9 for greater than 2 months or between -2.0 and -2.9 for 1 month. Six month SPI between 0 and -0.99.
Warning (moderate drought)	PDSI is between -1.0 and -1.9 for 9 months or more, -2.0 to -2.9 for at least 2 months, or -3.0 or less for at least 1 month. Six month SPI declining and between -1.00 and -1.49.
Emergency (severe to extreme drought)	PDSI is between -2.0 to -2.9 for 9 months or more, -3.0 to -3.9 for at least 2 months, or -4.0 or less for at least one month. Six month SPI declining and less than -1.5.

Table 4. Water storage levels associated with the various drought conditions.

Drought Stage	Storage Level
Normal	Average storage $\geq$ 60 %
Alert	Average storage = 40-59 %
Warning	Average storage = 25-39 %
Emergency	Average storage $\leq$ 25 %

Depending on the stage, the plan outlines mitigation and response actions that are to be carried out by the responsible tribal agency

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ACTIVITIES UNDER "NORMAL" CONDITIONS

Agency/Entity	Activities
Agriculture Program	• Quarterly monitoring of storage facilities • Monitor utilization plots • Implement grazing plan
BIA Forestry	• Perform prescribed burns and fuel reduction • Report fire vulnerability quarterly
Range Water Program	• Install new drinkers • Purchase trash pumps • Communicate storage conditions to HDNR Director on monthly basis

ACTIVITIES UNDER "EMERGENCY" DROUGHT CONDITIONS

Agency/Entity	Activities
Agriculture Program	• Deliver domestic water by hauling • Continue monthly reporting. Hold emergency meetings when necessary. • Implement supplemental feeding • Haul water to catchments. Identify need for catchment construction. • Implement emergency grazing plan • Move cattle to forage and/or reduce stocking rate.

Test of Hualapai Drought Plan (2005)

Tribal officials were presented with drought scenarios and how they should react, in accordance with their plan

Commented on roles and usefulness of the plan

Benefits:

- **Educated new staff on the plan and their roles**
- **Identified barriers to implementation**
- **Provided suggestions for improvement**

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Further Investment in Mitigation

Estimated Hualapai Tribe drought mitigation expenditures from 2003-2007 (Kerry Christensen, Hualapai Department of Natural Resources, personal communication, March 20, 2007).

	Hualapai Tribe Drought Mitigation Expenditures					
Mitigation Activities	**2003**	**2004**	**2005**	**2006**	**2007**	**Total**
Wetland protection	$385,865	$74,000	$60,241	$100,000		$620,106
Wells and pipeline		$127,357			$289,638	$416,995
Peach Springs well		$50,000				$50,000
Range monitoring		$25,000	$25,000	$25,000	$25,000	$100,000
Water catchments			$50,000	$50,000	$50,000	$150,000
Fencing		$18,000				$18,000
Tamarisk removal			$18,706			$18,706
Total	$385,865	$294,357	$153,947	$175,000	$364,638	**$1,373,807**

Step 1 Creating Political Momentum and Authority

✓ *Tribal Authority*

Step 2 Strategic Planning and Coordination

✓ *Formed drought task force; coordinator*

Step 3 Fostering Involvement and Common Understanding

✓ *public meetings and consultation*

Step 4 Investigating Drought Monitoring, Risk and Management Options

✓ *Some research, inadequate monitoring knowledge*

Step 5 Writing a Drought Plan

✓ *Wrote a drought plan*

Step 6 Implementing a Drought Plan

✓ *Plan test; mitigation investment*

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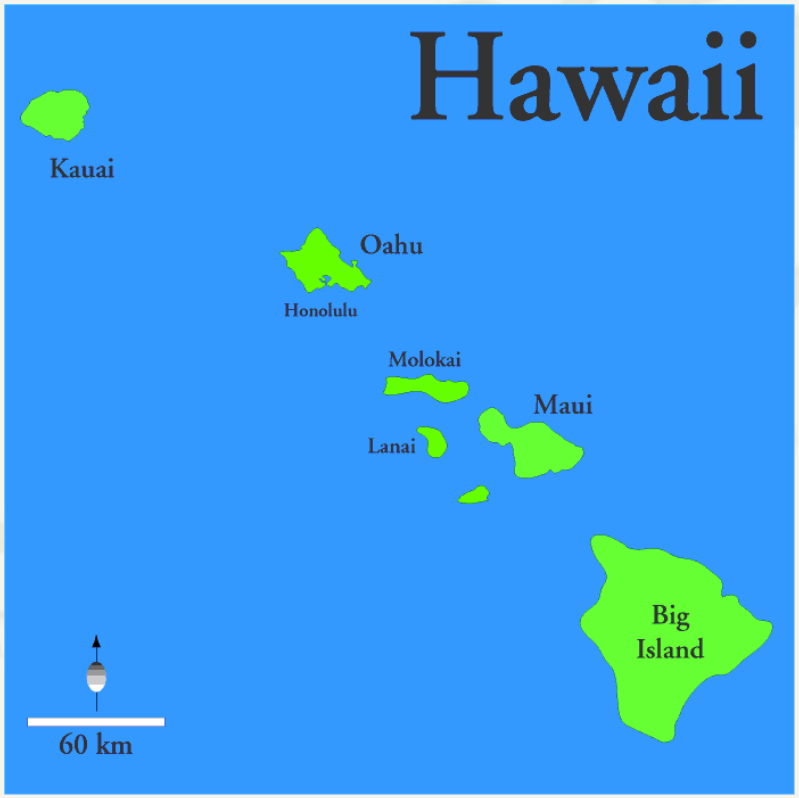
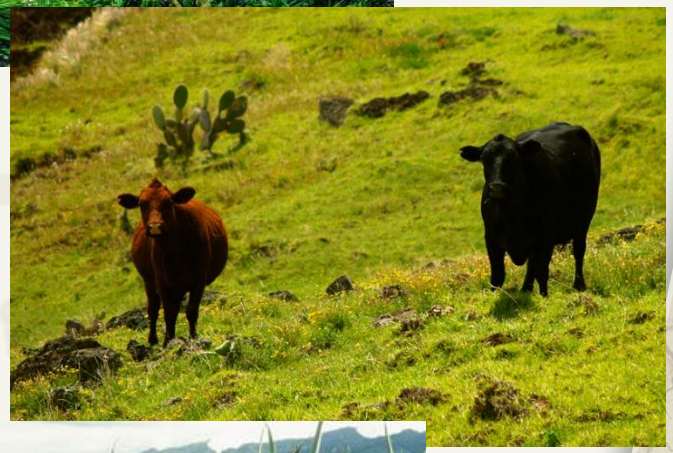
Hawaii Drought Planning and Mitigation Activities

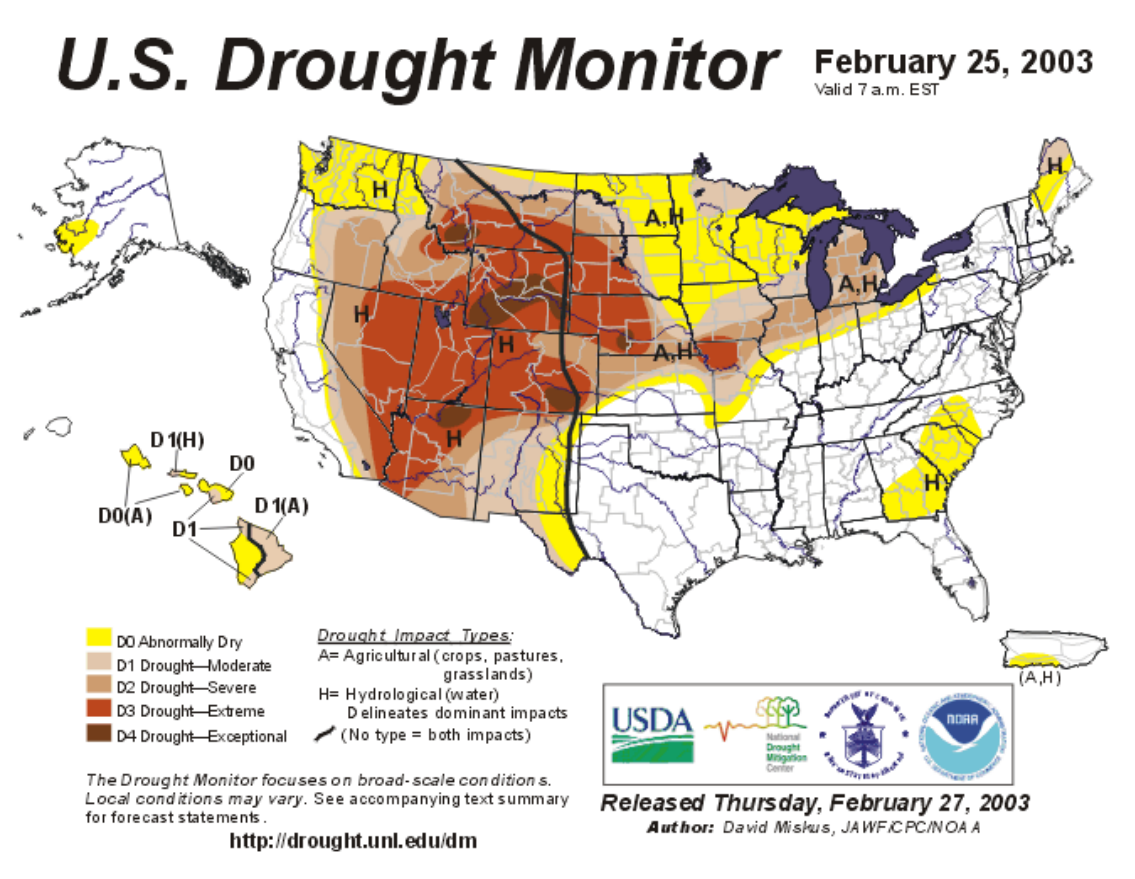


Economy:

- Tourism
- Ranching
- Farming
  - sugarcane
  - pineapple



Drought Planning Impetus: Drought



Received funding from US Bureau of Reclamation to develop plan

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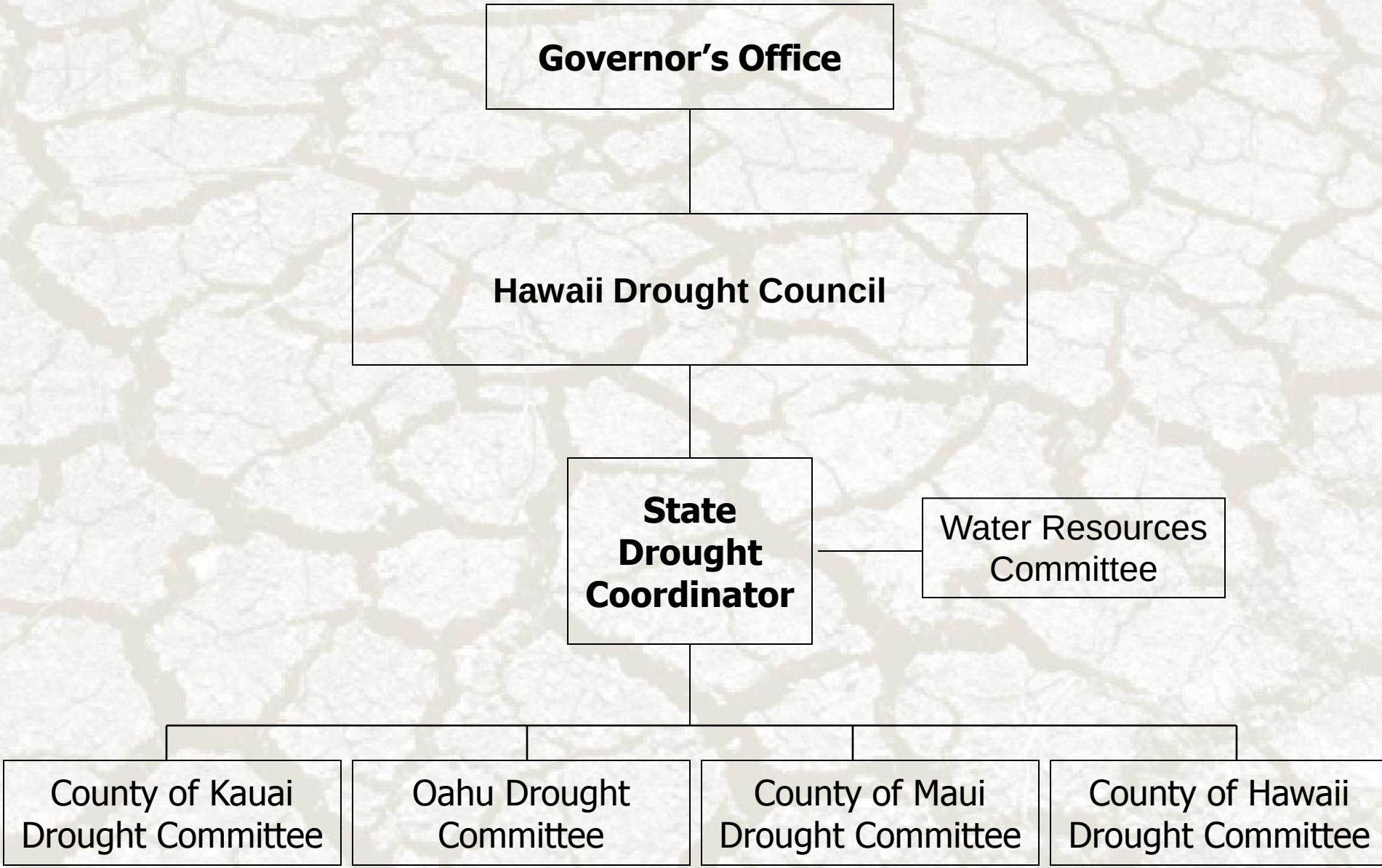
Hawaii Drought Leadership Structure



Hawaii Drought Monitor

Commission on Water Resource Management

Ke Kahuwai Pono

"The trustee who oversees the rightful sharing of water."

IMPACTS | NEWS | FORECAST | ASSISTANCE | PREPAREDNESS | RESEARCH

Click here

Current Conditions in Hawaii

U.S. Drought Monitor
Hawaii

February 2, 2010
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.1	99.6	77.1	36.9	13.0	0.0
Last Week (1/26/2010 map)	0.7	99.3	66.9	36.9	9.8	0.0
3 Months Ago (11/3/2009 map)	31.1	68.9	51.4	28.8	6.8	0.0
Start of Calendar Year (1/26/2010 map)	31.1	68.9	53.6	36.9	6.4	0.0
Start of Water Year (10/6/2009 map)	18.8	81.2	51.4	32.8	6.7	0.0
One Year Ago (2/3/2009 map)	23.1	76.9	54.7	33.7	5.4	0.0

Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

Released Thursday, February 4, 2010
Author: M. Rosencrans, CPC/NOAA

Source: National Drought Mitigation Center (NDMC)
For the United States Drought Monitor, click here.

What's New

Quick Links

- NWS Drought Information Statement
- What are the drought conditions in Hawaii?
- How is the drought affecting me?
- How can I get help?
- USGS WaterWatch
- Current Hydrologic Conditions
- USDA Hawaii Weekly Crop Weather Report (Downloadable pdf)

Department of Land and Natural Resources, State of Hawaii

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General Drought Impact Assessment

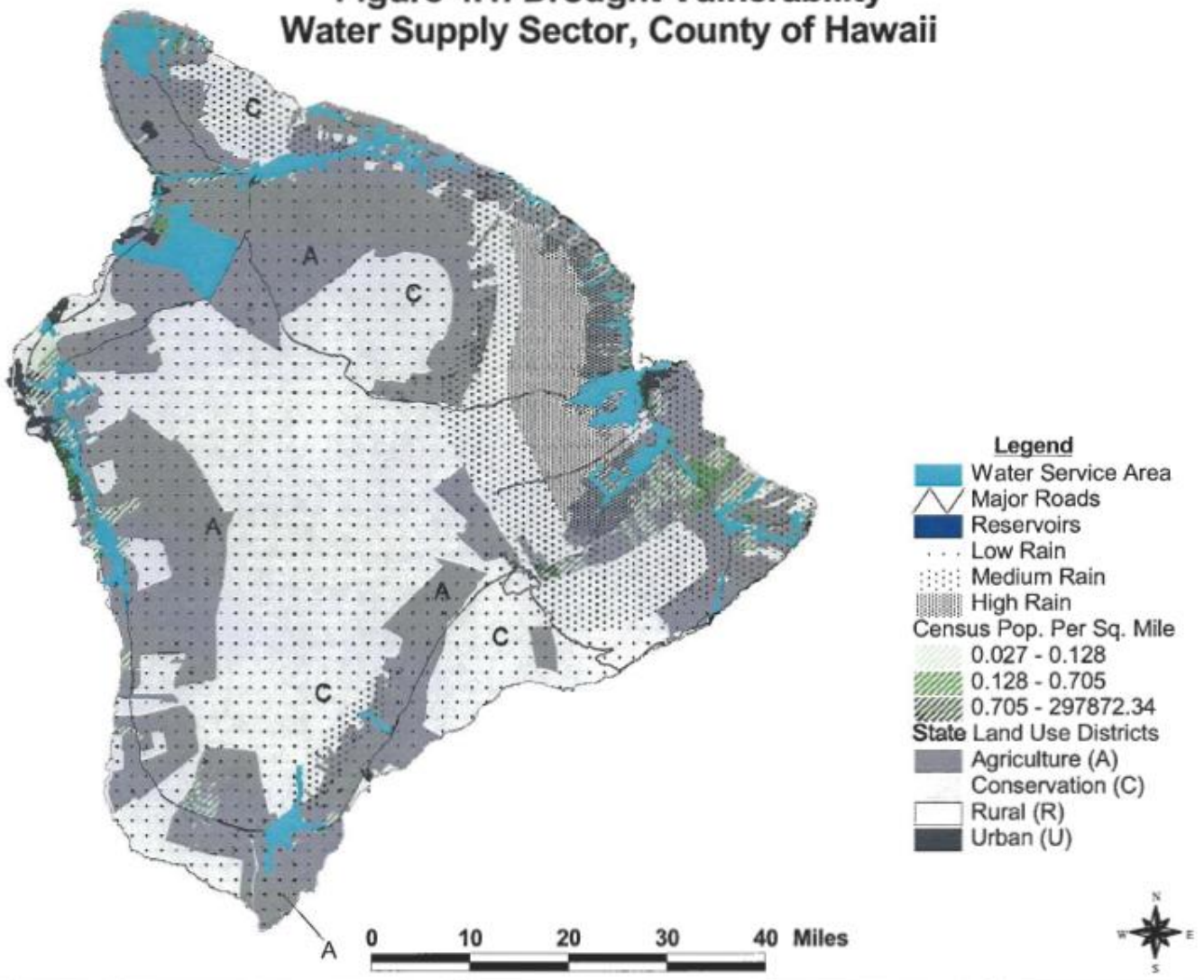
- Stakeholder Input

Table 5.4: Potential Drought Impacts

Water Supply	Agriculture & Commerce	Environment, Public Health & Safety
• Increased ground water depletion • Reservoir and lake draw-down • Reduced flow from springs • Water quality (chloride concentration, water temperature, pH, dissolved oxygen, turbidity) • Disruption of water supplies • Decline in revenue for water suppliers • Increased ground water depletion • Increased conflicts over water use • Mental and physical stress • Reduced quality of life/change in lifestyle	• Loss from crop production • Loss from dairy and livestock production • Loss from timber production • Loss from fishery production • Income loss for farmers • Unemployment from drought-related production declines • Loss to recreational and tourism industry • Loss to manufacturers and sellers of recreational equipment • Increased energy demand and reduced supply from drought-related power curtailment • Decline in food production • Reduced tax base • Loss of impaired navigability of streams, rivers and canals • Cost of water transport • Reduction of economic development • Decreased land prices • Mental and physical stress • Reduced quality of life/change in lifestyle • Population migration • Increased wind and water erosion	• Mental and physical stress • Health-related low flow problems (cross connection contamination, diminished sewage flows, increased pollutant concentrations, reduced fire fighting capability) • Loss of human life • Public safety from forest and range fires • Increased number and severity of fires • Increased respiratory ailments due to fires • Increased disease caused by wildlife concentrations • Increased conflicts over water use • Disruption of cultural belief systems • Loss of cultural sites • Reduction or modification of recreational activities • Loss of aesthetic values • Reduced quality of life/change in lifestyle • Population migration • Damage to animal and plant species • Loss of wetlands • Estuarine impacts • Loss of biodiversity • Increased wind and water erosion

Adapted from: Western Drought Coordination Council, *How to Reduce Drought Risk*, March 1998.

Figure 4.1. Drought Vulnerability
Water Supply Sector, County of Hawaii



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Drought Stages and Indicators

Table 5.3: Drought Stage Characteristics			
Drought Stage	SPI Time Interval and Value		
	Water Supply Sector	Agriculture & Commerce Sector	Environment, Public Health & Safety Sector
Normal	12-month SPI 0.99 to –0.99	3-month SPI 0.99 to –0.99	3-month SPI 0.99 to –0.99
Moderate	12-month SPI -1.00 to –1.49 for two consecutive months	3-month SPI -1.00 to –1.49 for two consecutive months	3-month SPI -1.00 to –1.49 for two consecutive months
Severe	12-month SPI -1.50 to –1.99 for two consecutive months	3-month SPI -1.50 to –1.99 for two consecutive months	3-month SPI -1.50 to –1.99 for two consecutive months
Extreme	12-month SPI less than –2.00 for two consecutive months	3-month SPI less than –2.00 for two consecutive months	3-month SPI less than –2.00 for two consecutive months

Recommended State Agency Drought Response Actions

Table 7-3: Recommended State Agency Drought Response Actions

Agency	Normal	Drought	Recovery
DOA	• Monitor reservoir levels. • Monitor stream levels at existing diversion locations. • Report any observed change in resource and ground-water aquifer conditions for irrigation source wells. • Notify system users of low reservoir conditions. • Notify the WRC, CLDCs, and SDC of declining reservoir levels. • Advise all users to prepare for possible implementation of voluntary and/or mandatory water conservation plans. • Advise and encourage water users to implement appropriate water conservation measures, wherever possible (e.g., voluntary reduction of water use for equipment/vehicle washdown and for premarket washing of produce and flowers, and utilization of efficient irrigation methods).	• Implement more frequent monitoring of reservoir, stream, and well levels. • Continue notification of system users regarding storage and supply conditions. • Implement more frequent updates to the WRC, CLDCs, and the SDC regarding storage and supply conditions, and emerging drought impacts. • Document supply conditions and drought impacts, and use this information to prepare emergency drought relief requests for submittal to the HDC. • Implement voluntary and/or mandatory water restrictions for system users. • Implement available water conservation measures and agency water shortage plans, if any.	• Continue frequent monitoring of reservoir, stream, and well levels. • Continue periodic notification of system users regarding storage and supply conditions. • Continue regular updating of the WRC, CLDCs, and the SDC regarding storage and supply conditions, improving drought conditions. • Conduct post-drought impact assessments and data collection on economic losses. • Evaluate the effectiveness of drought response and mitigation measures implemented by the agency pursuant to the drought episode. • Re-evaluate the adequacy of source and storage facilities. • Evaluate the quantity and water use for large agricultural water users.

Drought Communication Protocol

Table 7-1: Drought Communication Protocol (continued)

Drought Stage	Communication Actions and Guidelines			
	Hawaii Drought Council	**State Drought Coordinator**	**Water Resources Committee**	**County/Local Drought Committees**
Drought	• Convene quarterly HDC meetings to monitor current and forecasted drought conditions. • The Office of the Governor shall be updated quarterly on current conditions through its representative on the HDC and/or the SDC. • As conditions warrant, more frequent HDC meetings may be convened. • HDC State agency members (e.g., Department of Agriculture) may issue Public Service Announcements (PSA), water conservation and/or other Public Notices, as appropriate. • Issuance of State agency PSAs and/or Public Notices should be coordinated with the SDC.	• Based on consultation with the WRC, the SDC shall provide quarterly updated reports to the HDC (and CLDCs) on current and forecasted drought conditions. • If drought conditions worsen, monthly drought reports shall be submitted to the HDC and CLDCs. • SDC shall update and post current and forecasted drought information onto the Hawaii Drought Website. • Initiate regular monthly (and if necessary, weekly) communication and coordination with the WRC and CLDCs via email, fax, phone, or meetings.	• Convene at least quarterly to review/evaluate current and forecasted statewide drought conditions and report to the SDC. • WRC shall evaluate and incorporate CLDC drought information within reports to the SDC. • As conditions warrant, monthly WRC meetings may be convened. In this event, monthly drought reports shall be made to the SDC.	• Convene at least quarterly to review/evaluate local drought conditions and report to the SDC. • As conditions warrant, more frequent CLDC meetings should be convened. • CLDC shall communicate and notify local members regarding current and forecasted drought conditions. • Reports of drought impacts should be solicited from local stakeholders and reported to the SDC. • CLDC agency members (e.g., county water departments) may issue Public Service Announcements (PSA), water conservation and/or other Public Notices, as appropriate. • Issuance of county PSAs and/or Public Notices should be coordinated with the SDC.

Drought Mitigation Funding

- In 2007, funding was appropriated by the Hawaii State Legislature (Act 238) for drought mitigation in all Counties.
- Federal Emergency Management Agency (FEMA) funding for wildland fire mitigation on the Big Island.
- U.S. Bureau of Reclamation provided emergency drought assistance for a project on Oahu

Step 1 Creating Political Momentum and Authority

✓ *Voluntary participation; funding availability*

Step 2 Strategic Planning and Coordination

✓ *Drought Council, Coordinator, committees*

Step 3 Fostering Involvement and Common Understanding

✓ *public educational meetings*

Step 4 Investigating Drought Monitoring, Risk and Management Options

✓ *some research, management options*

Step 5 Writing a Drought Plan

✓ *Wrote a drought plan*

Step 6 Implementing a Drought Plan

✓ *responsibilities; mitigation funding*

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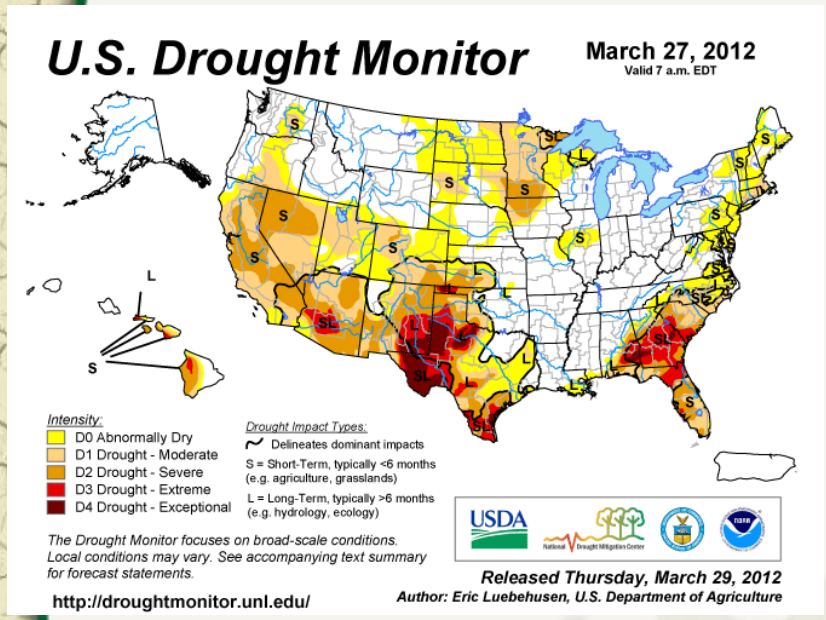
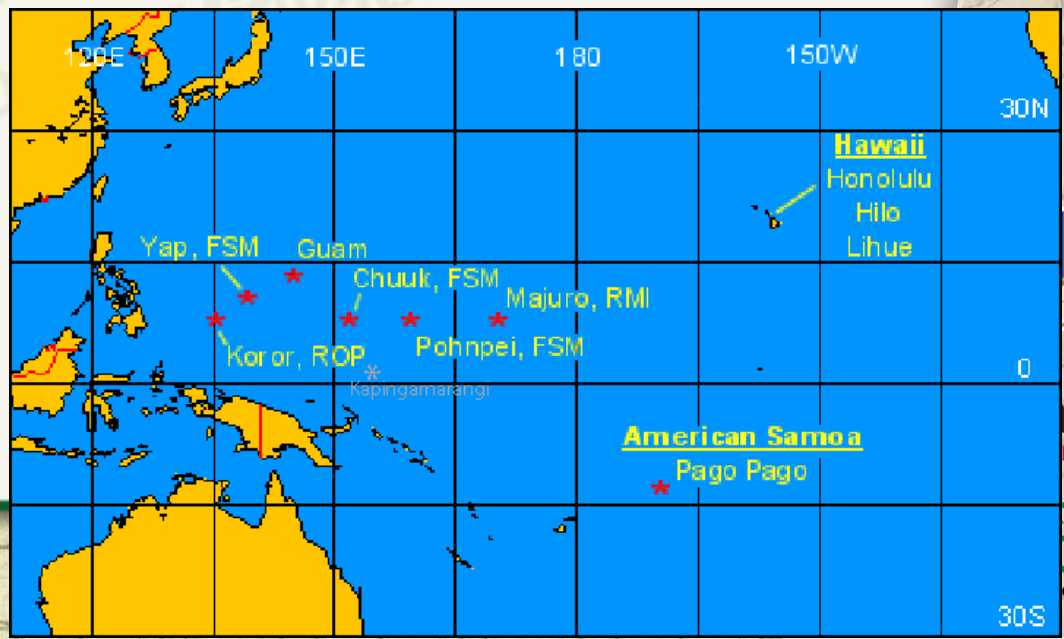
Introduction



- ✓ **U.S. Drought Monitor**
  - Geographic coverage
  - Used for drought monitoring, historical perspective, impacts, drought disaster declarations, allocation of disaster relief funds

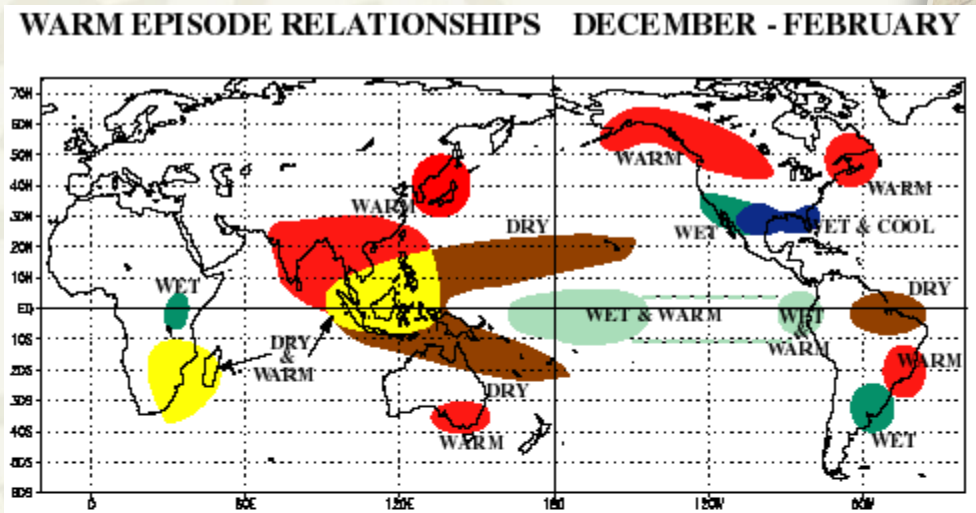
But, what about other parts of U.S.?

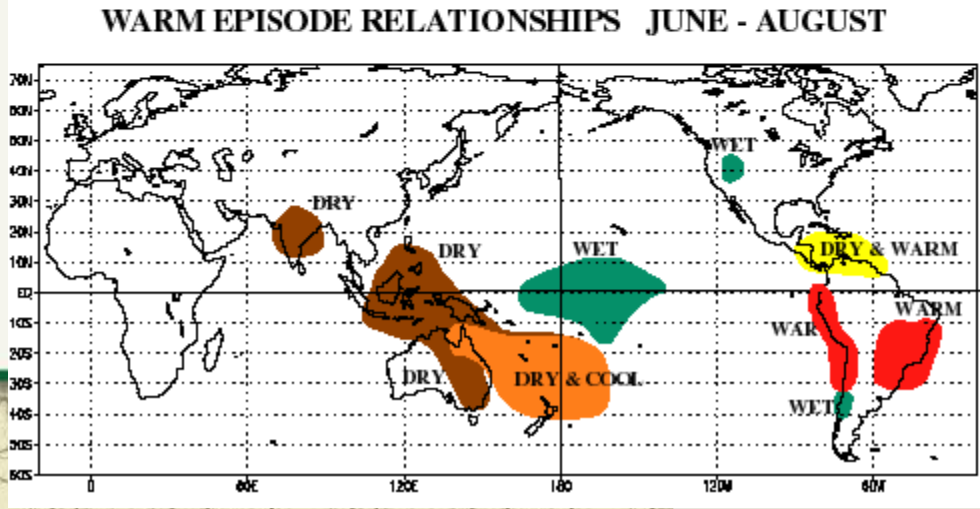
How to monitor drought there?



USDM:
Micronesia & American Samoa

- Drought is a significant issue
- Highly dependent on ENSO phase
- Can have rapid onset due to limited storage and dependence on catchment
- 1997-1998 El Nino:
  - FEMA sent portable desalination units to Majuro





If we don't have a large suite of objective drought indicators for the Pacific Islands, then how do we monitor drought?

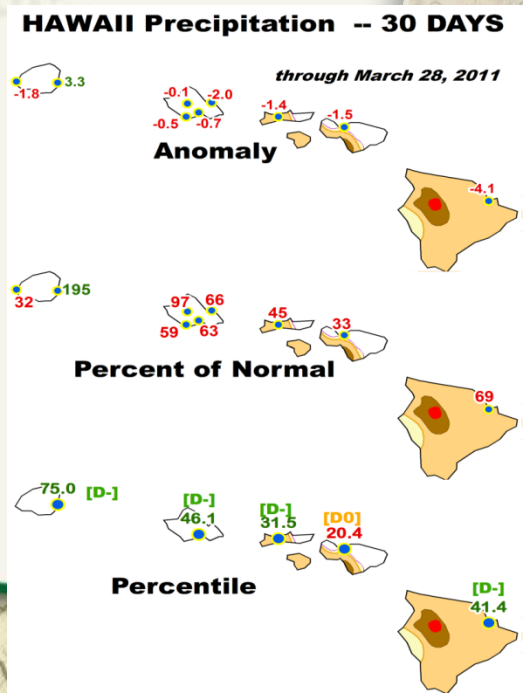
An even more basic question is: <u>How</u> is drought <u>defined</u> for a tropical island climate?

- ✓ **For these reasons, *local Pacific islanders' expertise* is crucial for getting it right – for getting Pacific Island drought monitoring done right on the USDM.**
- ✓ **BUT … the local expertise has to be *backed up by relevant on-the-ground data*. We can't just take someone's word for it or we have the possibility of *catering to special interest*.**

Drought Monitoring, Local Feedback, & Reports From the Field:
How to Do It for the Pacific Islands?

✓ **Objective Drought Indicators**

- Not many
  - ➢ Precipitation is available
  - ➢ But what about streamflow, Palmer Index, soil moisture, reservoir & lake levels, groundwater, etc.?
- NCDC exploring availability of station daily rainfall – current (real-time) and historical – to calculate:
  - ➢ Precipitation Percentiles
  - ➢ SPI
- Percent of normal rainfall
- Modeled data are also a possibility



Drought Monitoring, Local Feedback, & Reports From the Field:
How to Do It for the Pacific Islands?

- ✓ **Local Feedback & Reports from the Field -- *important***
  - Pattern after Kevin Kodama's process for Hawaii?
  - Weekly assessments of drought conditions across the Islands – conference calls (Monday or Tuesday) led by PEAC, PEAC emails USDM author summary & recommendations?
  - Agricultural & hydrological impacts – crop damage/low yield, low lake/reservoir levels, low streamflows, parched soils – historical record of measurements (or, if unavailable, based on local experience)?
  - Water restrictions (recommendations?) by local authorities, burn bans, etc.?

How is Drought Monitoring Done in the Hawaiian Islands?

- Drought Monitor in Hawaii
  - Background
  - Key partners
  - Primary impacts
  - USDM challenges in HI
- Starting the Drought Monitor in Micronesia & Am. Samoa
  - Latest progress
  - Challenges and issues
- Questions?

* From *2011 Drought Monitor Forum Pacific Islands Update* Presentation by Kevin Kodama, NOAA/NWS WFO HNL

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Drought Monitoring for the USDM in Hawaii

- Hawaii incorporated early on ***into USDM*** process
  - First noted in logs from Aug 1999 during experimental phase
- Fit well in development of ***Hawaii Drought Council and the Hawaii Drought Plan***
  - Initial planning in 2000
- Required ***broadening*** of usual hydrologist ***focus*** from flooding to drought
  - May 1999 NDMC workshop in Hilo very useful

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Key Partners for Hawaii

- Federal
  - NOAA / NWS
  - USGS
  - USDA / NRCS and FSA
- State
  - Land & Nat. Resources
  - Agriculture
  - Civil Defense
- County
  - Civil Defense
  - Water Supply
- Private
  - Cattlemen's Council
  - Coffee Grower's Assoc.
  - Others

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U.S. Drought Monitor – Data Sources for Hawaii

- Combine objective and subjective data
- Rainfall
  - % normal
  - Standardized Precipitation Index (SPI)
- Streamflow from USGS
- Reservoir levels
  - State Dept of Ag
  - Upcountry Maui, Kohala/Hamakua
- *Farm Service Agency Reports*
- Crop weather reports
- County water supply web sites
- Media
- Consult w/informal team consisting of county reps for water supply and agriculture.
  - Provides vetted input for USDM

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Primary Impacts in Hawaii

- Agriculture
  - Livestock
  - Crops
  - Fruits
  - Ornamentals

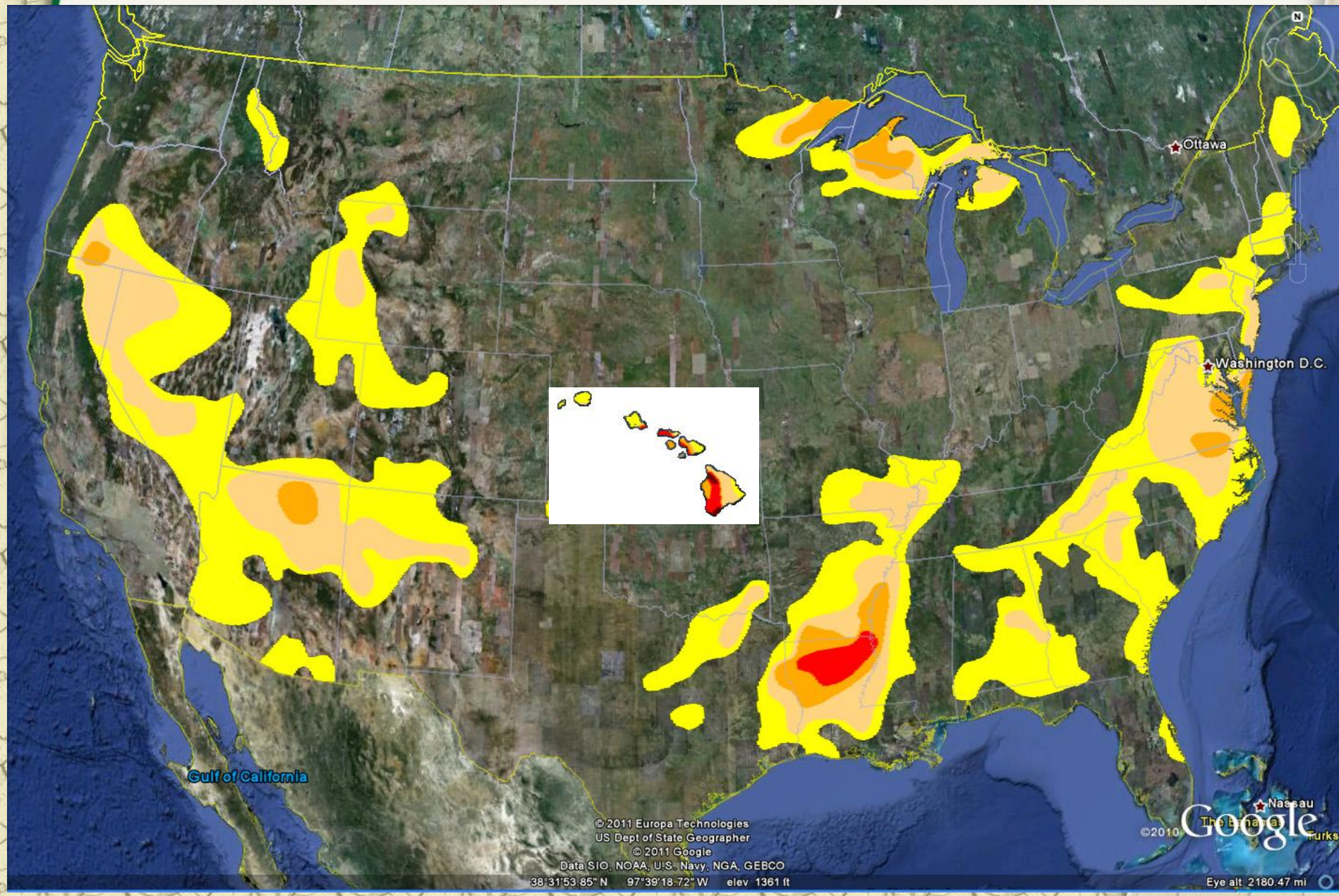
Primary Impacts cont.

- **Water Supply**
  - Surface water diversions
  - Catchment
  - Ground water (infrequent)
- Maui and the Big Island most affected due to higher reliance on surface water and catchment systems.

USDM Challenges in Hawaii

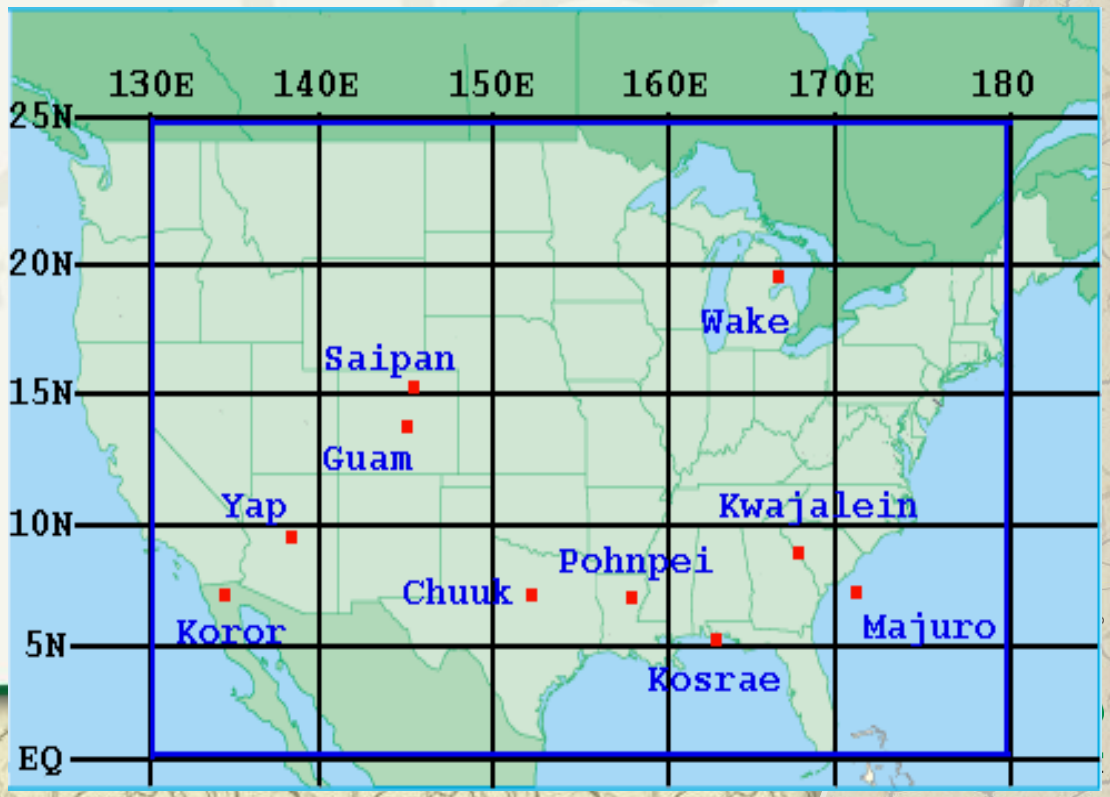
- Condense complexity of drought into a single category (for USDM purposes)
- Monitoring drought over several micro-climates
- Example: Agriculture impacts
  - Crops vs. livestock
  - Irrigated vs. non-irrigated
  - Timing
- Resolution...depicting conditions in extreme rainfall gradients

Size Considerations ...



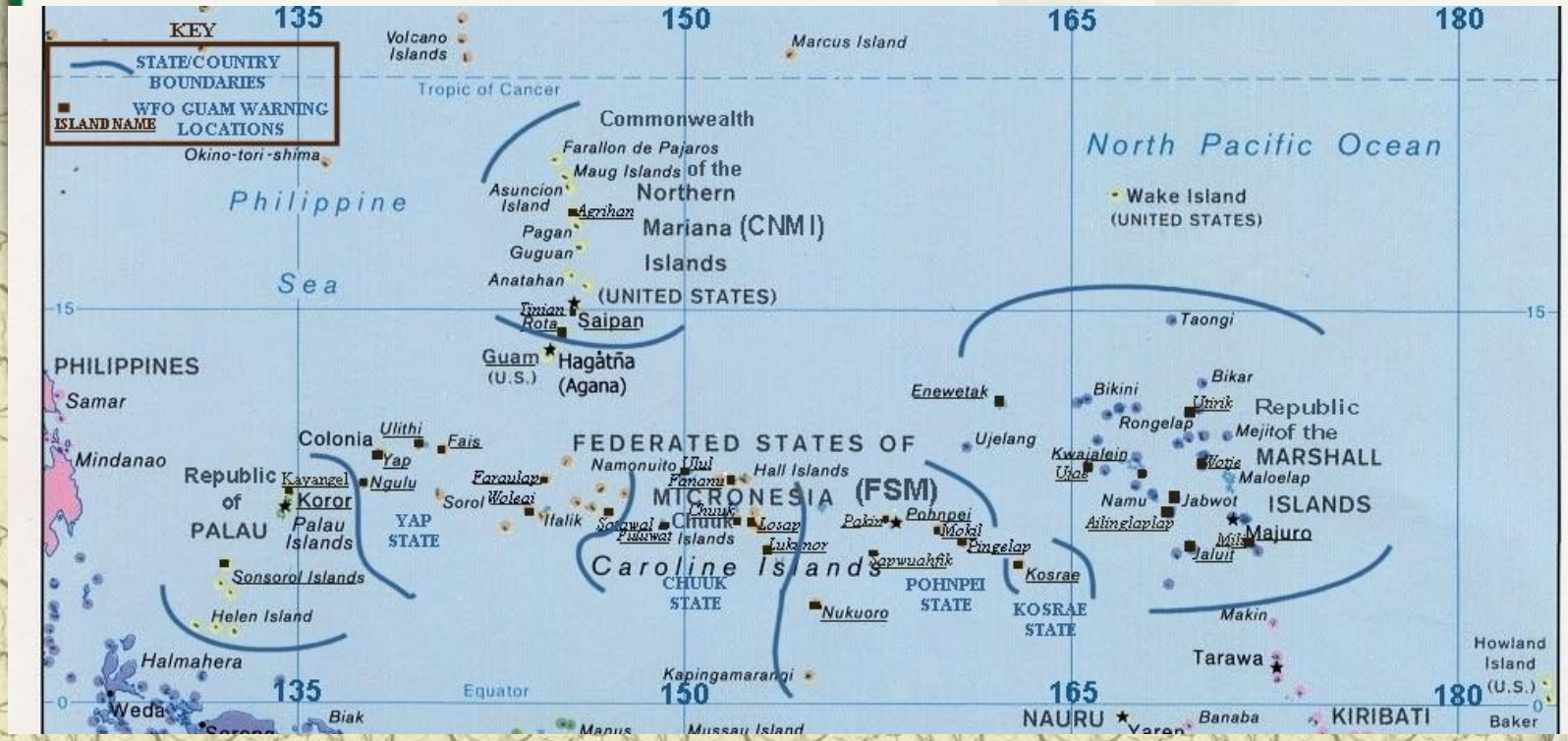
Issues

- ✓ **Large area covered, low population density**
- ✓ **Tropical Pacific island climate**
  - ➢ Meteorology, hydrology different from Mainland
  - ➢ Drought definition different – how do we define drought?
  - ➢ Impacts different
- ✓ **Sparse *in situ* data**
  - ➢ Few stations
  - ➢ Few drought indices
- ✓ **Satellite data unavailable**
  - ➢ Geography – small islands surrounded by water



Issues

- ✓ **Modeled data inapplicable**
  - Geography – small islands surrounded by water
  - Model grid box size too coarse
- ✓ **USDM weekly**
  - Need daily data, on a near-real time basis

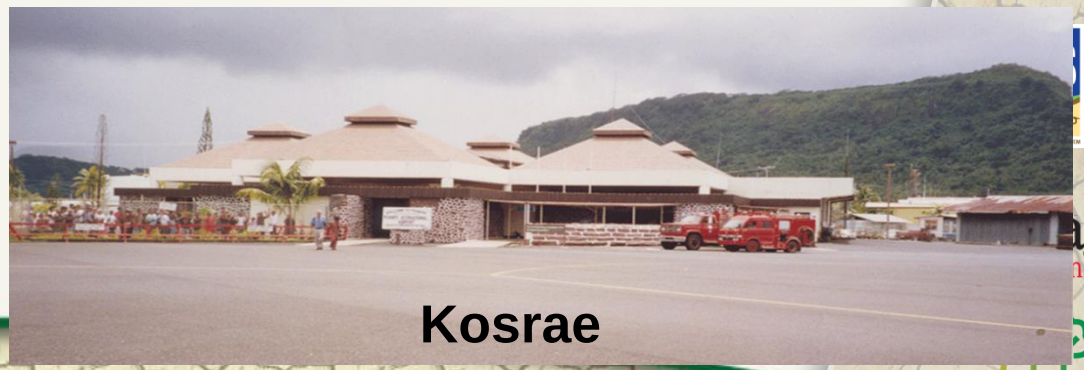


Solutions

- ✓ **Collaboration**
  - PEAC (Pacific ENSO Applications Climate) Center – Honolulu, HI
  - NWS (NOAA National Weather Service Office) – Guam
  - Local offices on the islands
- ✓ **Provide data, local observations, expertise**
  - What are drought impacts?
  - How is drought defined?


Guam NWS office

Yap


Kosrae

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Solutions

✓ Use what data are available

- Daily & monthly in situ observations of rainfall
- Assess historical & near-real time data
- Identify drought indices that can be used

SPI – Percent of Normal Precipitation

Inventory of GHCN-D Pacific Island precipitation and temperature data
(AQ = Am Samoa, CQ = N Marianas, FM = Micronesia, GQ = Guam, JQ = Johnston Is, KR = Kiribati,
LQ = Palmira Atoll, MQ = Midway Is, PS = Palau, RM = Marshall Is, TV = Tuvalu, FJ = Fiji,
WF = Wallis and Futuna, TN = Tonga, TL = Tokalau Is, NE = Niue, NR = Nauru, WS = Samoa,
Some of Marshall Is also have MH as ID)

Station ID	Lat	Long	Elev		Station Name	Precip POR	Mths	Temp POR	Mths	Precip NYRS*12	Completeness
AQC00914690	-14.33	-170.71	3.7	AS	PAGO PAGO WSO AP	1966-2011	539	1966-2011	538	552	97.6%
FJ000091650	-12.5	177.05	26		ROTUMA	1973-2011	110	1979-2011	3	468	23.5%
FJ000091680	-17.75	177.45	18		NADI AIRPORT	1961-2011	240	9999-9999	-999	612	39.2%
FMC00914751	6.97	158.22	36.6	FM	POHNPEI WSO	1951-2011	716	1951-2011	716	732	97.8%
FMC00914951	9.48	138.08	13.4	FM	YAP ISLAND WSO AP	1951-2011	716	1951-2011	716	732	97.8%
KR000091490	1.98	-157.48	3		CHRISTMAS ISLAND	1979-2011	4	9999-9999	-999	396	1.0%
KR000091610	1.35	172.92	4		TARAWA	1973-2011	25	9999-9999	-999	468	5.3%
PSC00914351	7.33	134.48	28.7	PW	KOROR WSO	1951-2011	716	1951-2011	716	732	97.8%
RMC00914375	8.73	167.73	2.1	MH	KWAJALEIN MISSLE RANGE	1952-2011	704	1952-2011	702	720	97.8%
RMC00914460	7.08	171.38	3	MH	MAJURO WBAS AP	1954-2011	680	1955-2011	673	696	97.7%
TV000091631	-5.67	176.13	3		NANUMEA	1973-2011	6	9999-9999	-999	468	1.3%
AQC00914000	-14.32	-170.77	408.4	AS	AASUFOU	1980-2010	278	9999-9999	-999	372	74.7%
CQC00914080	15.21	145.75	252.1	MP	CAPITOL HILL 1	1994-2010	182	1995-2010	160	204	89.2%
CQC00914801	14.17	145.24	179.2	MP	ROTA AP	1993-2010	184	1993-2010	141	216	85.2%
CQC00914855	15.12	145.73	65.5	MP	SAIPAN INTL AP	1988-2010	257	9999-9999	-999	276	93.1%
CQC00914874	15	145.63	81.7	MP	TINIAN	1987-2010	245	9999-9999	-999	288	85.1%
FJ000091652	-16.13	-179.98	63		UDU POINT AWS	1973-2010	52	9999-9999	-999	456	11.4%
FM000914163	9.54	138.12	20.1	FM	DUGOR	2000-2010	117	9999-9999	-999	132	88.6%
FM000914213	9.45	138.06	15.2	FM	GILMAN	1997-2010	150	9999-9999	-999	168	89.3%
FM000914429	9.48	138.08	10.1	FM	LUWEECH	1987-2010	277	9999-9999	-999	288	96.2%
FMC00914111	7.45	151.83	1.5	FM	CHUUK WSO AP	1990-2010	247	1990-2010	247	252	98.0%
FMC00914325	1.08	154.8	2.7	FM	KAPINGAMARANGI	1962-2010	258	1968-1987	78	588	43.9%
FMC00914395	5.35	162.95	2.1	FM	KOSRAE	1954-2010	492	1954-2010	424	684	71.9%
FMC00914446	9.61	138.18	14.9	FM	MAAP	1991-2010	226	1991-2010	175	240	94.2%
FMC00914585	9.57	138.11	3	FM	NORTH FANIF	1993-2010	191	9999-9999	-999	216	88.4%
FMC00914590	3.85	155.02	2.4	FM	NUKUORO	1985-2010	284	9999-9999	-999	312	91.0%
FMC00914710	6.93	158.16	85.3	FM	PALIKIR	1991-2010	126	1991-2010	119	240	52.5%
FMC00914720	6.22	160.7	2.4	FM	PINGELAP	1985-2010	278	1997-2010	145	312	89.1%
FMC00914808	9.62	138.16	19.8	FM	RUMUNG	1993-2010	199	9999-9999	-999	216	92.1%
FMC00914831	9.55	138.15	21.3	FM	TAMIL	1991-2010	180	1991-2010	113	240	75.0%
FMC00914843	5.33	163.01	14.9	FM	TOFOL	1987-2010	107	1990-2010	72	288	37.2%
FMC00914892	10.03	138.2	2		ULITHI	1989-2010	219	1989-2004	158	264	83.0%
FMC00914898	5.27	162.97	4	FM	UTWA	1990-2010	227	1990-2010	189	252	90.1%
FMC00914911	7.38	143.92	2.1	FM	WOLEAI ATOLL	1968-2010	343	1968-2004	275	516	66.5%
GQ000914727	13.35	144.77	3	GU	PIRATES COVE	2004-2010	71	9999-9999	-999	84	84.5%
GQC00914001	13.39	144.66	3	GU	AGAT	1978-2010	264	9999-9999	-999	396	66.7%
GQC00914156	13.52	144.85	106.7	GU	DEDEDO	1978-2010	288	9999-9999	-999	396	72.7%
GQC00914226	13.48	144.8	77.4	GU	GUAM NWSO TIYAN	1956-2010	544	1956-2010	544	660	82.4%
GQC00914275	13.29	144.75	9.1	GU	INARAJAN AG STN	1978-2010	178	9999-9999	-999	396	44.9%
GQC00914468	13.45	144.8	18.3	GU	MANGILAO	1970-2010	368	1970-1977	3	492	74.8%
GQC00914950	13.55	144.89	160	GU	YIGO	1978-2010	231	9999-9999	-999	396	58.3%

Standardized Precipitation Index
Micronesia and Samoa data

Current -1 -2 -3 -4 -5 -6 -7 -8 -9 -10 -11

SELECTED PACIFIC ISLANDS STANDARDIZED PRECIPITATION INDEX (SPI) SUMMARY
NATIONAL WEATHER SERVICE HONOLULU HI
DATA THROUGH THE END OF FEB 2012

SPI VALUES BASED ON PROVISIONAL COOPERATIVE OBSERVER AND TELEMETERED RAINFALL DATA FROM SELECTED PACIFIC ISLANDS.

NOTE: THIS SUMMARY WAS DEVELOPED AND PRODUCED IN SUPPORT OF RAINFALL MONITORING REQUIREMENTS. THE SPI PROVIDES A NORMALIZED VIEW OF MONTHLY RAINFALL. FOR MORE INFORMATION ON THE SPI AND THE PRODUCTION OF THIS SUMMARY, PLEASE SEE THE SPI INFORMATION PAGE.

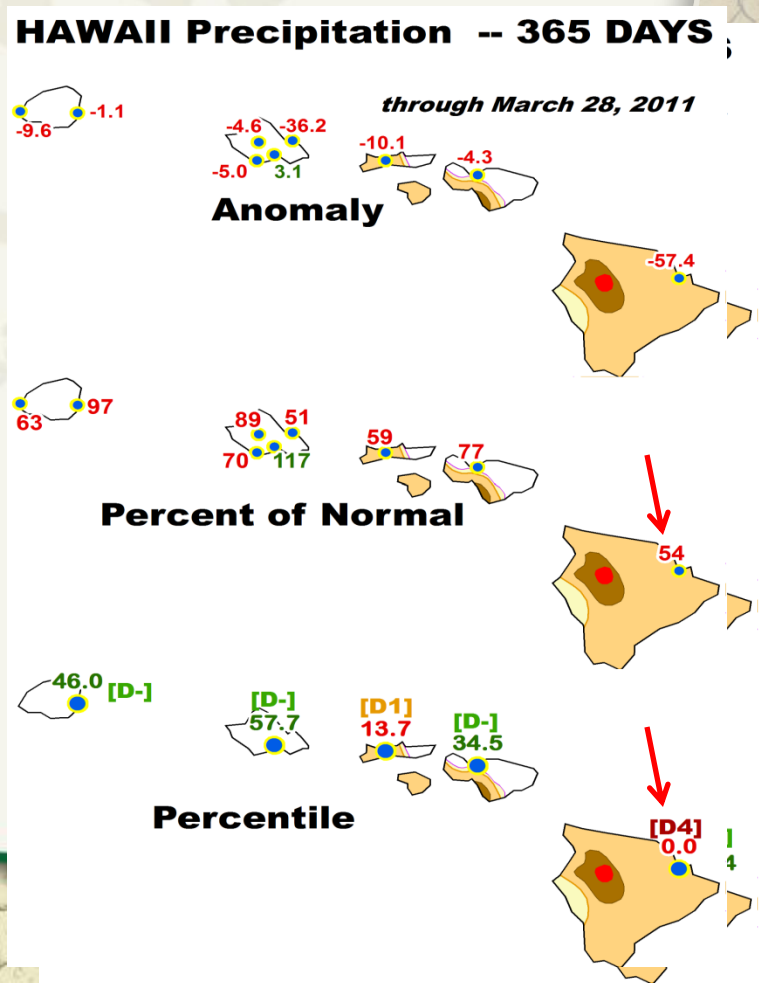
SPI CATEGORIES ARE AS FOLLOWS:	
2.00 AND GREATER	EXTREMELY WET
1.50 TO 1.99	VERY WET
1.00 TO 1.49	MODERATELY WET
0.99 TO -0.99	NEAR NORMAL
-1.00 TO -1.49	MODERATELY DRY
-1.50 TO -1.99	VERY DRY
-2.00 AND LESS	EXTREMELY DRY
-99.00	MISSING DATA

STATION	1-MO	2-MO	3-MO	6-MO	12-MO	18-MO	24-MO
WSO CHUUK	1.25	0.48	0.55	0.55	1.31	0.92	1.13
WFO GUAM	0.02	0.51	0.39	0.66	1.01	0.86	0.51
WSO KOROR	0.52	-0.49	-0.67	0.62	2.30	2.30	1.19
WSO MAJURO	-0.28	-0.11	-0.19	0.07	0.27	0.95	1.08
WSO PAGO PAGO	0.04	-0.78	-1.00	-0.51	-1.36	-0.57	-0.84
WSO POHNPEI	0.58	0.24	0.31	0.05	-0.04	-0.32	-0.26
WSO YAP	0.33	-0.73	-0.43	0.30	1.32	1.12	1.31
SAIPAN AP	1.28	0.24	0.14	-0.25	0.16	-0.60	-0.63
KWAJALEIN	0.23	0.18	-0.31	0.40	0.54	1.08	0.35
KOSRAE AP	1.16	0.41	0.78	0.89	0.72	-0.11	-0.17

Percentile versus Percent of Normal

- ✓ ***Percent of Normal*** **compares the value to some base period mean (*1971-2000* 30-year average)**
- ✓ ***Percentile*** **expresses how rare the value is compared to its historical record**
- ✓ **Examples:**
  - 30-days: 33% of normal occurs once every 5 years (20th percentile) (not a big deal)
  - 365-days: 54% of normal occurs rarely (once every 100 years or less often) (0th percentile) (rare, record dry?) *(click for map)*

http://drought.unl.edu/dm/monitor.html



Solutions

- ✓ **Rely on local observations & expertise for impacts**
  - Forest fires, browning of vegetation, crop impacts, varies with island
  - Streams and reservoirs – less useful, utility varies
  - Groundwater lens – minimal monitoring data, but major impact
- ✓ **Rely on local expertise for hydrology impacts**
  - Topography: low islands vs. high islands

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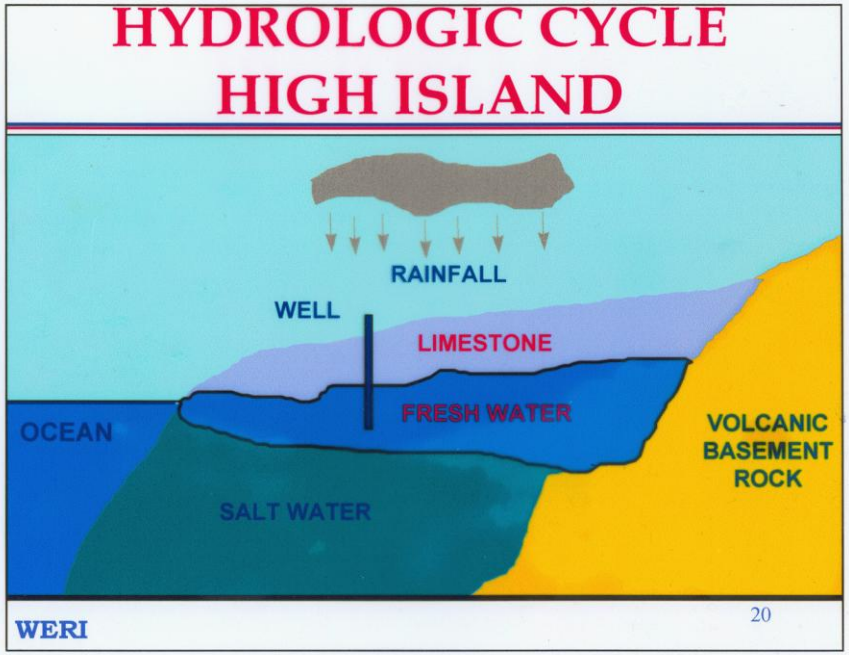
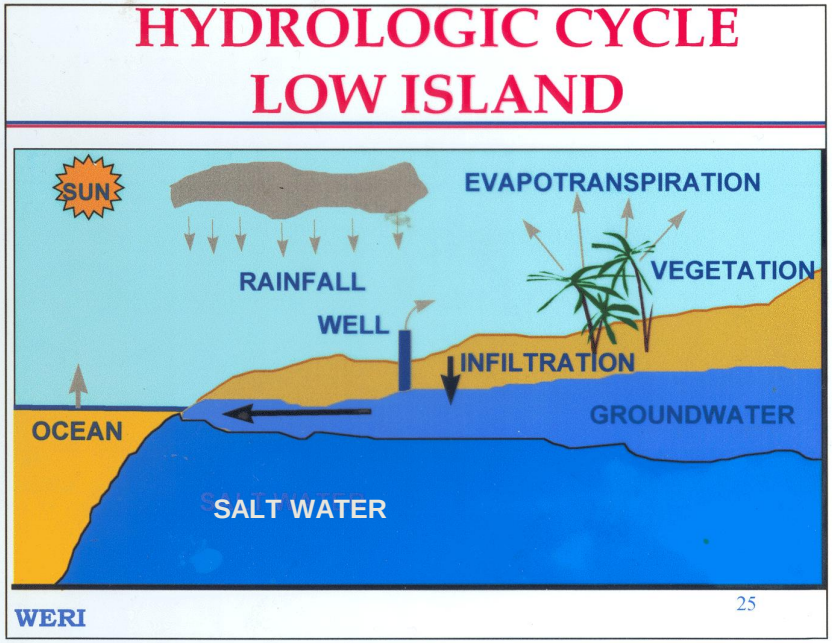
Hydrology – High Island vs. Low Island



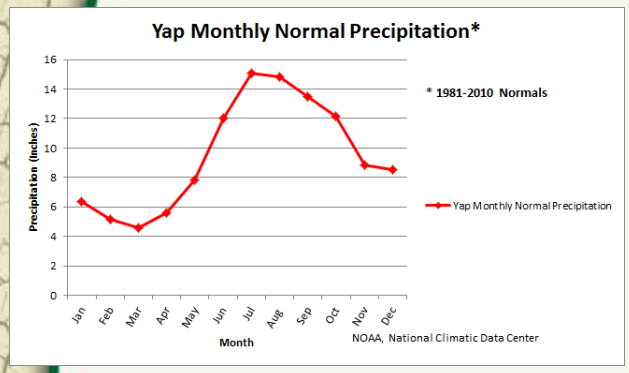
A few have streams and reservoirs.

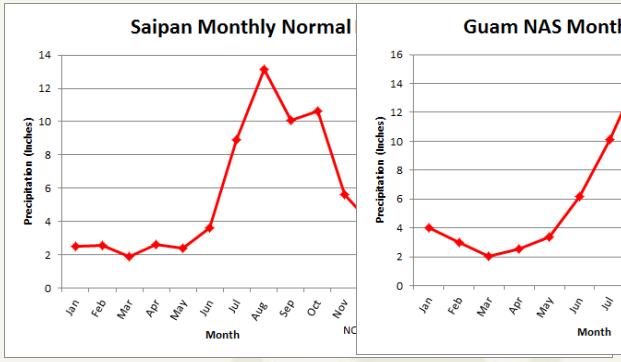
Ground water important in both.

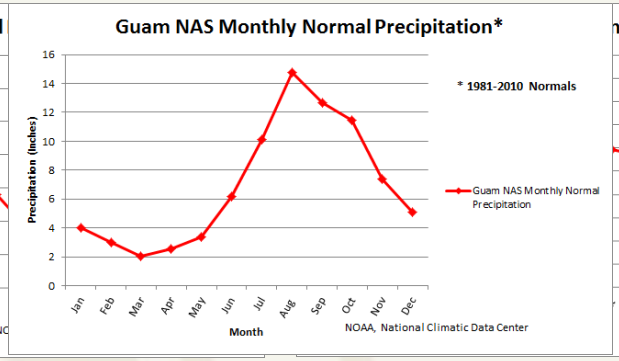
No reservoirs or streams.
Rain catchment important.

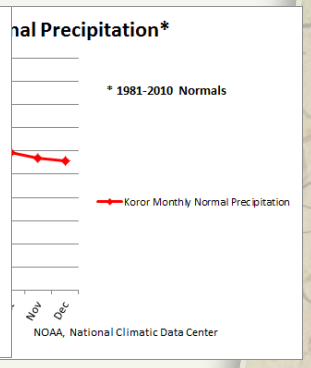


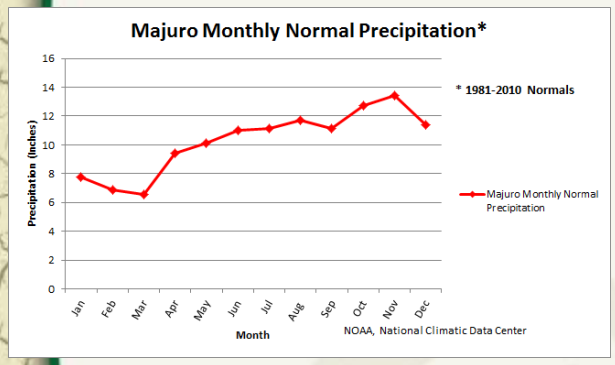
Climatology – Varies Island to Island

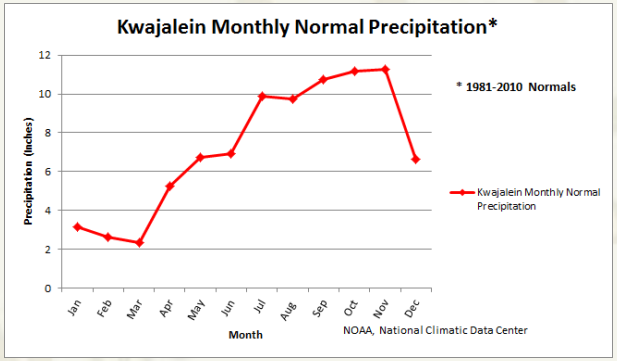


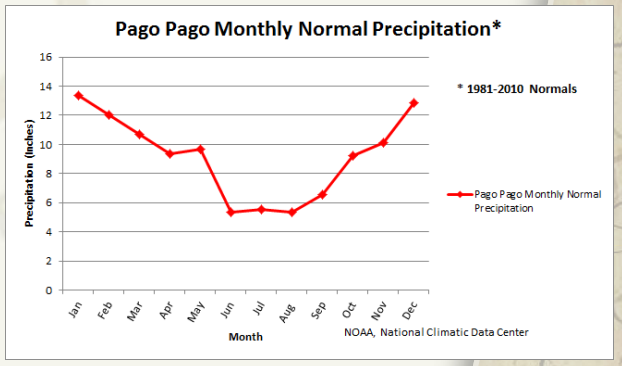


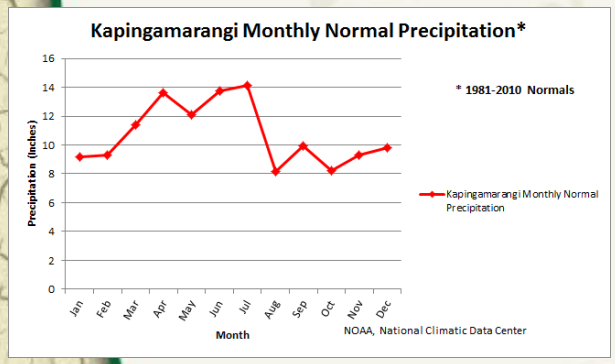


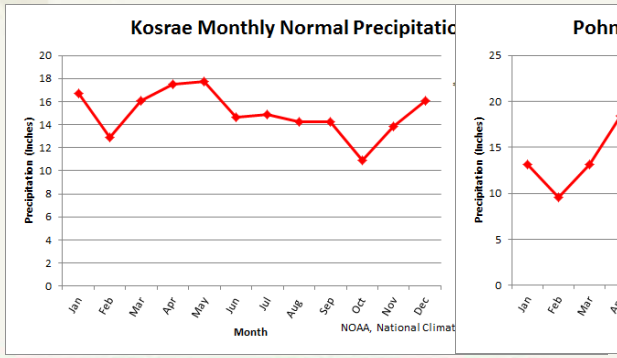


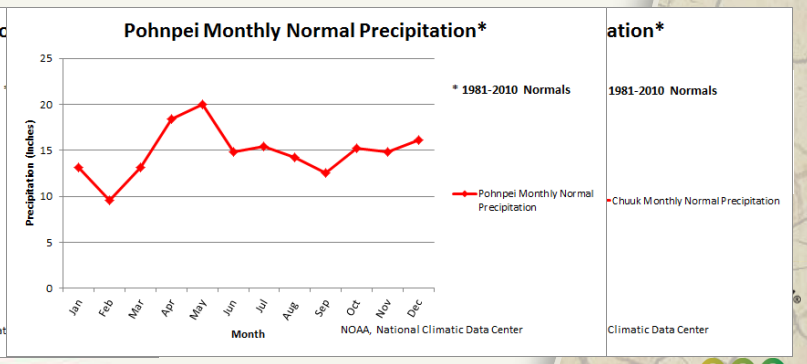












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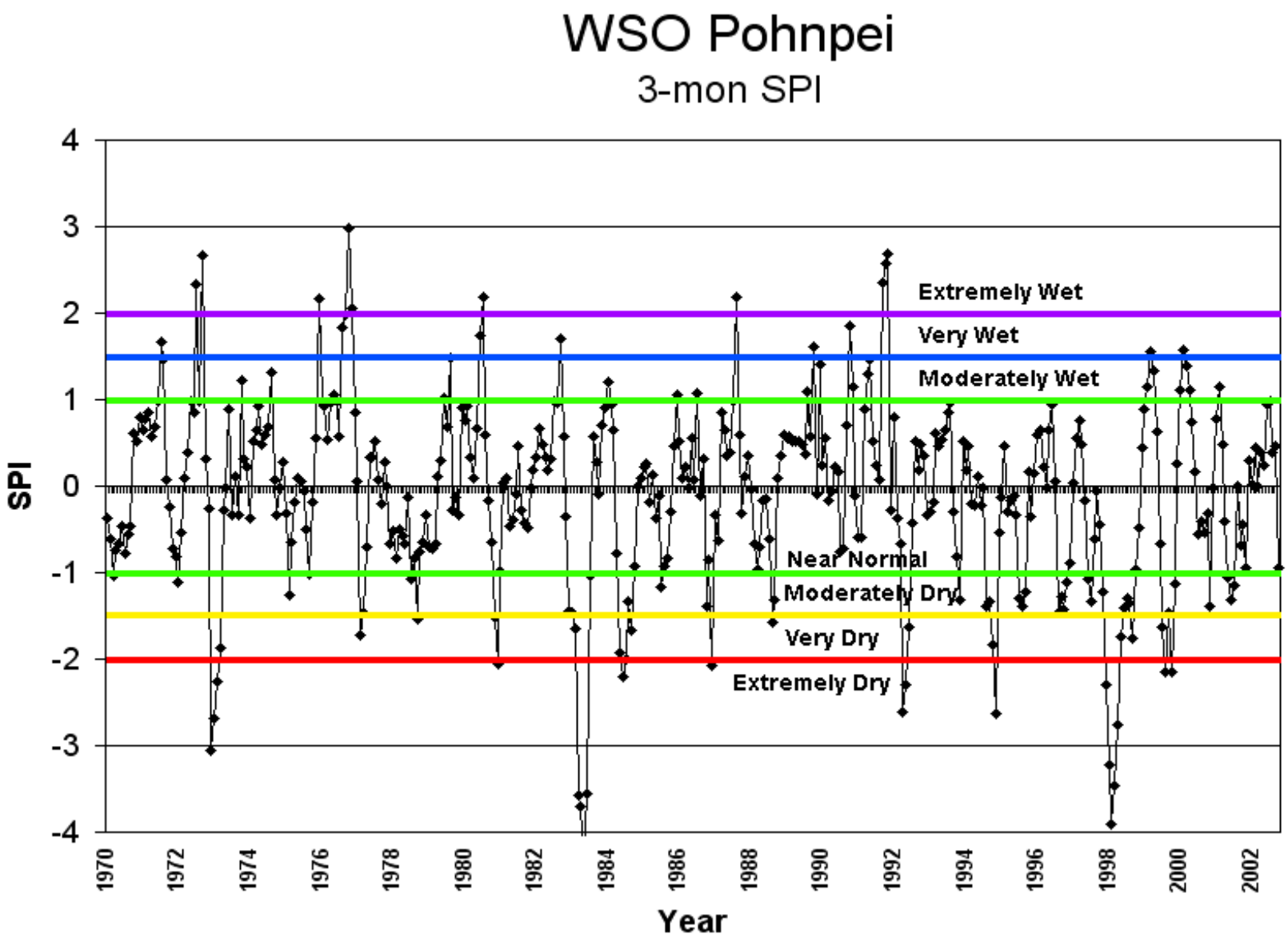
SPI


WSO Pohnpei
3-mon SPI
SPI
Year
Extremely Wet
Very Wet
Moderately Wet
Near Normal
Moderately Dry
Very Dry
Extremely Dry
4
3
2
1
0
-1
-2
-3
-4
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002

Solutions

- ✓ **Rely on local expertise for drought assessment methodology, guidance and monitoring rules**
  - Most islands can experience below-normal rainfall during their wet season and not suffer drought.
  - But below-normal rainfall during the dry season can give rise to drought.
  - There is high variability in monthly rainfall from month to month, so one dry month isn't much of an impact. Two or three months of below-normal rainfall on a mountain island is not much of a problem. Continued, persistent below-normal rainfall of long-enough duration can create drought problems.
  - Island-specific guidance (particularly w/ regard to impacts)

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Implementation

- ✓ **Monthly drought assessments for Pacific Islands**
  - Monthly PEAC conference calls.
  - Monthly rainfall data, monthly SPI & percent of normal rainfall
  - Table of drought classification instead of map

Hawaii, Big Island:
10,430 km^2
150 km across

Guam:
549 km^2
6 km x 48 km

Kwajalein*:
3 km^2
4 km x 1 km
* rounded

Kwajalein

Display of Pacific Island Drought Conditions on the USDM Map – Options

✓ In a Table?

(entire island in Dx drought status)

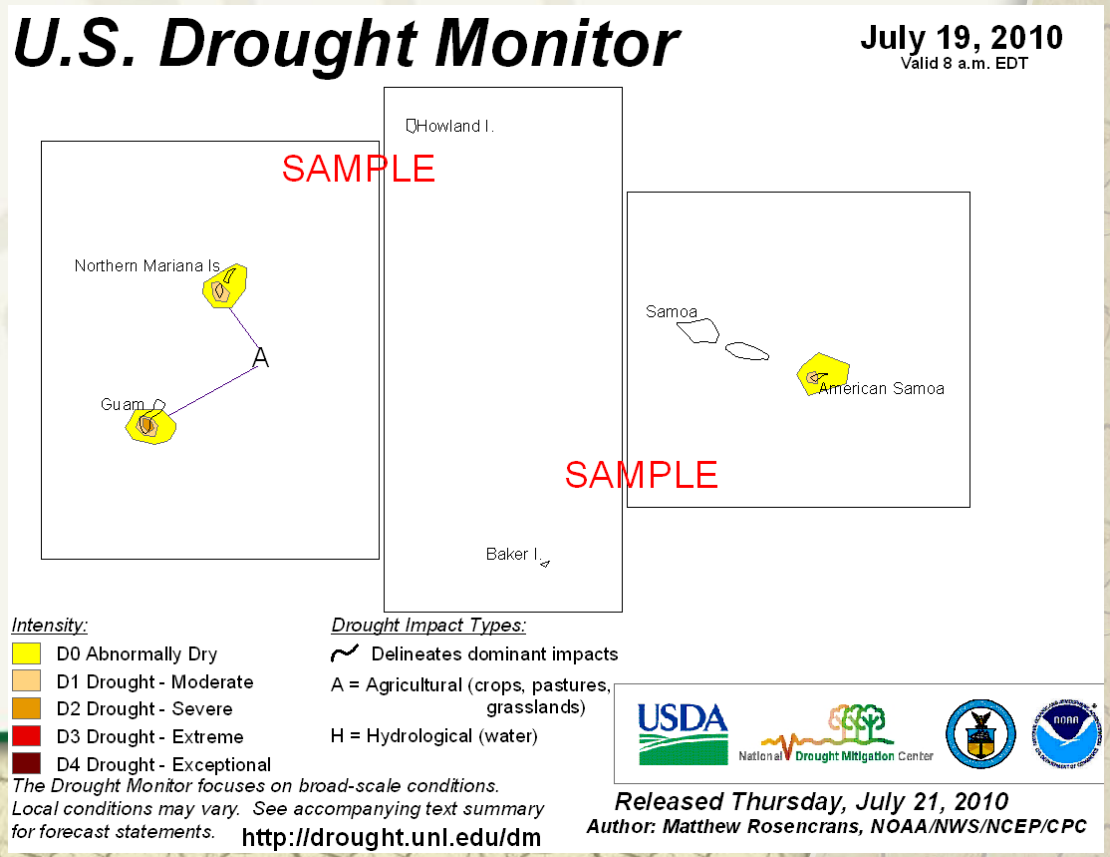
Pacific Island	Drought Status
Chuuk	No Drought
Guam	No Drought
Kapingamarangi	D3 - Extreme Drought
Koror	No Drought
Kosrae	D1 - Moderate Drought
Kwajalein	No Drought
Majuro	No Drought
Pago Pago	No Drought
Pohnpei	No Drought
Saipan	D0 - Abnormally Dry
Yap	No Drought

SAMPLE

✓ In Map Format?

(for the larger islands)

(different drought conditions for different parts of an island)



Experimental Classifications – Monthly

D0:	Abnormally Dry	SPI: -0.5 to -0.9
D1:	Drought - Moderate	SPI: -1.0 to -1.2
D2:	Drought - Severe	SPI: -1.3 to -1.5
D3:	Drought - Extreme	SPI: -1.6 to -1.9
D4:	Drought - Exceptional	SPI: -2.0 or less
S:	Short-term impacts, typically < 6 months (e.g. agriculture, grasslands)	
L:	Long-term impacts, typically > 6 months (e.g., hydrology, ecology)	

SAMPLE / EXPERIMENTAL

January 2012

Pacific Island	Drought Status	Reasoning:
Chuuk	No Drought	Jan SPI = -0.54, but 3mon to 24mon wet
Guam	No Drought	Jan SPI > -0.5, and all timescales wet
Kapingamarangi	No Drought	recent months wet or near normal, Feb-Jan near normal
Koror	D0 Abnormally Dry	Jan SPI = -1.65, 2&3mon dry, Feb-Jan wet, at least D0, D2-D3 justified
Kosrae	No Drought	Jan SPI = -0.64, but 2-12mon wet, borderline D0
Kwajalein	No Drought	Jan SPI > -0.5, most timescales wet
Majuro	No Drought	Jan SPI > -0.5, most timescales wet
Pago Pago	D1-S Mod. Drought	Jan SPI = -1.05, all timescales dry, this is wet season, Feb-Jan 80%
Pohnpei	No Drought	Jan SPI > -0.5, 2-6mon wet
Saipan	D0 Abnormally Dry	Jan SPI = -0.66, 2-6mon negative SPI, but this is dry season
Yap	D0 Abnormally Dry	Jan SPI = -1.73, 2-3mon dry SPI, but this is dry season

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Where do we go from here?

There has been interest expressed in collaborative multinational drought monitoring in Central America and the Caribbean.

Maybe as part of an expanded NADM???

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Where do we go from here?

- ✓ **Caribbean Islands may face similar challenges to drought monitoring that the Pacific Islands have faced and vice versa**
  - ➢ Geographical size, hydrology, climatology, data issues, coordination, communication, etc.
- ✓ **Central American countries may also be facing similar challenges**
  - ➢ Tropical climate, data issues, coordination, etc.

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What lessons can be learned from the Pacific Island drought monitoring experience – both for the NADM & for expanded multinational drought monitoring?

1. Data
2. Timeliness
3. Appropriate Drought Assessment Methodology
4. Impacts
5. Production Schedule
6. Collaboration

✓ Other questions:

- How does water management operate? Are there local utilities like the mainland? How much is locally sourced from things like rainwater collection? (Implies how important water management is to the drought picture.)
- What is the local hydrography (fresh water sources/sinks)? Where does the water go?
- Can proxy measures of drought be inferred from local salinity measurements (fresh water flow off the larger islands)?
- What is and isn't important from a precipitation standpoint relative to impacts? i.e., how long and/or steep do rainfall deficits have to occur before they matter, is time of year (seasonality of rainfall) important, how do temperatures impact conditions?
- What drought indicators and triggers are relevant locally?

Final Thoughts

- **No one size "fits all"!**
  - Several blue prints to follow and customize to your needs
- **Not a "fast track" process**
- **Work put in = quality of the end product**
- **Many lessons to be learned and shared!**
- **Free planning resources available at:**
  - http://drought.unl.edu
  - http://drought.gov

NIDIS

University of Nebraska Lincoln

National Drought Mitigation Center

Next Steps?

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