Board of Supervisors Memorandum

August 5, 2014

Drought Management Plan Review
Vulnerability Assessment in Drought Mitigation Report

Introduction

In June of 1999, Governor Jane Dee Hull issued a Drought Emergency Declaration (PCA 99006) following the state's third-driest winter in a century. Since then, sporadic wet episodes have only interrupted, but brought no long-term relief to persistent and cumulative drought.

The reservoir system that supplies Pima County with renewable Colorado River water continues to decline as local impacts to the environment (i.e., Cienega Creek and Agua Caliente Spring) increase, and drought sensitive economic sectors suffer setbacks. Drought affects more than just the water supply; primary and secondary impacts reverberate through the environment and economy with negative consequences for the region's wildlife, public health and other socio-economic sectors. Accordingly, staff has prepared the attached *Vulnerability Assessment in Drought Mitigation Report* describing Pima County's exposure to drought, sectors impacted by drought and their relative importance to the County. Currently, all of Arizona's counties are federally designated disaster areas due to drought.

Drought and Water Demand Forecast

Drought planning and water conservation will become increasingly important. The narrative of the last 18 years includes aberrations however the overall trend has been below or well below average precipitation and above average temperatures – similarly the best estimation of our forecast ahead.

University of Arizona researchers conclude droughts in parts of the Southwest are expected to become hotter, more severe, and more frequent as warming will continue, with longer and hotter heat waves as precipitation declines in the southern Southwest. Climate records indicate occurrences of multi-decadal drought exceeding the severity and duration of the current drought.

Dropping water levels in Lakes Mead and Powell could trigger a shortage declaration in 2016 (a 23 percent probability) or 2017 (51 percent probability), curtailing Central Arizona Project (CAP) water by 320,000 acre feet. The seven basin states that share Colorado River water have a shortage sharing agreement that identifies how much CAP water will be reduced giving the community more certainty about what sectors would receive less CAP water should a shortage be declared.

The Bureau of Reclamation Colorado River Basin Water Supply and Demand Study identified a wide range of future imbalances; the median long-term projected deficit is expected to be 3.2 million acre feet a year by 2060. The Lower Basin states (Arizona, California and Nevada) exceed their annual apportionment of 7.5 million acre feet in all study scenarios and will need additional water to meet demand.

The Arizona Department of Water Resources (ADWR) confirms this conclusion in its latest report, *Arizona's Next Century: A Strategic Vision for Water Supply Sustainability*. Conservation and maximum utilization of reclaimed water will only alleviate pressure on potable water demand, and despite declining per capita water use over the last 50 years, augmentation of water supplies through the importation of water from outside active management areas will be required.

However, ADWR also emphasizes that Arizona is not in a water crisis but that several adaptive strategies will need to be pursued. The major water providers have drought response plans in place in case the drought worsens and are employing strategies to delay implementation of increased drought response measures. Water providers have diversified their portfolios and are not dependent on just one water source (CAP, reclaimed water and groundwater) and are banking unused CAP water by recharging it in underground storage facilities. Local codes require water conserving indoor fixtures in new development (low flow toilets and faucets) and drought tolerant, desert landscaping.

Third National Climate Assessment

The Third National Climate Assessment, released in May 2014, documents an increase in the average temperature of the US over the last century (1.3°-1.9°F) with the recent decade being the hottest on record, both nationally and worldwide; 2012 was the hottest year on record for most of the US. The probability of extreme heat events has already doubled as climate change effects are underway and, contemplating a possible 10°F increase by the end of the century, is expected to intensify. Water resource managers are cautioned of reduced surface and groundwater supplies as precipitation declines and heat alters water consumption and withdrawal, increasing the likelihood of water shortages.

The report warns of current and future disruptions that affect "human health, water supply, agriculture, transportation, energy, coastal areas, and many other sectors of society, with increasingly adverse impacts on the American economy and quality of life." While some impacts may be unique to a particular region, cascading effects on production and distribution could limit local availability of energy and food, as examples.

In particular, agricultural productivity is vulnerable as well as natural ecosystems and associated biodiversity. Reduced yield and agricultural job loss is anticipated in the

Southwest, which produces a majority of US high-value specialty crops. Aesthetic and cultural value embedded in natural habitat is not easily quantified but the many benefits of a rich ecosystem are known to "support jobs, economic growth, health and human well-being." Drought has already caused widespread tree mortality; combined with more frequent and larger wildfires, the future conversion of sky island conifer forests to grassland is possible.

The snowpack and streamflow that supports habitat and draws tourism is also key to the Southwest's hydrology and water supply. Decline in winter and spring snowpack, earlier snowmelt and increased evaporation reduce runoff and streamflow into the reservoir systems that supply municipal water providers. The Colorado River, already over-allocated, will become less productive at a time of increasing demand and declining reservoirs.

The attached report highlights the impacts to the Southwest. The complete report is at this link: http://nca2014.globalchange.gov/report/regions/southwest .

County Drought Response Plan and Ordinance

In 2003, Governor Janet Napolitano signed a supplemental executive order (EO 2003-12) establishing the Arizona Drought Preparedness Plan (ADPP), an adaptable framework to assist state leaders, local governments and water managers in drought mitigation. The Preparedness Plan structural components are the State Drought Monitoring Technical Committee (MTC), the Governor's Drought Interagency Coordinating Group (ICG) and Local Drought Impact Groups (LDIG). Guidelines for response and mitigation based on each drought stage are outlined in the ADPP. The Governor's recommendation body, the ICG, recently convened in May and unanimously recommended that drought declarations remain in place; PCA 99006 has been in effect since 1999.

In 2006, Pima County established a drought task force and monitoring committee which implemented a drought planning process based on research from the National Drought Mitigation Center (MTC). The task force coordinated and led development of a response plan which was submitted and approved by the Board of Supervisors on June 20th. Ordinance 2006-43 enacted Chapter 8.70 of the Pima County Code, establishing the drought stages, water reduction measures for each stage and prohibitions on water wasting, incorporating the guidelines recommended in the ADPP.

The MTC collects climate and weather data to produce the *Arizona Drought Monitor Report* which details short and long term drought status and serves as the indicator for the county's drought stage. Out of 97 monthly drought monitor reports, only four months of normal conditions throughout Pima County have been recorded; all others have shown some level of drought ranging from Abnormally Dry to Extreme. Review of the short term map shows a predominance of Severe drought with oscillating pockets of Moderate and then a reversal following precipitation - Moderate drought with pockets of Severe conditions.

The current drought ordinance does not accurately communicate actual drought conditions and front loads more stringent restrictions than the recommended response framework within the ADPP. The County has remained in a Stage 1 response position communicating Abnormally Dry conditions since 2007.

The Pima County LDIG recommends revising drought stage and trigger events (Table 8.70.050) to more accurately reflect and communicate current conditions, improve coordination with other jurisdictional declarations, correct front loading of response measures, provide more flexibility and buffer against oscillating changes of status.

Conclusions

As described in the attached staff report, Pima County's open space and riparian habitat are most vulnerable to the impacts of sustained drought conditions. It is important that we continue to implement adaptive management strategies that include land conservation, riparian habitat restoration and protection of groundwater-dependent ecosystems.

Programs such as the *Community Wildfire Protection Plan* ensure Pima County is ready to respond to drought-induced wildfires. Existing building and land use codes requiring low water use fixtures and drought tolerant, native landscaping have helped reduce residential and commercial water consumption. Improved water quality at our wastewater reclamation facilities allows more uses of reclaimed water to support riparian habitat, replenish the aquifer and replace groundwater uses on parks and landscaping. Continued monitoring of local and state-wide drought conditions through the Local Drought Impact Group and ADWR Drought Program will enable Pima County to take proactive, planned mitigation measures should drought conditions persist or worsen.

Pima County declared a Drought Stage 1 in 2007. The response actions associated with this declaration are voluntary reduction in water use, restaurants asked to provide water only on request and hotels and motels urged to conserve water. Because of the community's proactive approach to water conservation, it is recommended that the Stage 1 declaration remain in place. However, should drought conditions persist or worsen, the Board of Supervisors may wish to re-evaluate this declaration in collaboration with other jurisdictions to ensure our community reacts to drought impacts in a well-coordinated manner.

Recommendations

It is recommended that the Board take the following actions:

1. Reaffirm the current Drought Stage 1 declaration

2. Approve recommended revisions to the ordinance.

3. Direct staff to continue to monitor drought status and its impacts through Local Drought Impact Group and coordinate with local water providers on drought responses.

4. Direct that relevant County departments assist LDIG by sharing information and data on drought impacts and drought preparedness.

Respectfully submitted,

C.H. Huckelberry
County Administrator

CHH/ dr–July 22, 2014

Attachments

c: John Bernal, Deputy County Administrator for Public Works
Jackson Jenkins, Director, Regional Wastewater Reclamation

PIMA COUNTY
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April 23, 2014

TO: Jackson Jenkins, Director

FROM: Kathleen M. Chavez, Water Policy Manager

SUBJECT: **Drought Management Plan Review, Vulnerability Conclusions and Recommendations**

Pima County has had in place a Drought Response Plan and Water Wasting Ordinance since 2006. The year following its adoption, Pima County issued a Drought Stage One declaration in conjunction with the City of Tucson. This declaration has remained in place since then and its response measure is voluntary reduction in water use.

During this time, Pima County's local drought impact group (LDIG), functioning as the drought monitoring committee established in the ordinance, has met regularly to monitor the status of drought in Pima County and to assess the drought impacts.

When Pima County adopted the Drought Response Plan, an emphasis was placed on water use impacts. However, drought has impacts to many sectors and therefore, an assessment of Pima County's vulnerability to drought was conducted. The attached report assesses Pima County's vulnerability to drought across several sectors.

Drought Vulnerability

In reviewing the vulnerabilities of Pima County to local drought conditions, a key vulnerability begins with the junior priority right to Colorado River water Arizona holds and implications for CAP delivery to the County's water providers. Summarizing the Bureau of Reclamation's Basin Study provides scenarios and certain future expectations for water policy planning.

- The Colorado River faces increased demand and reduced supply; the system is over-allocated and highly variable. Lower Basin states' demand for Colorado River water will exceed the 7.5 million acre-feet (maf) a year allocation in all scenarios.

- Reservoirs have and will continue to be used to meet demand that exceeds supply. Reservoir levels will continue to decrease without changing snowpack trends. Lake Mead is forecast to decline an additional eight feet due to the Bureau of Reclamation's reduced Lake Powell release, curtailed from 8.23 maf to 7.48 maf. Lower Basin delivery shortages could occur in 2016 or 2017, triggering an escalation of the City of Tucson's drought plan to Stage 2.

- Banking and recharge infrastructure will help forestall mandatory water use restrictions, as it has in southern California. Greater cooperation between federal, state and local governments and tribes will be required to plan for additional infrastructure of significant expense.

- Complete elimination of Colorado Basin vulnerability is not likely but employment of augmentation, re-use and conservation strategies, to include water transfers, has the potential to reduce vulnerability by as much as 50%. Vulnerability will remain present because of the hydrologic conditions driving it; two specific conditions are deemed as critical vulnerability events- long term mean natural flow at Lee's Ferry below the historical average of 15 maf and droughts lasting eight years or longer. These two trigger points could be included in drought response planning.

- Historical records indicate the current drought could continue and increase in severity. University of Arizona researchers expect drought to become more frequent, more severe and hotter with longer and hotter heat waves. The same research assumes decreased water availability and quality.

- CAP water availability has changed as more municipal and industrial allotments are maximized; excess water is unavailable despite requests for this allocation pool. Purchase of long term storage credits will become increasingly important and more competitive at a time when water for recharge and banking will become less available. Emerging water credit markets will become more influential.

- Water and energy prices will increase, cascading into economic sectors. Industries will increasingly consider water supply costs and local government resource planning when making decisions to base operations.

- Agriculture and ranching will decline in the County from rising costs and as land is converted to development with possible impacts to land use planning. Eventual increased enrollment in the Central Arizona Groundwater Replenishment District, of which a significant amount of development in the County utilizes for assured water supply, will require new water leases or the purchase of credits, such as the 100,000 acre-feet of long term storage credits recently purchased from the City of Tucson.

- Effluent will be a vital resource, as the only water source to increase with population, for generating long term storage credits or for reclaimed use to reduce groundwater withdrawal. Competing interests for the use of effluent will intensify. Future effluent discussion will include more indirect and direct re-use strategies.

Conclusions

Considering these possibilities in conjunction with County vulnerability will help in evaluating recommendations. To restate conclusions of vulnerability assessment;

1. County owned and maintained open space and riparian habitat is the most vulnerable county asset. The County's long term planning programs associated with these lands are also a significant asset. A drought management plan for the county should protect these investments by prioritizing adaptive management strategies and resources for these sectors.

2. Agriculture and ranching are not dominant economic drivers in Pima County however are valued as a distinct regional cultural heritage. Ranching is most beneficial to the county as a land management and habitat maintenance tool.

3. Birding and wildlife watching, combined with other outdoor recreation and tourism, are dominant economic drivers for the county. Birding offers economic benefits comparable to the region's largest copper mine. The county's habitat programs are benefiting these economic sectors.

4. Tourism is multi-faceted and duplicative in other sectors and sub-sectors. Of the drought sensitive industries considered in this narrative, it is the most dominant economic driver. Outdoor activities associated with the natural environment are the most popular county attractions.

5. Socio-economic impacts are second and third order impacts easily obscured. Collecting reports on all order of impact is an important function of Pima County's LDIG.

Revisiting the Pima County Drought Management Plan from 2006, specific goals adopted at that time were:

- Reduce water shortage impacts and hardships
- Reduce conflicts between water users
- Improve coordination of county departments and governments
- Improve procedures for monitoring and assessment
- Improve response to shortage
- Improve information sharing with the public
- Improve resource allocation

Additionally, consideration of mitigation actions sought answers to the following;

- Can the cause be mitigated?
- Can the cause be modified?
- If neither is possible, must the impact be accepted as a drought-related risk to the County?
- What is the cost/benefit ratio of mitigation actions identified?
- What actions are feasible and appropriate?
- What actions are environmentally sensitive?
- Do the actions address the right combination of causes to adequately reduce the relevant impact?
- Do the actions address short and long term solutions?
- Do the actions fairly represent the needs of affected individuals, groups and sectors?

Recommendations
Taking into account future expectations and reviewing the County's exposure and vulnerability in context of Drought Management Plan goals, suggested changes to the County's drought ordinance, department activities and LDIG include;

1. Revise drought stage and trigger events (Table 8.70.050) to more accurately reflect and communicate current conditions, improve coordination with other jurisdictional declarations, correct front loading of response measures, provide more flexibility and buffer against oscillating changes of status. Include some exceptions for rainwater harvesting systems to incentivize use. Provide a range of status condition allowing discretion in stage declaration and distinction, for example of a recent and limited Severe finding versus a prolonged Severe finding with more pronounced impacts. A draft ordinance in included in the report

Current Table 8.70.050

Indicator	**Arizona Drought Monitor Report Based on Findings Related to Pima County**
Stage 1 Alert	**Abnormally Dry**
Stage 2 Warning	**Moderate**
Stage 3 Emergency	**Severe**
Stage 4 Crisis	**Extreme**

Suggested Revised Table 8.70.050

Indicator	**Arizona Drought Monitor Report Based on Findings Related to Pima County**
Stage 1 Alert	**Moderate-Severe**
Stage 2 Warning	**Severe-Extreme**
Stage 3 Emergency	**Extreme-Exceptional**
Stage 4 Crisis	**Exceptional**

2. Consider appropriate levels of duplication with the City of Tucson and other providers to encourage cooperation and prevent disparate enforcement

3. Cooperation and consolidation of effort is necessary. LDIG, as a component of the ADPP, is designed to augment the response plan (ordinance) as a repository of assessment information and as a recommendation body. Formalize decision making process within LDIG to coordinate new declarations with water providers. Table 8.70.050 serves as a guideline for drought declaration; LDIG analysis and report to the County Administrator is integral to providing context of drought status

4. Increase public education and information collection and dissemination with drought sensitive sectors. Conduct a review of department procedures for receiving and responding to violations of the drought and water wasting ordinance

5. Designate a Drought Liaison within relevant County departments responsible for information sharing of drought impacts and other pertinent data with LDIG

6. Continue implementation of the Sustainability Action Plan for County Operations (SAPCO), Water and Wastewater Infrastructure, Supply and Planning (WISP) Study and Action Plan and Water Resource Asset Management Plan (WRAMP)

7. Consider purchase of wells near groundwater dependent ecosystem areas and permanently retire the groundwater rights associated with them

8. Continue refinement of the County's Strategic Plan for Use of Reclaimed and similar strategy and criteria for use or transaction of accrued Long Term Storage Credits

9. Initiate a process to identify data and information gaps and assess changing vulnerability over time to provide LDIG improved analysis.

Next Steps

LDIG has reviewed the draft Vulnerability Assessment in Drought Mitigation Report. It is recommended that the final report and attached draft ordinance be presented to LDIG for review and comment at their next regularly scheduled meeting May 12. Following their review, it is recommended the final Drought Vulnerability Report and Ordinance be forwarded to the Board of Supervisors for review and approval.

Should you have any questions, I am available at your convenience.

Enclosures: Vulnerability Assessment in Drought Mitigation Report
Draft Drought Response Plan and Water Wasting Ordinance Chapter 8.70

Vulnerability Assessment

In Drought Mitigation

PIMA COUNTY

WASTEWATER RECLAMATION

Pima County

Regional Wastewater Reclamation Department

Water Resources Unit

April 2014

Vulnerability Assessment in Drought Mitigation

Arizona is one of twelve states with a mitigation based drought plan. Disaster management, and corresponding research, has evolved over the years from short-term crisis response to more long range, proactive risk management planning for expected impacts, or mitigation. The goal of mitigation is to reduce vulnerability to a range of identified risks ahead of time.

Vulnerability, in its research definition, is composed of three characteristics: Exposure, Sensitivity and Adaptive Capacity.[1] Exposure is the probability of a certain area to experience a hazard- drought- and to what magnitude and duration. Drought maps produced by the US Drought Monitor and the Arizona Monitoring Technical Committee record current and past drought exposure. Sensitivity is somewhat self-explanatory, as the degree to which a system or sector can be altered or will respond after exposure. Adaptive capacity refers to a system's ability to adjust and mitigate primary and secondary impacts. Important to adaptive capacity is the ability to collect reporting on all order of impacts across many sectors, a key function of drought impact assessment groups, such as Pima County's Local Drought Impact Group (LDIG).

In reviewing planning practices, Colorado's Hazard Mitigation and Drought Response Plan is mentioned in multiple studies as an example of an effective plan. The 2013 update, approved in September, includes a revised vulnerability assessment and tools to rank individual counties within different sectors. Applied to their drought planning process, vulnerability is a determination after "assessing the threat from potential drought hazards to various sectors across social, economic, environmental, and political fields." A vulnerability assessment is defined as a "process of identifying, quantifying, and prioritizing (or scoring) the vulnerabilities in a system."[2]

A similar vulnerability assessment of Pima County would help inform the drought update process by reviewing the county's historical exposure, listing the natural resource and environmental, economic, social, and municipal sectors deemed sensitive, determining the size and relative importance of those sectors to the county, and exploring the county's adaptive capacity to mitigate impacts, primary and secondary, to these sectors, which include:

1. County Assets- County land, parks, planning, recreational areas, water rights and wells.
2. Economic Sectors- Agriculture and Ranching; Energy and Mining; Hunting, Fishing and Other Outdoor Recreation; Tourism and Sports; and Forestry and Logging.
3. Municipal and Industrial (M&I); Private wells.
4. Environment.

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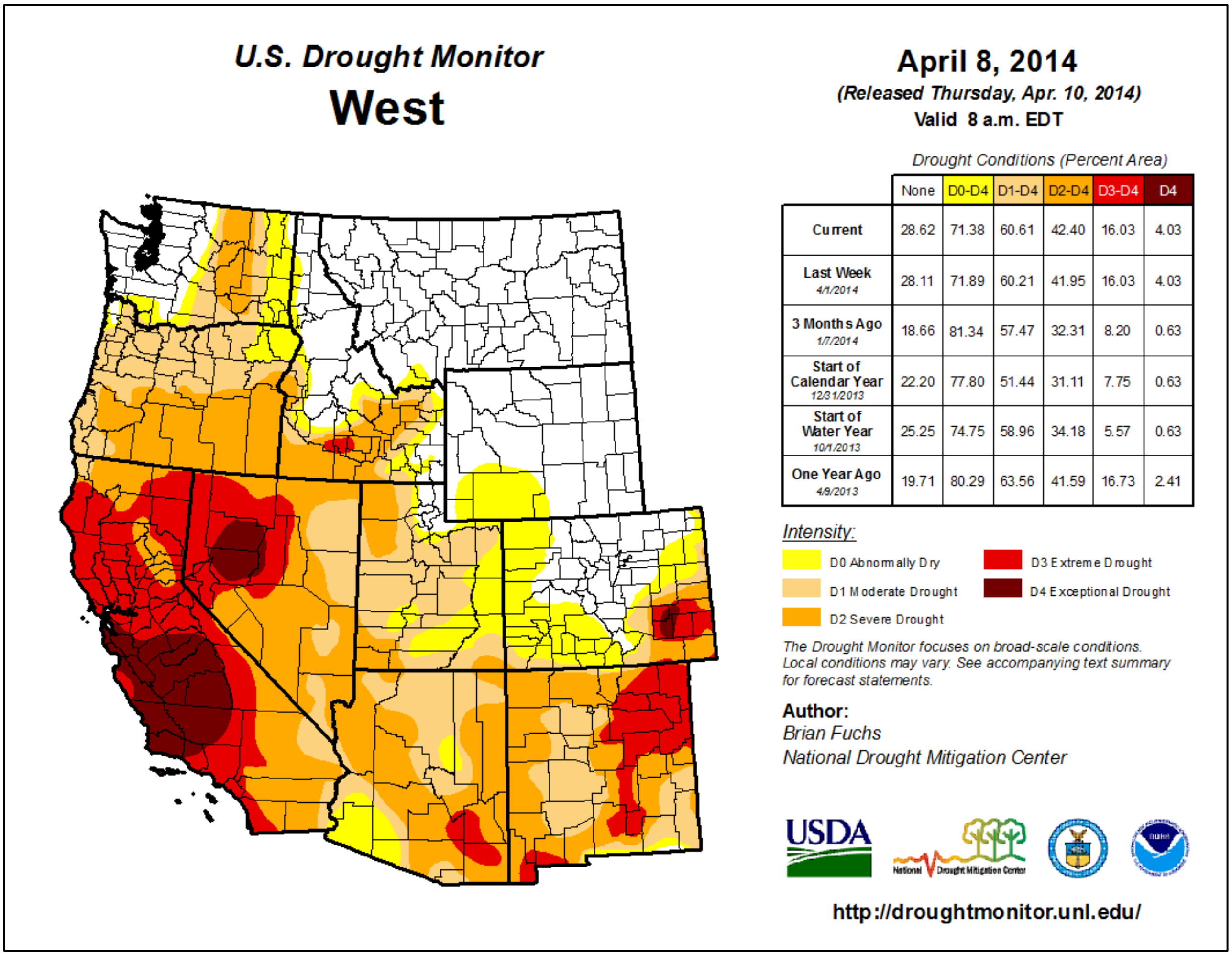
[1] McCarthy, Canziani, Leary, Dokken, White; *Climate Change 2001: Impacts, Adaptation and Vulnerability.* Cambridge University Press, 2001.
[2] Colorado Drought Mitigation and Response Plan, Annex B. 2013

Exposure

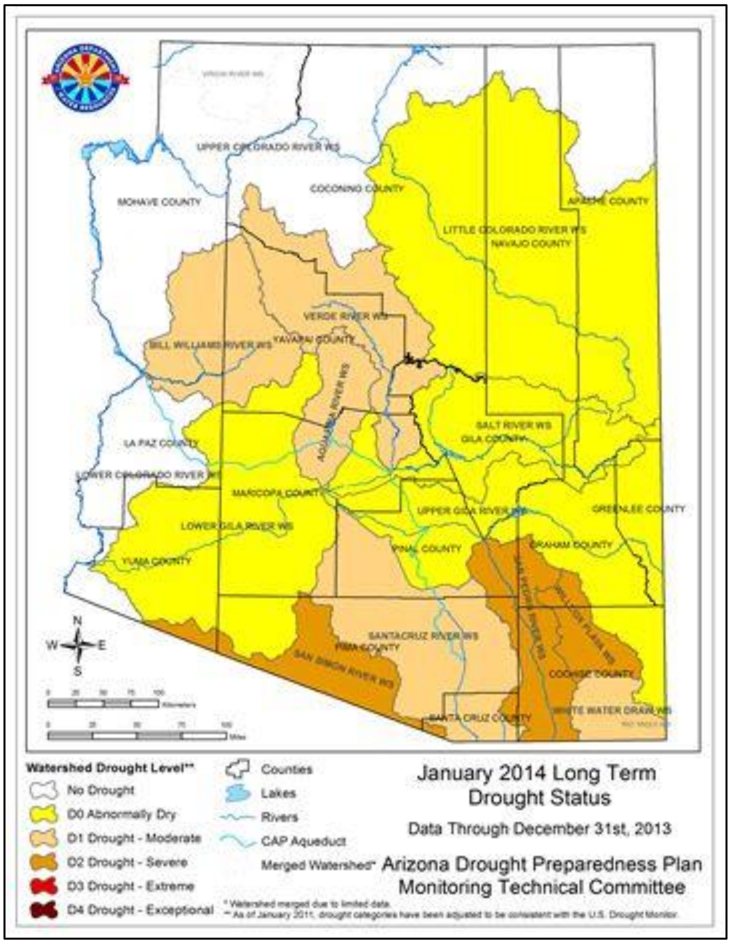
According to the US Drought Monitor Pima County exposure as of April 2014 is Extreme drought in the northeast corner of the county, radiating to Severe and Moderate drought throughout most of the county with Abnormally Dry condition along the western border (see figure 1).

Figure 1-US Drought Monitor



The Arizona Department of Water Resources' (ADWR) Arizona Monitoring Technical Committee long-term maps indicate an improvement to Moderate drought in the Santa Cruz watershed, the San Simon area in Severe. The portion of the Lower Gila watershed within the county continued in Abnormally Dry status (see figure 2).

Figure 2-ADWR Long Term Drought Status Map



As chronicled in a previous memo[3], Pima County has reported a predominance of Severe drought with oscillating pockets of Moderate finding from January to July 2012 and then a reversal- Moderate drought with pockets of Severe from August 2012 to March 2013. April, May and June, prior to this year's monsoon, recorded Severe drought in entirety, followed by some sustained Severe with Moderate and Abnormally Dry easing following monsoon activity in July and August.

A cursory review of previous years' drought maps show no discernible pattern given the highly variable seasonal precipitation. Summer monsoons have eased drought conditions in some years but then are absent in others, where the only relief came from winter storms. However, in the last eight years, no drought in entirety has only been recorded in May and June of 2010 and September and October of 2008. Pima County's exposure to drought could be defined as sustained and variable.

[3] Water Resources Unit Memo. Drought Ordinance Review. June 24, 2013.

Sensitivity

The Colorado Drought Mitigation and Response Plan assesses vulnerability by cataloging assets and resources in systems across sectors that are sensitive to drought exposure, then identifies the threats to each resource, assigning a quantifiable value and/or rank order to those resources. Quantifying the magnitude of possible impact allows prioritization of sectors and mitigation. Assigning a “score” of sensitivity, as the Colorado Plan does with each county, is beyond the scope of this paper. The effort here is to define sectors within the county to further understand the magnitude of impact possible and discuss the economic and social importance of those sectors to the county.

County Assets

County Critical and Riparian Habitat

As part of Pima County’s Sonoran Desert Conservation Plan (SDCP) and the Critical Habitat and Biological Corridors and Riparian Protection components, the county’s effort in defining critical habitat for Priority Vulnerable Species has led to the acquisition and management of numerous creek, canyon and wash parcels. Priority habitats and corridors include specific sites deemed as critical habitat or Priority Riparian Resources:

- Arivaca, Bear, Cienega, Rincon, Sabino, Tanque Verde Creeks.
- Bear, Brown, Cochie, Davidson, Edgar, Gardner, Madera Sutherland, Wakefield Canyons.
- Agua Caliente, Agua Verde, Black, Brawley, Canada del Oro, La Milagrosa, Sopori/Papalote, Sutherland Washes.
- Tumamoc Hill, Happy Valley, Los Morteros, Madera Highlands and Elephant Head Pineapple Cactus Mitigation lands.
- Bingham Cienega, Cienega Creek and Sweetwater Natural Preserves.
- Colossal Cave, Tortolita and Tucson Mountain Parks.

Priority Habitats

- Altar Valley
- Baboquivari Mountains
- Cienega Creek
- Eastern Tucson Riparian Complex
- Organ Pipe/Goldwater Complex
- Sabino Canyon
- San Pedro River
- Santa Rita Mountains
- Silverbell Mountains
- Tortolita Mountains
- Tucson Mountains

This inventory, combined with county ranches, form conceptual reserves- Tortolita, San Pedro Valley, Northern Altar Valley, Upper Santa Cruz and Southern Altar Valley Reserves.

County Ranches

Ranching has been deemed compatible with the SDCP and contributes to the open space strategy of the county by defining the urban boundary and preserving sensitive wildlife habitat, corridors and water resources. Maintenance of traditional ranching and agriculture industry, heritage and cultural resources, historic sites such as Canoa Ranch, are also goals of the Ranch Conservation component of SDCP. Assisting ranchers and retaining them as land stewards by entering into cooperative management agreements following purchase allows for continued traditional land use, preventing conversion to development. Ranching has historically occurred in biologically rich and riparian areas, making ranch sites suitable for habitat and species conservation.

There are 16 county ranches[i], all but one working and grazing cattle. Biological value of these lands varies but includes a mixture of Important Riparian Area, Biological Core, Special Species Management Area and Multiple Use designations per the Conservation Land System (CLS). Two, the Bar V and Sopori, are mentioned as shallow groundwater areas. The Bar V has perennial and intermittent stream flow while the Six Bar Ranch has intermittent streams and springs. Sopori Ranch has the benefit of irrigated pasture land, allowing reduced livestock dependence on native forage. Cattle operation is reduced at most ranches, herd inventory held at less than permitted capacity to reflect drought conditions.

County Planning

County owned and managed land is vulnerable to drought impacts as are the county's conservation plans. The planning associated with and dependent upon the land is a vital county asset and impact assessment and adaptive capacity of each must be taken in to consideration.

1. Sonoran Desert Conservation Plan (SDCP)
2. Conservation Land System (CLS)
3. Multi Species Conservation Plan (MSCP) & Section 10 Permit
4. Pima Prospers (Comprehensive Plan Update)

The biological goal of the SDCP, the critical habitat component, is long-term survival of indigenous plant and animal species by "maintaining or improving habitat conditions and ecosystem functions necessary" for each. Complementing land acquisition, the SDCP represents "long-term investment in research, monitoring and adaptive management to ensure the sustained bio-diversity of our region."[4]

The CLS is a guide to the county's land acquisition program by way of categorizing and prioritizing biologically important lands, or Habitat Protection Priorities. The CLS is informed by listing Priority Vulnerable Species, defining biological standards and extensive mapping representing "the ultimate

[4] Protecting Our Land, Water and Heritage: Pima County's Voter-Supported Conservation Efforts.

expression of those lands where conservation is fundamental and necessary to achieve the Plan's biological goals."[5]

The MSCP is the county's response and responsibility in meeting Endangered Species Act (ESA) requirements and receiving a Section 10 permit from the US Fish and Wildlife Service, which will allow certain disturbance of ESA protected species provided mitigation and conservation measures are in place to compensate. The MSCP "will institutionalize many SDCP principles" at the federal level by recording SDCP open space lands as mitigation acreage- an estimated 116,000 acres will be needed for Section 10 compliance as well as continued program and ecological monitoring.

"The County is responsible for management of County owned and leased mitigation lands to ensure that the natural and cultural resource values for which they were secured persists over time. How the County manages these lands for the benefit of natural (especially biological) resources has a direct and critical relationship to the MSCP and, ultimately, the County's receipt of the Section 10 permit."[6]

The MSCP is a way to streamline and provide more certainty for public and private sector development in complying with ESA. These plans, the SDCP, CLS and MSCP, converge with the county's Comprehensive Plan, and current update, Pima Prospers, to represent the county's land use, economic and environmental development strategy- integrating natural and cultural resource protection and land use and infrastructure planning.

County Parks and Recreation

Pima County Natural Resources, Parks and Recreation maintains 42 parks, associated ball fields, 10 pools, one golf course and 22 trail heads[ii] as well as other community recreational resources less sensitive to drought. Obviously, large turf areas require significant irrigation and are very drought sensitive. With the implementation of new software, EnergyCap, water use and demand is being tracked at all county water meters allowing benchmarking and informing better management decision-making.

The Loop, recognized locally and nationally as a regional asset, is a 131 mile shared use path connecting the county's river parks and greenways as well as surrounding communities and other county venues. Reclaimed infrastructure serves most of the river park system; to the extent possible, park irrigation is served by the county's share of effluent.

County Riparian Restoration and Flood Control Projects

Pima County Regional Flood Control District performs its legally required function of installing structural flood control infrastructure across jurisdictional boundaries with bond funds and state and federal resources. Where possible, RFCD supports riparian restoration projects in wash corridors and floodplains. The Floodprone Land Acquisition Program (FLAP) has acquired more than 7,000 acres of land susceptible to flooding in a proactive mitigation effort to reduce development risk in vulnerable

[5] Ibid.
[6] Pima County's Multi-Species Conservation Plan: Balancing Development and Habitat Conservation. Nov 2012.

floodplain. RFCD owns valuable wildlife habitat with significant ecological value[7]. Completed and pending projects include:

1. Cienega Bottomlands Restoration Project
2. Cortaro Mesquite Bosque Construction Project
3. Kino Environmental Restoration Project (KERP)
4. Pantano Jungle Restoration Project
5. Rillito River/Swan Wetlands Ecosystem Restoration Project
6. Lower Santa Cruz River Living River Project
7. Big Wash Rehabilitation
8. Paseo de las Iglesias Phase I
9. Arroyo Chico Multi-Use Project
10. Avra Riparian Restoration and Groundwater Replenishment Project
11. El Rio Medio
12. Tres Rios del Norte

Additionally, RFCD participates in effluent recharge projects that recharge the aquifer earning the county valuable water credits at Underground Storage Facilities such as:

1. Marana High Plains Effluent Recharge Project (MHPERP)-managed by RFCD
2. Lower Santa Cruz River Managed Recharge Project (LSCRMRP) –managed by a joint cooperative that includes RFCD

RFCD also maintains the county's river park system along the urban and wash periphery, connected by The Loop:

1. Cañada del Oro River Park
2. Harrison Greenway
3. Julian Wash Greenway
4. Pantano River Park
5. Rillito River Park
6. Santa Cruz River Park

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[7]WRRC, Riparian Restoration Efforts in the Santa Cruz River Basin. Fabre, Cayla. Mar 2009.

County Water Rights

Pima County Regional Wastewater Reclamation Department (RWRD) treats wastewater and produces effluent, a water source that increases with population growth and will play an increasingly important role in future water planning. Through several inter-governmental agreements, regional sharing of effluent has equated to the county receiving a 10% share of Metro area effluent and ownership of non-Metro area production. Long Term Storage Credits (LTSC) are accrued by storing effluent at the county's permitted recharge facilities. In addition, land acquisition has included certain water rights, giving the county a water portfolio of approximately 15,000 acre-feet (af). Water is withdrawn from 578 county wells; 91 non-exempt, 300 exempt (mostly water quality monitoring) and 187 other wells used for dewatering, water quality and industrial use. Compliance, maintenance and reporting tasks are the responsibility of the county department assigned to the well. The county shares 10,000 af of effluent with the City of Tucson as the Conservation Effluent Pool, to be utilized in future agreed-upon environmental restoration projects.

Total County Effluent Production	65,389 af
County Share from Metropolitan Area Facilities	3,319 af
County Share from Non-Metropolitan Area Facilities	3,993 af
Accrued Long Term Storage Credits (LTSC)	7,573 af
Irrigation Grandfathered Rights (IGR)	4,216 af
Type 1 Non-Irrigation Rights	2,566 af
Type 2 Non-Irrigation Rights	994 af

Other County Venues

Other county affiliated tourist and community attractions include the Kino Veterans Memorial Stadium, Arizona-Sonoran Desert Museum, Pima Air & Space Museum, Pima County Fairgrounds, Titan Missile Museum, Old Tucson Studios, and various motorsports tracks.

Agricultural and Ranching Economic Sector

A 2007 census of the agricultural industry in Pima County conducted by the US Department of Agriculture (USDA), National Agricultural Statistics Service (NASS) surveyed the operation of farms, market activity and production within the county.

The market value of products sold from the 622 operating farms totaled $67.5 million, with $49.4 million, or 73%, in crop sales and $18.1 mil, or 27%, in livestock sales. The average market share per farm was $108,521. There were 71,160 irrigated farm acres in 2007, a decline of 10% from 2002.

The 2011-2007 USDA NASS annual statistics bulletins augment information provided since the 2007 census- the 2012 Census of Agriculture is expected in early 2014. Market cash receipts in 2011 were $64.4 million (72%) in crop sales and $24.9 million (28%)in livestock sales for a total of $89.3 mil, an increase (25%) from combined 2010 crop sales of $52.1 million (73%) and livestock sales of $19.5 million (27%), or $71.6 million.

Most recent data from 2011 and 2010 detail 10,000 harvested acres of upland cotton generating 1,392 pounds per acre for a total production of 29,000 bales. Examining other crops, 4,400 harvested acres of durum wheat produced 396,000 bushels and 2,000 harvested acres of alfalfa hay produced 19,000 tons.

Number of Farms

In quantifying the number of farms within the county, the census included the North American Industry Classification System (NAICS) code 112990; All Other Animal Production. This class, the second largest represented in terms of number, describes specialty and miscellaneous activity as well as dog kennels and bird, rat and worm production, industries not impacted by drought to the same degree as farms and ranches. The number of what could be considered traditional farms and ranches, to include livestock such as llamas and alpacas, is somewhat lower.

With 218 farms, or ranches, beef cattle represents the majority of operations in the county, 35%. There are 202 farms classified by NAICS as other animal production, or 32% of all farms. The next most predominate type of farm is greenhouse, nursery or floral operations. For better clarity, if NAICS code 112990 is removed, beef cattle farms constitute 52% and greenhouses and nurseries 11% of working farms- followed by sheep and goat farms (9%), poultry and egg production (7%), hay, sugarcane and other crops (6%), cotton farms (4%), dairy cow and milk (4%), Fruit and nut orchard (3%), hog and pig farms (2%), vegetable, melon and potato farms (1%) and oilseed and other grain (1%).

Regionally, a majority of farms are located in the Marana area with some situated along the Brawley Wash- these operations producing mostly durum wheat, cotton, barley and sorghum. There is some production along the San Pedro River, in the county’s northeast boundary, of oat and alfalfa.

Market Value

The sale of cattle and calves, 11,687 in 2007, represents the vast majority of livestock sales in Pima County, totaling $7.5 million. Factoring in sheep and goat sales of $111,000, poultry and egg production ($44,000) and hog and pig sales ($53,000), cattle and calve operations were 97% of livestock market value.

Other livestock production is tracked though market value is not disclosed, such as the sale of horses and other equines, miscellaneous animals and various animal products, to include honey and wool.

Nursery and greenhouse production includes floriculture crops, cut flowers, garden plants, indoor foliage plants, potted flowering plants and greenhouse vegetables and herbs. Value of sales within this subsector totaled $6.3 million, a marked decline from the previous agricultural census in 2002 which recorded $30 million in sales, though that would include landscape nursery sales correlating to the housing boom. The census calculates approximately 2 million square feet of green house or similar protected area within the county.

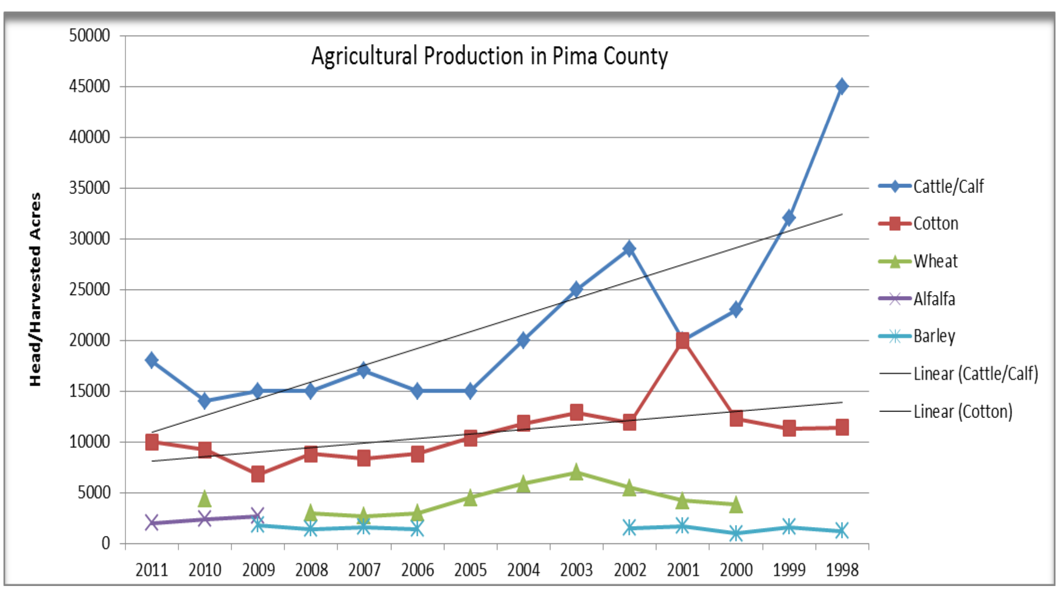
At $4.2 million in market value, grain, oilseed and dry bean and pea sales increased 45% from 2002. Wheat sales totaled $1.96 million followed by hay and other crops ($1.43 million), sorghum ($1 million), barley ($806,000), and finally, vegetable, melon and potato sales ($328,000). Data of cotton and cottonseed sales were not disclosed in either the 2007 or 2002 census.

Production

Pima County is not a major agricultural producer in Arizona, though it consistently ranks 6th in cotton and 5th in durum wheat production since 1998. Yuma leads the state, followed by Maricopa, Pinal, Graham, La Paz and Cochise counties. Pinal County is the primary livestock producer- over $600 million in sales in 2010. With a large cattle inventory in 1998, Pima County ranked 6th in the state at the time but after a 60% reduction in herd numbers, fell to 9th and has fluctuated as low as 11th.

In 2007, Pima County produced 39,232 bales of cotton from 16,227 harvested irrigated acres, compared to Pinal production of 224,237 bales from 73,718 acres. Durum wheat and barley production by the agricultural counties is in the millions of bushels, surpassing Pima County's farming sector, harvesting several hundred thousand bushels.

With $15 billion in retail sales and merchant wholesale, Pima County's agricultural sector comprises less than one percentage (0.5%) of the regional economy and a fraction (0.08%) of its employment. However, ranching and farming are considered important to the history and culture of the county, which has taken steps to preserve tradition.



Energy and Mining Economic Sector

Electric

Electric utilities operating in Pima County are Tucson Electric Power (TEP)- owned by UniSource Energy, Trico Electric Cooperative, Sulphur Springs Valley Electric Co-Op, Arizona Public Service, and Ajo Improvement Company. Specific employment numbers are not available though economic Census Bureau data categorizes a range of between 1,000 and 2,500 county residents employed by the electric utility sector.

TEP serves some 400,000 customers in the Tucson Metro region while UniSource provides natural gas and electric to 235,000 customers in northern and southern Arizona. TEP's service boundary includes Green Valley, Sahuarita, Corona de Tucson, the SR-83 corridor, Vail, Tucson, Catalina Foothills and Marana along the I-10 corridor.

TEP receives power from a number of coal-powered generating stations in which it has a varying percentage of ownership. In northwest New Mexico, at the *San Juan station* TEP produces 340 MegaWatts (MW) and at *Four Corners station*, 110 MW. *Luna station*, in southwest New Mexico, generates 190 MW for TEP. In Arizona- the *Navajo station*, 168 MW; *Springerville station*, 777 MW; and locally at the *Irvington station*, 586 MW. In total, TEP has access to 2,651 MW of electric power produced from generating stations in the metro area as well as across the state and in New Mexico, to include power purchasing agreements[8]. Two-thirds of TEP's capacity is powered by coal, one-third by natural gas.

Arizona's Generation and Transmission Cooperatives provide generation and transmission to rural customers through its membership. Arizona Electric Power Cooperative (AEPCO) is responsible for generation. "Rural electric co-ops were first established in the 1930s to bring electricity to rural areas that for-profit utilities refused to serve. Leaders adopted a cooperative business model where customers are owners. By the 1950s, local distribution co-ops outgrew their ability to meet the growing energy needs of their members. They formed their own power generation and transmission (G&T) cooperatives. Four Arizona electric co-ops formed AEPCO in 1961"[9]- which includes Trico Electric and Sulphur Springs Valley. Arizona Electric Power Cooperative owns and operates the coal and natural gas powered Apache generating station in Cochise, Arizona, which is capable of 605 MW of generation.

Trico's service area surrounds the regions adjacent to, but outside, TEP service area and extends, according to the Arizona Corporation Commission, to include a majority of Pima County. Sulphur Springs Valley is primarily a service provider to Cochise County but extends service to the southeastern border of Pima County.

Arizona Public Service (APS) is the largest provider in the state, serving central Arizona from Casa Grande to Flagstaff and various pockets around smaller communities. Conversely, APS is a smaller provider in Pima County; APS transmits electric to the Ajo area and the northeast corner of the county.

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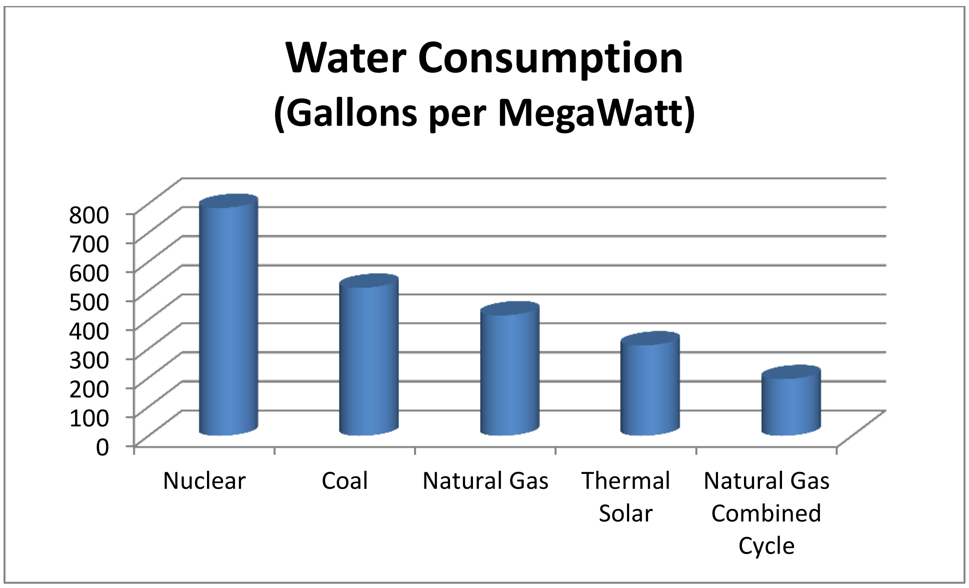
[8] TEP & UNS 2011 Summer Preparedness Report, Apr 11, 2011.
[9] http://www.azgt.coop/azgt-cooperative-energy/member-owned/

APS's generating station portfolio includes: *Four Corners station*, 782 MW; *Cholla station*, near Holbrook, 615 MW; *Navajo station*; *Redhawk natural gas station*, near the Palo Verde plant; a west Phoenix natural gas station; and *Palo Verde Nuclear Generating Station*, of which APS operates and owns 29.1 percent.

Water consumption by generating station fuel type varies. Nuclear power plants consume 785 gallons per MW hour. Coal burning plants require an average of 510 gallons per MW hour; natural gas, 415 gallons; and natural gas combined cycle, 195 gallons. Thermal solar plants consume on average 311gallons per MW hour though large plants in California require between 800-1000 gallons[10]. Of course, photovoltaic solar and wind energy do not require water.

Figure 3-Water Consumption by Fuel Type



Solar

Given the climate of our region, local governments and their partners hope to capitalize on and expand the solar energy sector. From Pima County's Solar One Stop and Renewable Energy Incentive District program to the City of Tucson's designation as a Solar America City, local government recognizes the potential for growth in research and development of renewable energy in the county.

TREO counts 35 established solar companies in the county engaged in manufacturing, distribution and installation, while the US Energy Information Service records the following solar plants in the county:

1. Amonix UASTP Solar Power Station 1.9 MW
2. Prairie Fire Tucson Electric Power 5 MW
3. UASTP I Tucson Electric Power 1.2 MW

[10] ASU, School of Geographical Sciences. The Water Costs of Electricity in Arizona. Martin Pasqualetti, Scott Kelley. Dec 22, 2008.

4. UASTP II Tucson Electric Power 2.8 MW
5. Picture Rocks Solar, LLC NVT LICENSES, LLC 20 MW
6. Roger Road WWTP SunE M5C Holdings LLC .9 MW
7. Avra Valley Solar First Solar Energy LLC 25 MW
8. RE Ajo 1 LLC 4.5 MW

Mining

Mining is not necessarily incompatible with Pima County's long-term goals provided disturbance to the Conservation Land System (CLS) is manageable. The County Administrator has concluded development of "high job generating, high salary generating copper mining enterprise that does not compromise our environmental and other community values" is possible.[11]

Arizona is the top copper producing state in the nation, extracting more than $2 billion in mineral commodities in 2012, though declining from record $7.5 billion in 2007 sales.[12] Of all US domestic copper mining- 1.15 million tons worth $9 billion- 99% of production originates from eighteen mines in the West, Arizona leading. Pima County's mines ranked fourth, fifth and sixth among the state's copper operations. Demand remains high, as export to developing countries, mainly China, continues to increase leading to a projected increase in production.[13]

Copper prices have reached several record highs, $4.62 per pound in February 2011, but some market volatility remained through 2011. Current prices (December 2013) range from $3.18 to $3.37 per pound depending on type of production. Molybdenum now trades between $12 and $9 per pound, a dramatic decrease from the 2007 price of $29.91 per pound.

Census statistics tally NAICS coded mining, quarry, oil and gas extraction industries responsible for $145 million in annual payroll (2011) originating from 39 firms, oil and gas extraction a small subset. Categorized employment is between 1,000 and 2,500. Large mining operations in the county include the Sierrita and Mission Mines in Green Valley, extracting copper and molybdenum, and the copper producing Silver Bell Mine in Marana. The cement Rillito Mine, CA Portland Cement Company's site, and other sand and gravel pits are present in the county as well. The proposed Rosemont Mine continues through the environmental impact analysis process though Pima County has deemed impact to the CLS unmanageable given the magnitude of disturbance.

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[11] June 22 2012 County Memo, A Tale of Two Mines- A Analytical Comparison of the Proposed Rosemont Copper Mine with the Proposed Oracle Ridge Mine.

[12] Ascarza, William. "Mine Tales: Copper Isn't the Only Mineral Common in Arizona." Arizona Daily Star, 4 Nov. 2013. Web. <http://azstarnet.com/news/local/mine-tales-copper-isn-t-the-only-mineral-common-in/article_63b82335-f729-5467-b225-04fb663a13e7.html>.

[13] USGS 2013 Mineral Commodity Summaries. Daniel Edelstein. http://minerals.usgs.gov/minerals/pubs/commodity/copper/mcs-2013-coppe.pdf

Freeport McMoRan operates the Sierrita Mine, the nation's fifth largest copper mine[14] producing 177 million pounds of copper in 2011, employing more than 1,200. Literature distributed by Freeport claims a direct and indirect economic impact of $286.7 million in Pima County and employee compensation of $99 million and secondary job creation of some 4,500 positions[15]. Expansion of mining activity at this site is under consideration.

ASARCO produced 134 million pounds of copper concentrate in 2012 at the nation's seventh largest mine- Mission Mine, which employed 620 with annual payroll and benefits of $58 million. The Silver Bell Mine, ranked 13th in the country, also an ASARCO operation, employed 175 with payroll and benefits totaling $16.6 million. Production at Silver Bell was 45.9 million pounds of copper in 2012.

Copper production in Pima County has remained relatively stable during the past decade, each mine extracting approximately the same tonnage every year, although all are dwarfed by the very large Morenci Mine (800 million pounds per year). Water consumption used in production fluctuates depending on multiple factors- average gallons per pound of copper produced was highest at the Sierrita Mine (54.6), followed by the Mission Mine (25) and Silver Bell (6.7)[16].

Hunting, Fishing and Other Outdoor Recreation Economic Sector

Hunting and Fishing

An Arizona State University study, *The Economic Importance of Fishing and Hunting*, tallied 2001 expenditures and wages and jobs generated for each county, finding these activities to have been an "immensely powerful part of the Arizona collective economic fabric" with a statewide economic impact of $1.34 billion supporting 17,190 jobs.

In Pima County, hunters spent $8.2 million on equipment and $9.4 million on trip expenses- $17.6 million total. Arizona Game and Fish measured 131,345 hunter days active in the county- 42,130 of those were travelers to the region, 65% of Arizona travelers from Maricopa County. Total fishing expenditure topped $66 million, $22.7 million in trip expenses and $44.2 million in equipment purchases as anglers, mostly local residents, were active for 153,893 fishing days. Combined, $84.5 million was spent in county- the local associated businesses employing 1,187 residents, paying $18.3 million in wages and generating $5.4 million in state and local tax revenue

Wildlife Watching

In a more recent report, the Tucson Audubon Society surveyed participants observing, feeding or photographing wildlife, or non-consumptive activities, both at home and traveling to a wildlife watching destination. Total retail sales in Pima County related to birding and similar activity was $179 million in 2011, factoring in a multiplier effect sums to $304 million. Payroll for associated 2,736 industry jobs was

[14] USGS 2011 Minerals Yearbook
[15] L. William Seidman Research Institute, Arizona State University
[16] Arizona Department of Mines and Mineral Resources. Water Consumption at Copper Mines in Arizona. Special Report 29. M Singh.Dec 2010.

$98 million. Of total retail sales, $41 million was spent by neighboring county residents and $42 million from out of state travelers. The county's economic activity generated $20 million in state and local tax revenue.

Other Outdoor Recreation

A similar study to the ASU economic analysis of hunting and fishing reviewed OHV (off-highway recreational vehicle) activity, where a vehicle such as an ATV, 4-wheel drive, SUV, motorcycle or sand rail was used as recreation or to engage in outdoor activity (hunting, fishing, camping, hiking, sight-seeing, etc.). Pima County residents spent $112 million on OHV vehicles in 2001, $323 million in total OHV spending to include $71.7 million on trip expenses such as fuel ($24.2 million), lodging ($5.5 million) and food ($14.1 million) and groceries ($17.5 million) as well as $139.4 million on accessories and equipment. "Driving back roads" and "Sightseeing" were the most popular activity with 836,803 OHV days occurring in the county, just over a third travelers from other counties. In all, this sector had a $400 million economic effect with 3,307 industry employees receiving $84 million in wages and generating $17.7 million in state and local tax revenue.

Tourism and Sports Economic Sector

Three and a half million tourists travel to Pima County each year, a majority enjoying outdoor attractions such as Saguaro National Park and the Arizona-Sonoran Desert Museum, combined with other major events like the world's largest gem and mineral show, PGA's Accenture Match Play and the Vaqueros Rodeo Parade. In 2011, tourist recreation, lodging, dining, shopping and entertainment venues generated $2.4 billion in sales in Pima County, supporting over 21,000 local jobs. Visitors spent $627 million on food services, $422 million on shopping and $320 million on other travel spending. $976 million is generated by visitors from Mexico. Maintaining and expanding the region's tourism is a priority for the county's economic development organizations, TREO and the Metropolitan Tucson Convention and Visitors Bureau. Of the $154 million in local taxes generated, a portion is directed to the county's Sports and Tourism Bureau to further promote this sector and youth and amateur sports, an economic driver in its own right[17].

The county supports El Tour de Tucson which attracts 9,000 cyclists, approximately half visiting to the area, and 30,000 spectators generating $80 million[18]. Amateur league play at Kino Sports Complex is promising with over 500 games played during the 2011 amateur baseball season. County investment in the facility is luring amateur baseball, soccer and other sports[19]. The Fort Lowell Soccer Shootout brings

[17] http://www.visittucson.org/media/tourism-pays/tucson-pima/

[18] http://tucsoncitizen.com/pima-county-news/category/sports/

[19] http://tucsoncitizen.com/pima-county-news/2012/08/07/amateur-sports-at-kino-sports-complex-benefits-the-whole-community/

more than 300 teams to the county and accounts for over $3 million in direct spending[20]. Not to be overlooked, the county's only ski resort, Mount Lemmon Ski Valley recorded over 190,000 in attendance in 2011.

Forestry and Logging Economic Sector

This economic sector does not have a significant presence in Pima County. Extrapolating from employer statistics, the Census Bureau's 2011 County Business Pattern report shows 21 businesses with a combined employment of less than 250 employees (a categorized range of 100 to 249) in the Agriculture, Forestry, Fishing and Hunting sector[21]- most of which occurs in agriculture. Annual payroll, in 2011, was $4.3 million. The 2010 Non-Employer Statistics report recorded ten businesses, comprised mostly of sole proprietorship establishments, associated with specific forestry and logging industry code, with $286,000 in receipts that year, a decline from the previous year's $420,000. The relative small size of this sector precludes it from mitigation discussion.

Municipal and Industrial Water Sector

The county is served by 22 water providers- a mix of private water companies, improvement districts and municipal and governmental water systems[iii]. Pima County is not a water provider though unincorporated residents in the county receive water from Tucson Water and other smaller water providers. County residents could be impacted by water supply curtailment of the M&I sector, however those providers maintain their own jurisdiction and elected boards, of which the county has no authority. The county has worked closely with all water providers and will continue to do so in water planning efforts. The infrastructure, regulatory structure and planning processes associated with the regions' water companies has been thoroughly covered during the City/County Water and Wastewater Study and Action Plan[22], adopted in 2010.

It is important to note that in Arizona, M&I drought plans are a requirement for community water systems. Per ARS Section 45-342, both small and large providers are to submit a System Water Plan[iv] that includes a water supply plan, water conservation plan, and drought preparedness plan and provide and update to ADWR every five years. In addition, Annual Water Use[v] reports are required as well, in an effort by ADWR to "help ensure that community water systems reduce their vulnerability to drought and are prepared to respond to potential water shortage conditions"[23].

The Central Arizona Ground Water Replenishment District (CAGRD) facilitates development in Active Management Areas (AMA's) where infrastructure is lacking to deliver renewable water. CAGRD Member Lands and Member Service Areas are subdivisions and water providers or local governments,

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[20]Johnson, Kyle. "Tucson Soccer Enticing Sports Tourism." Arizona Sonora News Service, n.d. Web. 11 Mar. 2014. <http://arizonasonoranewsservice.com/stories/34-stories/274-tucson-soccer-enticing-sports-tourism>

[21]Defined as establishments primarily engaged in growing crops, raising animals, harvesting timber, and harvesting fish and other animals from a farm, ranch, or their natural habitats.

[22]http://www.tucsonpimawaterstudy.com/

[23]http://www.azwater.gov/AzDWR/StatewidePlanning/Drought/CWS.htm

respectively that enroll for legal authority to pump groundwater and then have the GRD manage the required recharge for that groundwater pumping. The GRD recovers the cost of operation through property tax bills, in the case of enrolled subdivisions, and water provider rate schedules.

GRD's water supply portfolio includes a CAP M&I priority subcontract, water and effluent leases and purchase of long term storage credits, with the goal of acquiring 25,000 acre-feet per year (afy) by 2015. Excess CAP no longer reliably available as part of its portfolio, GRD is planning an acquisition strategy that includes effluent, Colorado River entitlements and fallowing, reallocations and credit purchases to meet a projected demand of 136,500 afy by 2035. Costs will increase to subdivisions through taxes and through water companies increasing rates to cover the acquisition of new water to recharge in order to meet obligations. In the Tucson AMA, 93% of subdivisions are enrolled either as a Member Land or Service Area.[24]

While not a water service provider, Pima County can employ demand management strategies through land use planning and development standards. County water conservation Code amendments were enacted in 2006 and 2007 requiring low use fixtures, renewable water use requirement for turf facilities, irrigation conservation measures and restrictions on fountains and water features. The county encourages sustainable home building through its Green Building and LEED Certification programs. The Comprehensive Plan's Water Resource Element helps to clarify water supply and use impacts of requested land use changes. All are examples that contribute to drought preparedness and mitigation through water and energy conservation. However, discussion within Pima County's Local Drought Impact Group (LDIG) suggested county land and resource management adapt and incorporate drought mitigation more robustly; progression beyond policies promoting water conservation to policies derived from an expectation of "a new normal" of severe and prolonged drought, to include associated impacts. Counties draft conservation and climate change planning within their Comprehensive Plans and development standards to varying degree; unknown at this time is the willingness of the public, or appropriateness, of county Development Services initiating adoption of more stringent strategies considered elsewhere, such as creating disincentives (fines) for conventional, non-LEED certified new construction or mandating water efficient fixtures as retrofit for existing buildings.

Suggested adaptation discussed low impact development (LID), an approach to stormwater management that allows more natural hydrologic function within development by forgoing complex infrastructure and engineering designed to shed water expeditiously for increased infiltration of rainwater into the local aquifer. Green space is key to LID strategy of managing stormwater as close to its source point as possible. Natural landscape features and pervious surfaces control water runoff effectively and more economically than conventional stormwater engineering while filtering runoff. Other benefits are realized by the supported green space that improve quality of life for the surrounding neighborhood to include "enhanced property values and re-development potential, greater marketability, improved wildlife habitat, thermal pollution reduction, energy savings, smog reduction, enhanced wetlands

[24] Central Arizona Groundwater Replenishment District Membership in the Tucson Active Management Area 2005-2009. Pima Association of Governments, Sept. 2011.

protection, and decreased flooding." [25] Expanded application of LID can help maintain or restore watershed level flows and ecology.

In practice, LID employs multi-benefit bio-retention basins, urban forest streetscapes, rain gardens, green rooftops and bio-swales as well as retro-fitting techniques such as curb cutting to direct rainwater into street side green basins. Pima County has prepared LID guidance documents based on case studies and best management practices compiled through its LID Working Group[26] and PAG encourages incorporation of LID design into projects and land planning efforts. A successful example of such design is the Kino Environmental Restoration Project (KERP), which captures stormwater for irrigation while sustaining recreated upland and riparian habitat.

Potential Sector Impacts

Some impacts are universal across sectors. Threat from wildfire, increased operating or maintenance costs, decreased spending, revenue and production, sector unemployment and reduced quantity, quality and reliability of water supplies threaten drought sensitive sectors as a whole.

Wildfire

In addressing the threat of wildfire, Pima County's Community Wildfire Protection Plan (CWPP) is an effort to improve fire prevention and suppression of identified at-risk public and private lands in the wildland-urban interface (WUI). A number of tactics are employed to reduce fire risk and priority is assigned to the WUI and the municipal watersheds and critical wildlife habitat within. The CWPP recognizes the need to reduce hazardous vegetative fuels while improving watershed and range health and restore ecosystem processes to improve resiliency- cooperating regional fire agencies are encouraged through the plan to adopt these same goals that include consideration of watershed and riparian health given that "wildlife, and unique plant communities, especially desert areas with saguaro cactus, (are) important economically for maintaining property values and tourism."

Following the creation of Core Teams, significant analysis of various factors (vegetative fuel type, normal and extreme rainfall years, topography, population density, slope, native/non-native species, etc.) identified 1.5 million acres of WUI; 18% of these acres are deemed to have high resource value as cultural, historic, or sensitive wildlife habitat areas and watersheds, another 8% classed as having high fire risk and 59% at moderate risk. The CWPP concedes additional site-specific analysis of fuel and vegetation treatment within sensitive species habitat may be needed given complexity of habitat conservation plans and threatened and endangered populations.

Overall, the CWPP has taken into account the "environmental, economic, and aesthetic resources" of the county and responded accordingly with a strategy that prioritizes resource protection and fuel reduction and is informed of drought and non-native vegetation impact:

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[25] Stormwater Strategies Chapter 12 Low Impact Development." Www.nrdc.org. Natural Resources Defense Council, n.d. Web. 9 Apr. 2014. <http://www.nrdc.org/water/pollution/storm/chap12.asp>.

[26] http://rfcd.pima.gov/pdd/lid/workinggroup.htm#background

Many of these wildland fire ignitions have occurred within areas infested with nonnative grasses such as buffelgrass, red brome, and Mediterranean grass…Continued extreme weather conditions, dry fuels, increased nonnative invasive vegetation, and increased fuel loading on federal and nonfederal lands contribute to the potential for catastrophic wildland fires within Pima County. Wildfires… exhibit erratic behavior due to dry light and heavy fuels from high average daily temperatures and seasonal droughts. In recent years, the southwest United States has experienced widespread and intense drought, which has been stressing forests (Karl et al. 2009). Record wildfires are also being driven by rising temperatures and related reductions in spring snowpack and soil moisture (Westerling et al. 2006). Associations between wildfire and hydroclimate in western forests indicate that increased wildfire activity over recent decades may be tied to reduced winter precipitation and an early spring snowmelt, particularly in mid-elevation forests (Westerling et al. 2006). If the Southwest becomes warmer and drier, as projected by many climate models, wildland fire seasons are anticipated to increase in length and severity driven by rising spring and summer temperatures and related reductions in spring snowpack and soil moisture (Karl et al. 2009; Westerling et al. 2006; USDA 2012). If periods of extended drought and warmer temperatures become more common in Pima County, increases in wildland fire occurrences, particularly in higher-elevation vegetation associations, and fire severity can be anticipated.

Appropriate vegetative types can absorb the natural process of fire, thus critical wildlife habitat restoration and non-native eradication is a purposeful fire suppression tactic. To that end, the CWPP stresses partnership with the Southern Arizona Buffelgrass Coordination Center (SABCC) and private landowners in completing fuel modification plans supplemented by inmate labor crews working Treatment Management Units. Public education and reporting is an important component; homeowners can help by reviewing their property for compliance with the Firewise Communities program recommendations while SABCC has developed a smartphone app that records individual reports of buffelgrass infestation to improve eradication efforts and mapping of high risk areas.

County Assets

Neither a water provider nor engaged in drought sensitive industry, impacts to the county are varied and can be most profound at the second order- loss of tax base from decreased economic output, for instance. Direct impacts are more straightforward- loss of buildings or assets to fire or loss of landscaping. The most significant vulnerability is to county open space lands and planning efforts, in which case county asset vulnerability overlaps with environmental vulnerability. Impacts across county departments include:

1. Increased management requirements
2. Decreases in revenue
3. Loss of groundwater wells
4. Diminished water rights inventory

Foregoing a detailed scientific analysis of drought impact to county land, it is important to note drought, combined with sector water use, has already degraded riparian areas in the county's land inventory. The Water Resources Research Center (WRRC) has undertaken an environmental water needs assessment, examining and compiling the existing science of environmental water needs, or e-flow, necessary for the maintenance of healthy aquatic ecosystems and riparian areas. This effort will help quantify streamflow volume needed to support these environs[27].

Suffice for this discussion, riparian habitat decline is underway. The Cienega Creek has experienced decreased stream flow, as documented by PAG's "Drought Impacts on Flow Extent Along Lower Cienega Creek" report:

The perennial flow extent was reduced to 0.93 miles in June 2013, the lowest flow extent on record and 0.31 miles shorter than the previous June. This is only 10% of the flow extent compared to the wet years in the mid 1980s when fully 9.5 miles flowed in Preserve during the dry season[28].

Cienega Creek and its wildlife and plant diversity have been recognized as a state resource, earning an "Outstanding Water" designation (R18-11-112) by the Arizona Department of Environmental Quality (ADEQ). As a result, site-specific water quality standards are established to maintain and protect the existing water quality. The certificate of in-stream flow rights was granted by the Arizona Department of Water Resources (ADWR) to Pima County Regional Flood Control District in December 1993 (No. 89090.0000). Both Cienega and Davidson Canyon have priority aquatic and riparian resources as specified in the Sonoran Desert Conservation Plan.[29]

Similar decline is recorded at Sabino Creek, Arivaca Creek, Bingham Cienega and the Upper Cienega Creek and San Pedro River. To compensate for increased aging and morbidity of cottonwood species, the US Fish and Wildlife Service has planted replacement cottonwoods in the Arivaca Cienega. Drought induced decline of riparian habitat has reduced the leopard frog's range, resulting in a decline of that population in Cienega Creek and elsewhere. Dying trees and brush remain as fuel for wildfire increasing the potential for scorching and sterilization of the soil- thus precluding any replacement growth[30].

The County's Natural Resources, Parks and Recreation Department (NRPR) has measured the natural spring at Agua Caliente Regional Park, recording decline over the past decade. Lack of recharge to the aquifer has caused flow to reduce from 106 gallons per minute in 2000 to 13 gpm in 2003, eventually ceasing flow in 2012. In that time, the park's three ponds have been reduced to one, which is supplemented with up to 65,000 gallons a day of groundwater to maintain below normal water level.[31]

County riparian restoration and flood control projects rely mostly on effluent as a water source. Some projects utilize storm water collected after flood events from detention basins or rain water harvesting, which of course receive less water during drought. Discussion with project managers included the consideration that effluent may be put to other uses, stressing the need for resilient design that does not

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[27]WRRC, Environmental Flows and Water Demands: Southeastern Arizona Region, July 2012.

[28]PAG. Drought Impacts on Flow Extent Along Lower Cienega Creek. August 2013

[29] Mier, Mead. "Draft Pima County Drought Vulnerability Assessment for Review." 13 Jan. 2014. E-mail.

[30]Davis, Tony. "Cienega Creek, Other S. AZ. Streams, Increasingly Dry." Azstarnet.com. Arizona Daily Star, 29 July 2012. Web. 03 Jan. 2014. <http://azstarnet.com/news/science/environment/cienega-creek-other-s-az-streams-increasingly-dry/article_f0e30953-13be-5a93-86e0-4fe6ae6a061b.html>.

[31] Jung, Yoohyun. "Historic Park's Pond Drying Because of Drought." AZPM.org. Arizona Public Media, 29 Aug. 2013. Web. 09 Mar. 2014. <https://www.azpm.org/p/home-featured/2013/8/29/26428-historic-parks-pond-water-drying-because-of-drought/>.

rely on groundwater and sustains wildlife habitat[31]. Should effluent dependent restoration projects receive diminished allocations, they would be susceptible to the same drought stressors non-effluent riparian areas are currently experiencing. Curtailment of the water supply translates into decreased effluent production and thus declining long term storage credit accumulation and less water available for restoration.

The county's parks provide recreation and a venue for amateur and youth sports. Turf and park landscape experience reduced growth and die back of annual roots from reduced photosynthetic activity and decreased pest resistance in turn during drought. This increases the cost of maintenance as more water and chemical application is needed for pest and weed control to maintain plant health. Park districts have reported increased injury, and thus liability, due to hard fields[32].

Agriculture and Ranching

This sector is not a significant economic driver in Pima County, though it is a valued cultural tradition and as previously mentioned, helps define an urban boundary while keeping intact biologically important habitat. Perhaps the most sensitive sector, impacts include:

1. Loss of crop, decreased yield
2. Loss of livestock, reduced herd size and limited forage availability
3. Decreased, unreliable water for irrigation and livestock
4. Higher feed and water costs, increased consumer prices
5. Reduced livestock health and birthing rates
6. Forced sell of livestock

Ranching is becoming cost prohibitive as forage conditions decline and ranchers are forced to rely on feed. Across central Arizona, cattle operations are selling off approximately 20% of their herds in response to drought conditions and preparing for more liquidation. This has long term implications as herds must be reconstituted over many years. In the short term, beef prices, already impacted by drought, will continue to rise.[33]

Agricultural production loss in the state has resulted in all 15 counties, including Pima County, declared as natural disaster areas by the USDA.[34] Forage production across the state was 66% of average in 2013 with below average production expected to continue; livestock water shortages were reported across Pima County and cropland water shortages in the Upper San Pedro area.[35]

[31] WRRC. Riparian Restoration Efforts in the Santa Cruz River Basin. Fabre, Cayla. March 2009.

[32] http://www.sdaco.org/m/downloads/2013/T-1%20The%20Drought%20Will%20Impact%20All%20of%20Us.pdf

[33] Patrick, John. "Arizona drought forcing ranchers to sell cattle" KVOA.com. KVOA News, 06 Feb. 2014. Web. 09 Mar. 2014. <http://www.kvoa.com/news/arizona-drought-forcing-ranchers-to-sell-cattle/>.

[34] Ronquillo, Ina. "USDA drought declaration now covers all of Arizona" KGUN9. KGUN News, 07 Mar. 2014. Web. 09 Mar. 2014. <http://www.jrn.com/kgun9/news/USDA-drought-declaration-now-covers-all-of-Arizona-249075751.html>.

[35] Natural Resource Conservation Service

Energy and Mining Sector

Energy generation and mining can have water intensive production processes. The energy/water nexus describes the requirement of both for the delivery of each. As demand for energy increases, energy production will demand more water. And water cannot be delivered or recovered from wells without energy. Energy is a significant cost component of water production, delivery and wastewater treatment.

Research during the Colorado plan found that this sector had some buffer from drought given these industries generally had senior water rights yet "there are compound impacts between power producers and the mining industry because nearly all of the current power generation in (Colorado) is fossil fuel based. Any impacts to the mining industry will in turn impact power providers and the effects will cascade back to water providers, mining, and society as a whole[36]." Impacts to consider include:

1. Decreased, unreliable water for processing
2. Decreased production, increased import from other electric generating stations
3. Increased consumer cost
4. Electrical power cutbacks, rolling brownouts, blackouts
5. Secondary impacts from power outages (public health threat, economic interruption)
6. Infrastructure loss and outages from wildfire

Analyses of incidents in Arizona indicate the energy sector is vulnerable to weather extremes. The Springerville Generating Station came under threat during the Wallow Fire in 2011. Forecast models illustrated the potential cascading failure. Peak energy demand during extreme temperatures, associated with drought, strains infrastructure trying to generate and transmit enough electricity for air conditioning, which constitutes 70% of residential consumption. A September 2011 blackout in Arizona and California occurred for multiple reasons but a report noted the heavy power imports required during record heat days. Of note- it took 11 minutes for the cascading failure to occur, lasted 12 hours and cost the San Diego area alone $100 million in lost economic output. Public health was threatened as sewage spilled onto beaches after pump failures. It is plausible brownouts and blackouts will increase as well as the negative economic impact of such events.[37] TEP states it has active extreme event response plans in place with emergency towers and specialty replacements packages for deployment.

Electricity costs will rise for the consumer due to decreased hydroelectric efficiencies, increased cooling water costs and air quality controls. Summer demand generation is already twice as costly as off peak generation. The under-utilized solar generating capacity of Arizona must be considered- estimates place that capacity at approximately 2.5 gigawatts of concentrating solar electricity capable of delivering 5.8 gigawatt hours.[38]

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[36] Colorado Drought Mitigation and Response Plan Annex B. August 2013

[37] Sundt, Nick. "Rising Temperatures Expose Cities' Vulnerable Electrical Supplies."ClimateScienceWatch.org. Climate Science Watch, 24 May 2012. Web. 10 Mar. 2014. <http://www.climatesciencewatch.org/2012/05/24/rising-temperatures-expose-cities-vulnerable-electrical-supplies/>.

[38] Repetto, Robert. "Economic And Environmental Impacts of Climate Change In Arizona."Demos.org. Demos, n.d. Web. <http://www.demos.org/sites/default/files/publications/AZ_ClimateChangeInTheStates_Demos.pdf>.

Hunting, Fishing and Other Outdoor Recreation

Drought stresses habitat and impacts game which in turn impacts associated consumptive and non-consumptive uses. Arizona Game and Fish hauls an average of 400,000 gallons of water each year to remote catchments to keep wildlife alive through the summer. Taxes from sales in this sector benefit conservation programs which then suffer from decreased spending at a time when more money is needed. Impacts include:

1. Increased wildlife mortality, reduced health and birthing rates
2. Loss of critical habitat, dry streams and springs
3. Increased competition further reduces population, drives game to urban areas
4. Increase in rabies and disease, human interactions with wildlife
5. Decreased participation, decreased money for management
6. Threat from wildfire causing forest, campground closures
7. Disruption in animal behavior, migrations

Tourism and Sports

Sectors interdependent upon each other compound impacts due to related vulnerabilities. Many county assets are environmental and recreational assets that draw tourism. Many factors influence personal decision in choosing recreation, or business conference and retreat destinations. Analysis of “a marked hot-season drop-off of business travel to Arizona, measured by business segment hotel rooms sold during the summer months” points to the deterrent effect of prolonged and excessive summer heat (exacerbated by urban heat island effects). Further experience “confirms that visitation is highly sensitive to climate and its effects. Controlling for other influences, drought reduces visits to some national parks by seven percent.”[39]

Given the complexity of tourism, the full range of impacts may be obscure but direct impacts include:

1. Decreased visitation, length of stay, participation and revenue
2. Increased operational costs

Environment

Environmental impacts for this analysis are considered in the context of a county or economic nexus. Habitat loss and decreased biodiversity from drought, or secondary impact of wildfire or disease, has wide ranging impacts and is not easily quantified or mapped. It is not possible to assign a value to Pima County's environment though it is an economic driver. Habitat lost is not recovered without expensive restoration and even then natural ecological functions may not return, leaving permanent disruption.

Shallow groundwater areas provide water to more sensitive wildlife habitats that are part of larger wildlife corridor systems. PAG's “Shallow Groundwater Areas in Eastern Pima County, Arizona” report has documented 32 such areas in 10 regions and the trend of water well pumping in vicinity. This allows for

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[39] Repetto, Robert. "Economic And Environmental Impacts of Climate Change In Arizona."Demos.org. Demos, n.d. Web.

some insight into the level of shallow aquifer decline, illustrating the most vulnerable areas where drought combined with human consumption compounds impacts by the competing interests[40].

Municipal Water Sector

The municipal and industrial sector's vulnerability is a function of water service providers' physical systems, water portfolio and associated rights and drought mitigation plans. Key factors for reliability are water supply, distribution, demand and adaptive capacity.

As one mitigation strategy for municipal vulnerability, the state has created the Arizona Water Banking Authority (AWBA) to maximize the state's Colorado River allotment. Preparing for shortages, the AWBA stores water that might not otherwise be retrieved from the Colorado, firming these supplies for the M&I sector by earning long term storage credits- 32,399 acre feet in the Tucson AMA. Additionally, shortage sharing agreements for Colorado River water offer clarity and a process to reduce water deliveries by agreed priorities, curtailing agriculture and recharge use while sparing municipal demand[vi].

Specific impacts that community water systems are vulnerable to during drought include:

1. Reduction in M&I well production
2. Reduction in storage reserves
3. Disruption of water supplies
4. Degraded water quality
5. Higher water treatment costs
6. Sediment and fire debris loading to reservoirs following a wildfire
7. Loss of operations revenues
8. Increased expenses for public education
9. Loss of system flexibility
10. Limited new hookups, construction

Socio-Economic Sector

This sector includes many second order impacts that are not immediately recognized but follow from vulnerabilities in the other sectors. For instance, the condition of the environment enhances or detracts overall quality of life and land value. Second order impacts can lag and remain sometimes after first order impacts have subsided.

Socio-economic vulnerability is greater where the economic base is composed of a larger percentage of drought sensitive economic sectors, impacting supporting industry and negatively affecting associated indirect spending and any economic multiplier effect.

[40] PAG. Shallow Groundwater Areas in Eastern Pima County, Arizona: Water Well Inventory and Pumping Trend Analysis. Oct 2012.

Correlating indirect impacts reverberate through the economy- "recent study by researchers at the Sandia National Laboratory considered impacts of precipitation declines on the half-dozen industries with the greatest water consumption (e.g., agriculture, utilities, mining, chemical manufacturing), sectors that make relatively small contributions to the state's GDP. The study found that economic damages would be spread widely throughout the rest of the state's economy because of higher input costs, lower consumer incomes and spending, population changes and changes in the state's inter-regional competitiveness. Retail trade, food manufacturing and construction would be among the sectors most severely affected by these secondary effects but no sector would be unscathed. This study found Arizona to be among the nation's most vulnerable states."[41]

Additionally, drought related health impacts will place added stresses on the public. "Asthma attacks and allergies will be exacerbated by higher air pollution levels, including ozone, particulates from dust and wildfires, and higher pollen counts that start earlier in the spring. Higher ozone and particulate levels are reliably linked to increased mortality and morbidity. Among the elderly, stroke and heart attack increase with rising heat… In the past decade, a six percent increase in heat-related mortality was observed for each one degree Fahrenheit rise in the heat index and mortality also rose with the duration of the heat wave. Low-income households are much more vulnerable to these health effects because the high cost of electricity…[42]

Impacts can be categorized by secondary economic impact and behavioral and public health and include:

1. Decreased public health, increased respiratory distress and other disease
2. Diminished quality of life
3. Increased unemployment and crime
4. Reduced income
5. Poor housing sales
6. Relocation
7. Diminished tax base
8. Compromised water and air quality
9. Stress, depression and suicide
10. Loss, replacement of private wells

There are 7,600 exempt wells in the Tucson AMA. Private well users are susceptible to dropping water tables during drought requiring owners to deepen or drill a new well to access water. Increasing depth to water results in increased pumping costs and can lower water quality, to include more mineralization.

[41] Repetto, Robert. "Economic And Environmental Impacts of Climate Change In Arizona."Demos.org. Demos, n.d. Web.
[42] Ibid.

Public Education and Impacts

Arizona's Drought Preparedness Plan (ADPP) workgroups investigating mitigation goals across sectors realized the necessity of increasing public awareness and drought education and improving information dissemination. A drought public information campaign can have many messages depending upon the audience and mitigation intended. A common purpose is to maintain a clearinghouse of conservation, drought and assistance information for the public at large.

LDIG is a link between local communities and the state, providing input and information on a sub-regional scale, and while the state maintains a public information clearinghouse (website), improving outreach and education is a defined LDIG task within the ADPP. Updated comprehensive information on the county's drought plan, coordination with the state and other jurisdictions, notifications of wildfire or habitat and wildlife impacts, climate forecasts, public health and educational workshop alerts are examples for public information dissemination.

Expanding beyond general public education, messaging can target sectors and be tailored to local conditions. For example, tourism messaging could be coordinated with the Metropolitan Tucson Convention and Visitors Bureau, educating that audience of living in a desert environment and introducing alternative recreational opportunity to impacted sectors or stressing continued operation despite drought. Residents concerned with municipal supply could be educated on the various tiers of CAP shortage level reductions. Private well owners could receive targeted messaging emphasizing conservation and potential impacts from drought-related water table declines. Improved outreach could help increase impact reporting locally, especially second order impacts.

Conclusions

1. County owned and maintained open space and riparian habitat is the most vulnerable county asset. The County's long term planning programs associated with these lands are also a significant asset. A drought management plan for the county should protect these investments by prioritizing adaptive management strategies and resources for these sectors.

2. Agriculture and ranching are not dominant economic drivers in Pima County however are valued as a distinct regional cultural heritage. Ranching is most beneficial to the county as a land management and habitat maintenance tool.

3. Birding and wildlife watching, combined with other outdoor recreation and tourism, are dominant economic drivers for the county. Birding offers economic benefits comparable to the region's largest copper mine. The county's habitat programs are of benefit to these economic sectors.

4. Tourism is multi-faceted and duplicative in other sectors and sub-sectors. Of the drought sensitive industries considered in this narrative, it is the most dominant economic driver. Outdoor activities associated with the natural environment are the most popular county attractions.

5. Socio-economic impacts are second and third order impacts easily obscured. Collecting reports on all order of impact is an important function of Pima County's LDIG.

Recommendations

Suggested changes to the drought ordinance and recommendations submitted to LDIG include:

1. Revise drought stage and trigger events (Table 8.70.050) to more accurately reflect and communicate current conditions, improve coordination with other jurisdictional declarations, correct front loading of response measures, provide more flexibility and buffer against oscillating changes of status. Include some exceptions for rainwater harvesting systems to incentivize use. Provide a range of status condition allowing discretion in stage declaration and distinction, for example of a recent and limited Severe finding versus a prolonged Severe finding with more pronounced impacts.

2. Consider appropriate levels of duplication with the City of Tucson and other providers to encourage cooperation and prevent disparate enforcement.

3. Cooperation and consolidation of effort is necessary. LDIG, as a component of the ADPP, is designed to augment the response plan (ordinance) as a repository of assessment information and as a recommendation body. Formalize decision making process within LDIG to coordinate new declarations with water providers. Table 8.70.050 serves as a guideline for drought declaration; LDIG analysis and report to the County Administrator is integral to providing context of drought status.

4. Increase public education and information collection and dissemination with drought sensitive sectors. Conduct a review of department procedures for receiving and responding to violations of the drought and water wasting ordinance.

5. Designate a Drought Liaison within relevant County departments responsible for information sharing of drought impacts and other pertinent data with LDIG.

6. Continue implementation of the Sustainability Action Plan for County Operations (SAPCO), Water and Wastewater Infrastructure, Supply and Planning (WISP) Study and Action Plan and Water Resource Asset Management Plan (WRAMP).

7. Consider purchase of wells near groundwater dependent ecosystem areas and permanently retire the groundwater rights associated with them.

8. Continue refinement of the County's Strategic Plan for Use of Reclaimed and similar strategy and criteria for use or transaction of accrued Long Term Storage Credits.

9. Initiate a process to identify data and information gaps and assess changing vulnerability over time to provide LDIG improved analysis.

The Pima County Local Drought Impact Group has considered a number of recommended drought response strategies. The current Pima County Drought Response Plan includes short term water restrictions targeted to public water demand. To address anticipated long term persistent drought conditions, drought responses should be long term; requiring permanent water conservation measures such as low impact development and development standards.

- Education and outreach should educate visitors and seasonal residents on the importance of water efficiency in our desert environment. Education should include private well owners who could be impacted by declining groundwater levels
- Strategies for the environmental sector could include rainwater catchments and acquisition and protection of water rights
- Rising temperatures and persistent drought can by mitigated by green spaces incorporated in land use design
- Cooling centers for communities could be established during summer power outages to help low income areas
- On-going drought monitoring is needed to distinguish between short term and long term drought impacts
- The impacts of CAP shortage declarations at various tiers should be evaluated
    - Shortage Level One impacts to the availability of excess CAP water and the agricultural settlement pool
    - Shortage Level Two impacts to further reductions to the agricultural settlement pool and potential for increased agricultural groundwater pumping
    - Shortage Level Three impacts to more reductions to the agricultural settlement pool and impacts to CAP water rates for all CAP water subcontractors

Potential mitigation strategies for various sectors impacted by drought can include:

Wildlife and environment

1. Water catchments
2. Import water to remote areas (costly)
3. Acquire and protect water rights
4. Desert wash protection
5. More environmental restoration projects
6. Use reclaimed water for environmental restoration. This source of water is “drought-proof”

Tourism

1. Education focusing on living in a desert environment instead of drought

2. Collaborate messaging with Tucson Convention & Visitors Bureau

Water Supply

1. Education to private well owners

2. Consistency in drought declarations among jurisdictions (all are in stage 1 until a Colorado River shortage is declared)

3. Effluent may need to be reallocated during prolonged drought

4. Implement long term water conservation measures such as low impact development and rainwater harvesting to sustain landscaping

Forestry

1. Wildfire plans for federal lands

2. Wildfire plans for county, especially lands abutting Forest Service

3. Continue invasive species control (buffelgrass eradication)

Energy

1. Water shortages can limit power production

2. Drought impacts might affect power production

3. Increase reliance on renewable energy

4. Provide community cooling centers

5. Build more green spaces that provide passive cooling

New ordinance with long term restrictions may be needed during prolonged drought

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i

- Bar V Ranch- 1,763 fee acres/12,674 acres grazing lease. Shallow ground water area. Biological Core, Important Riparian Area. Perennial, Intermittent Stream Flow. 34/55 Priority Vulnerable Species (PVS).
- Sands Ranch- 5,040 fee acres.
- Clyne Ranch- 880 fee acres. Important Riparian Area, Multiple Use. 15/55 PVS.
- Empirita Ranch- 2,700 fee acres. Biological Core, Important Riparian Area. High sensitive archaeological zone. 1,600 acre feet (af) water right.
- Marley Ranch- 6,337 fee acres. Largest working ranch at 114,400 acres.
- Rancho Seco- 9,574/21,662 acres. Multiple Use.
- Sopori Ranch- 4,135/10,480 acres.
- Canoa Ranch- 4,800 acres. Non-working ranch.
- Buckelew Farm- 505/2,000 acres. Working farm. 1,092 af Irrigation Grandfathered Right (IGR). Multiple Use, Important Riparian, Special Species Management Area.
- King 98 Ranch- 1,034/3,096 acres. IGR, fallow fields. Multiple Use, Special Species Management and Important Riparian Areas. Water rights may provide restoration opportunity for a stretch of the Altar and South Mendoza washes.
- Diamond Bell Ranch- 191/29,904 acres. Biological Core, Multiple Use and Special Species Management Areas.
- Six Bar Ranch- 3,292/9,000 acres. Currently stocked at about 20% of allowed use, due to drought conditions. Biological Core, Important Riparian Area corridor.
- A-7 Ranch- 6,829/34,195 acres. County operated, county employees and owned cattle. Cow/calf operation of 300 head- 40% of allowed use. Biological Core, Multiple Use Management and Important Riparian Area.
- Carpenter Ranch- 560 acres. Cochie Spring and an associated riparian area- Important Riparian Area, Multiple Use Management Area, and Special Species Management Area. Livestock grazing on the Carpenter ranch has been significantly reduced during the current drought.
- Old Hayhook Ranch- 839 acres. Non-working ranch. Historic Preservation site and cultural resource protection.
- Steam Pump Ranch- Non-working, cultural resource historic ranch site.

ii

- Agua Caliente Park
- Ajo Regional Park
- Arthur Pack Regional Park
- Augie Acuna Los Niños Park
- Brandi Fenton Memorial Park
- Branding Iron Park
- Canoa Preserve Park
- Casas Adobes Park
- Catalina Neighborhood Park
- Catalina Regional Park
- Children's Memorial Park

- Curtis Park
- Dan Felix Memorial Park
- Denny Dunn Park
- E.S. "Bud" Walker Park
- Ebonee Marie Moody Park
- Feliz Paseos Park
- Flowing Wells Park
- Forrest "Rick" Rickard Park
- George Mehl Foothills Park
- Lawrence Park
- Linda Vista Park
- McDonald Park
- Meadowbrook Park
- Mike Jacob Sports Park
- Mission Ridge Park
- Northwest Community Park
- Palo Verde II Park (tennis courts in Ajo)
- Picture Rocks Park
- Pima Prickly Park
- Richardson Park
- Rillito Regional Park
- Rillito Vista Park
- Star Valley Park
- Summit Old Nogales Park
- Sunset Pointe Park
- Ted Walker Park
- Thomas Jay Regional Park
- Three Points Veteran Memorial Park
- Vesey Park
- Wildwood Park
- Winston Reynolds-Manzanita Park

- Ajo Pool (E.S. "Bud" Walker Park)
- Brandi Fenton Splash Pad
- Catalina Pool
- Flowing Wells Jr. High School Pool
- Kino Pool (Mulcahy YMCA)
- Los Niños Pool
- Manzanita Pool
- Northwest YMCA - Thad Terry Pool
- 9. Picture Rocks Pool and Splash Pad
- Wade McLean Pool (Marana High School)

- 36th Street Trailhead
- Abrego
- Agua Caliente Park

- Agua Caliente Hill South
- Avenida de Suzenu
- Bear Canyon
- Camino de Oeste
- Campbell
- Central Arizona Project
- Colossal Cave Road
- David Yetman West
- El Camino del Cerro
- Explorer
- Gabe Zimmerman Davidson Canyon
- Gates Pass
- Iris Dewhirst Pima Canyon
- King Canyon
- Richard Genser Starr Pass
- Richard McKee Finger Rock
- Sarasota
- Sweetwater Preserve
- Ventana Canyon
- Gilbert Ray Campground
- Anza Trail connections

iii

- Arizona State Prison
- Avra Water Co-Op
- Arizona Water Company-Oracle
- Community Water Company-Green Valley
- DMAFB Water System
- Farmers Water Company
- Flowing Wells Improvement District
- Green Valley Domestic Water Improvement District
- Lago del Oro Water Company
- Las Quintas Serenas Water Company
- Los Cerros Water Company
- Marana Domestic Water Improvement District
- Metropolitan Water Improvement District
- Rancho Sahuarita Water Company
- Ray Water Company
- Saquaro Water Company
- Town of Marana
- Town of Oro Valley
- Tucson Water
- University of Arizona System
- Vail Water Company
- Voyager Water Company

[iv]The System Water Plan consists of three components:
Water Supply Plan – describes the service area, transmission facilities, monthly system production data, historic demand for the past five years, and projected demands for the next five, 10 and 20 years.
Drought Preparedness Plan – includes drought and emergency response strategies, a plan of action to respond to water shortage conditions, and provisions to educate and inform the public.
Water Conservation Plan – addresses measures to control lost and unaccounted for water, considers water rate structures that encourage efficient use of water, and plans for public information and education programs on water conservation.

[v]Includes such information as water pumped or diverted, water received from other suppliers, water delivered to customers, and effluent used or received.

[vi]While CAP holds a junior priority within Arizona and will be subject to shortages, CAP would manage shortage by first reducing the excess water deliveries and ceasing portions of its recharge operations. If additional reductions were warranted, CAP would limit its water delivery to agricultural customers, who have limited rights to CAP water and could turn to pumping groundwater or other sources. If reductions were to be required beyond this level, then CAP would begin to recover the excess water stored underground to protect existing municipal and industrial CAP customers from experiencing reductions in deliveries of CAP water and to recover water stored to meet Arizona's obligations pursuant to Indian Water Rights Settlements.

Climate Change Impacts in the United States

CHAPTER 20
SOUTHWEST

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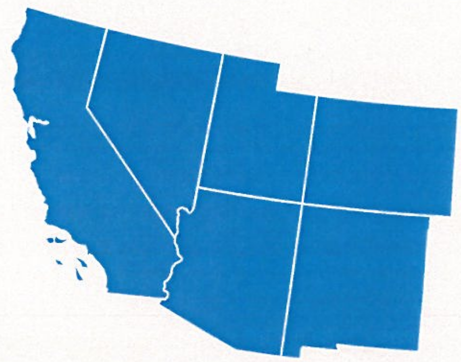

Recommended Citation for Chapter

Garfin, G., G. Franco, H. Blanco, A. Comrie, P. Gonzalez, T. Piechota, R. Smyth, and R. Waskom, 2014: Ch. 20: Southwest. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 462-486. doi:10.7930/J08G8HMN.

On the Web: http://nca2014.globalchange.gov/report/regions/southwest

INFORMATION DRAWN FROM THIS CHAPTER IS INCLUDED IN THE HIGHLIGHTS REPORT AND IS IDENTIFIED BY THIS ICON

20 SOUTHWEST

Key Messages

1. Snowpack and streamflow amounts are projected to decline in parts of the Southwest, decreasing surface water supply reliability for cities, agriculture, and ecosystems.
2. The Southwest produces more than half of the nation's high-value specialty crops, which are irrigation-dependent and particularly vulnerable to extremes of moisture, cold, and heat. Reduced yields from increasing temperatures and increasing competition for scarce water supplies will displace jobs in some rural communities.
3. Increased warming, drought, and insect outbreaks, all caused by or linked to climate change, have increased wildfires and impacts to people and ecosystems in the Southwest. Fire models project more wildfire and increased risks to communities across extensive areas.
4. Flooding and erosion in coastal areas are already occurring even at existing sea levels and damaging some California coastal areas during storms and extreme high tides. Sea level rise is projected to increase as Earth continues to warm, resulting in major damage as wind-driven waves ride upon higher seas and reach farther inland.
5. Projected regional temperature increases, combined with the way cities amplify heat, will pose increased threats and costs to public health in southwestern cities, which are home to more than 90% of the region's population. Disruptions to urban electricity and water supplies will exacerbate these health problems.

The Southwest is the hottest and driest region in the United States, where the availability of water has defined its landscapes, history of human settlement, and modern economy. Climate changes pose challenges for an already parched region that is expected to get hotter and, in its southern half, significantly drier. Increased heat and changes to rain and snowpack will send ripple effects throughout the region's critical agriculture sector, affecting the lives and economies of 56 million people – a population that is expected to increase 68% by 2050, to 94 million.[1] Severe and sustained drought will stress water sources, already over-utilized in many areas, forcing increasing competition among farmers, energy producers, urban dwellers, and plant and animal life for the region's most precious resource.

The region's populous coastal cities face rising sea levels, extreme high tides, and storm surges, which pose particular risks to highways, bridges, power plants, and sewage treatment plants. Climate-related challenges also increase risks to critical port cities, which handle half of the nation's incoming shipping containers.

Agriculture, a mainstay of the regional and national economies, faces uncertainty and change. The Southwest produces more than half of the nation's high-value specialty crops, including certain vegetables, fruits, and nuts. The severity of future impacts will depend upon the complex interaction of pests, water supply, reduced chilling periods, and more rapid changes in the seasonal timing of crop development due to projected warming and extreme events.

Climate changes will increase stress on the region's rich diversity of plant and animal species. Widespread tree death

and fires, which already have caused billions of dollars in economic losses, are projected to increase, forcing wholesale changes to forest types, landscapes, and the communities that depend on them (see also Ch. 7: Forests).

Tourism and recreation, generated by the Southwest's winding canyons, snow-capped peaks, and Pacific Ocean beaches, provide a significant economic force that also faces climate change challenges. The recreational economy will be increasingly affected by reduced streamflow and a shorter snow season, influencing everything from the ski industry to lake and river recreation.

Observed and Projected Climate Change

The Southwest is already experiencing the impacts of climate change. The region has heated up markedly in recent decades, and the period since 1950 has been hotter than any comparably long period in at least 600 years (Ch. 2: Our Changing Climate, Key Message 3).[2,3,4] The decade 2001-2010 was the warmest in the 110-year instrumental record, with temperatures almost 2°F higher than historic averages, with fewer cold air outbreaks and more heat waves.[4] Compared to relatively uniform regional temperature increases, precipitation trends vary considerably across the region, with portions experiencing decreases and others experiencing increases (Ch. 2: Our Changing Climate, Key Message 5).[4] There is mounting evidence that the combination of human-caused temperature increases and recent drought has influenced widespread tree mortality,[6,7] increased fire occurrence and area burned,[8] and forest insect outbreaks (Ch. 7: Forests).[9] Human-caused temperature increases and drought have also caused earlier spring snowmelt and shifted runoff to earlier in the year.[10]

Regional annual average temperatures are projected to rise by 2.5°F to 5.5°F by 2041-2070 and by 5.5°F to 9.5°F by 2070-2099 with continued growth in global emissions (A2 emissions scenario), with the greatest increases in the summer and fall (Figure 20.1). If global emissions are substantially reduced (as in the B1 emissions scenario), projected temperature increases are 2.5°F to 4.5°F (2041-2070), and 3.5°F to 5.5°F (2070-2099). Summertime heat waves are projected to become longer and hotter, whereas the trend of decreasing wintertime cold air outbreaks is projected to continue (Ch. 2: Our Changing Climate, Key Message 7).[11,12] These changes will directly affect urban public health through increased risk of heat stress, and urban infrastructure through increased risk of disruptions to electric power generation.[13,14,15,16] Rising temperatures also have direct impacts on crop yields and productivity of key regional crops, such as fruit trees.

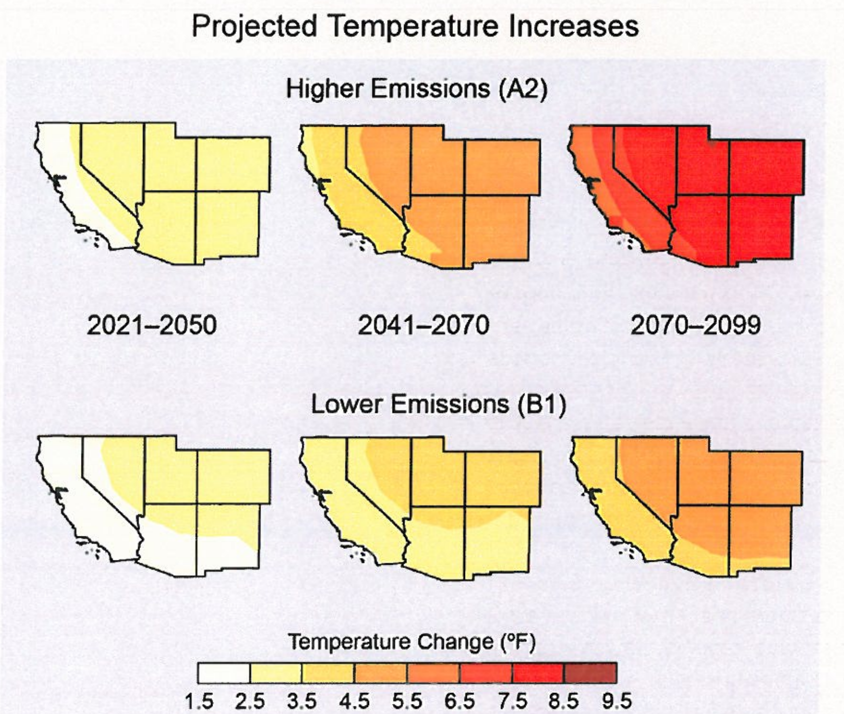

Figure 20.1. Maps show projected changes in average, as compared to 1971-1999. Top row shows projections assuming heat-trapping gas emissions continue to rise (A2). Bottom row shows projections assuming substantial reductions in emissions (B1). (Figure source: adapted from Kunkel et al. 2013[17]).

Projections of precipitation changes are less certain than those for temperature.[17,18] Under a continuation of current rising emissions trends (A2), reduced winter and spring precipitation is consistently projected for the southern part of the Southwest by 2100 as part of the general global precipitation reduction in subtropical areas. In the northern part of the region, projected winter and spring precipitation changes are smaller than natural variations. Summer and fall changes are also smaller than natural variations throughout the region (Ch. 2: Our Changing Climate, Key Message 5).[17] An increase in winter flood hazard risk in rivers is projected due to increases in flows of atmospheric moisture into California's coastal ranges and the Sierra Nevada (Ch. 3: Water).[19] These "atmospheric rivers" have contributed to the largest floods in California history[20] and can penetrate inland as far as Utah and New Mexico.

The Southwest is prone to drought. Southwest paleoclimate records show severe mega-droughts at least 50 years long.[21] Future droughts are projected to be substantially hotter, and for major river basins such as the Colorado River Basin, drought is projected to become more frequent, intense, and longer lasting than in the historical record.[18] These drought conditions present a huge challenge for regional management of water resources and natural hazards such as wildfire. In light of climate change and water resources treaties with Mexico, discussions will need to continue into the future to address demand pressures and vulnerabilities of groundwater and surface water systems that are shared along the border.

Vulnerabilities of Native Nations and Border Cities

The Southwest's 182 federally recognized tribes and communities in its U.S.-Mexico border region share particularly high vulnerabilities to climate changes such as high temperatures, drought, and severe storms. Tribes may face loss of traditional foods, medicines, and water supplies due to declining snowpack, increasing temperatures, and increasing drought (see also Ch 12: Indigenous Peoples).[22] Historic land settlements and high rates of poverty – more than double that of the general U.S. population[23] – constrain tribes' abilities to respond effectively to climate challenges.

Most of the Southwest border population is concentrated in eight pairs of fast-growing, adjacent cities on either side of the U.S.-Mexico border (like El Paso and Juárez) with shared problems. If the 24 U.S. counties along the entire border were aggregated as a 51st state, they would rank near the bottom in per capita income, employment rate, insurance coverage for children and adults, and high school completion.[24] Lack of financial resources and low tax bases for generating resources have resulted in a lack of roads and safe drinking water infrastructure, which makes it more daunting for tribes and border populations to address climate change issues. These economic pressures increase vulnerabilities to climate-related health and safety risks, such as air pollution, inadequate erosion and flood control, and insufficient safe drinking water.[25]

Key Message 1: Reduced Snowpack and Streamflows

Snowpack and streamflow amounts are projected to decline in parts of the Southwest, decreasing surface water supply reliability for cities, agriculture, and ecosystems.

Winter snowpack, which slowly melts and releases water in spring and summer, when both natural ecosystems and people have the greatest needs for water, is key to the Southwest's hydrology and water supplies. Over the past 50 years across most of the Southwest, there has been less late-winter precipitation falling as snow, earlier snowmelt, and earlier arrival of most of the year's streamflow.[26,27] Streamflow totals in the Sacramento-San Joaquin, the Colorado, the Rio Grande, and in the Great Basin were 5% to 37% lower between 2001 and 2010 than the 20th century average flows.[4] Projections of further reduction of late-winter and spring snowpack and subsequent reductions in runoff and soil moisture[28,29] pose increased risks to the water supplies needed to maintain the Southwest's cities, agriculture, and ecosystems.

Temperature-driven reductions in snowpack are compounded by dust and soot accumulation on the surface of snowpack. This layer of dust and soot, transported by winds from lowland regions, increases the amount of the sun's energy absorbed by the snow. This leads to earlier snowmelt and evaporation – both of which have negative implications for water supply, alpine vegetation, and forests.[30,31] The prospect of more lowland soil drying out from drought and human disturbances (like agriculture and development) makes regional dust a potent future risk to snow and water supplies.

In California, drinking water infrastructure needs are estimated at $4.6 billion annually over the next 10 years, even without considering the effects of climate change.[32] Climate change will increase the cost of maintaining and improving drinking

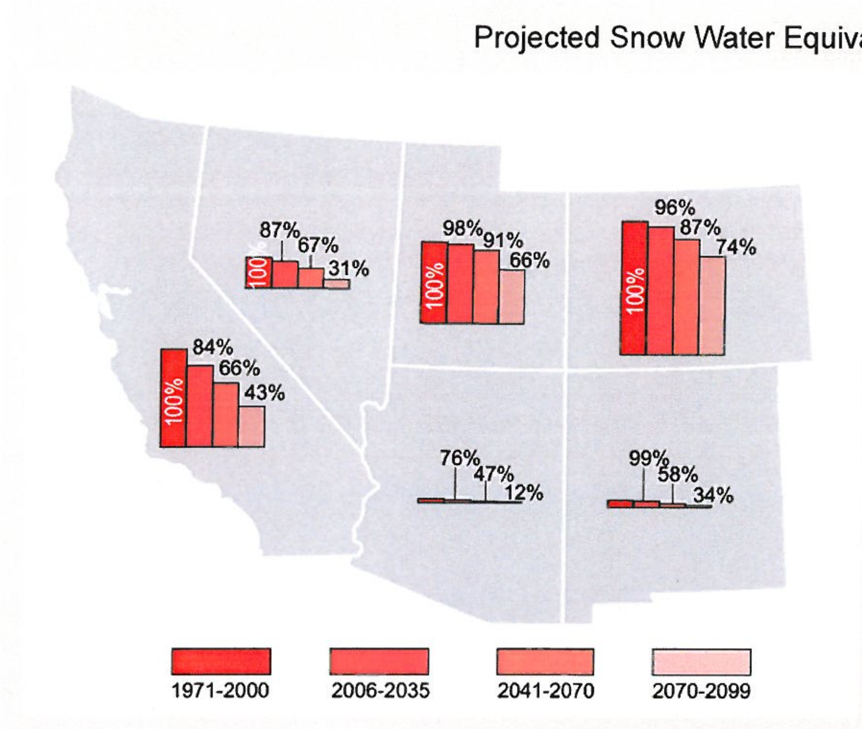

Figure 20.2. Snow water equivalent (SWE) refers to the amount of water held in a volume of snow, which depends on the density of the snow and other factors. Figure shows projected snow water equivalent for the Southwest, as a percentage of 1971-2000, assuming continued increases in global emissions (A2 scenario). The size of bars is in proportion to the amount of snow each state contributes to the regional total; thus, the bars for Arizona are much smaller than those for Colorado, which contributes the most to region-wide snowpack. Declines in peak SWE are strongly correlated with early timing of runoff and decreases in total runoff. For watersheds that depend on snowpack to provide the majority of the annual runoff, such as in the Sierra Nevada and in the Upper Colorado and Upper Rio Grande River Basins, lower SWE generally translates to reduced reservoir water storage. (Data from Scripps Institution of Oceanography).

water infrastructure, because expanded wastewater treatment and desalinating water for drinking are among the key strategies for supplementing water supplies.

Conservation efforts have proven to reduce water use, but are not projected to be sufficient if current trends for water supply and demand continue.[41] Large water utilities are currently attempting to understand how water supply and demand may change in conjunction with climate changes, and which adaptation options are most viable.[42,43]

The Southwest's Renewable Potential to Produce Energy with Less Water

The Southwest's abundant geothermal, wind, and solar power-generation resources could help transform the region's electric generating system into one that uses substantially more renewable energy. This transformation has already started, driven in part by renewable energy portfolio standards adopted by five of six Southwest states, and renewable energy goals in Utah. California's law limits imports of baseload electricity generation from coal and oil and mandates reduction of heat-trapping greenhouse gas emissions to 1990 levels by 2020.[33]

As the regional climate becomes hotter and, in parts of the Southwest, drier, there will be less water available for the cooling of thermal power plants (Ch. 2: Our Changing Climate),[34] which use about 40% of the surface water withdrawn in the United States.[35] The projected warming of water in rivers and lakes will reduce the capacity of thermal power plants, especially during summer when electricity demand skyrockets.[36] Wind and solar photovoltaic installations could substantially reduce water withdrawals. A large increase in the portion of power generated by renewable energy sources may be feasible at reasonable costs,[37,38] and could substantially reduce water withdrawals (Ch. 10: Energy, Water, and Land).[39]

Scenario for Greenhouse Gas Emissions Reductions in the Electricity Sector

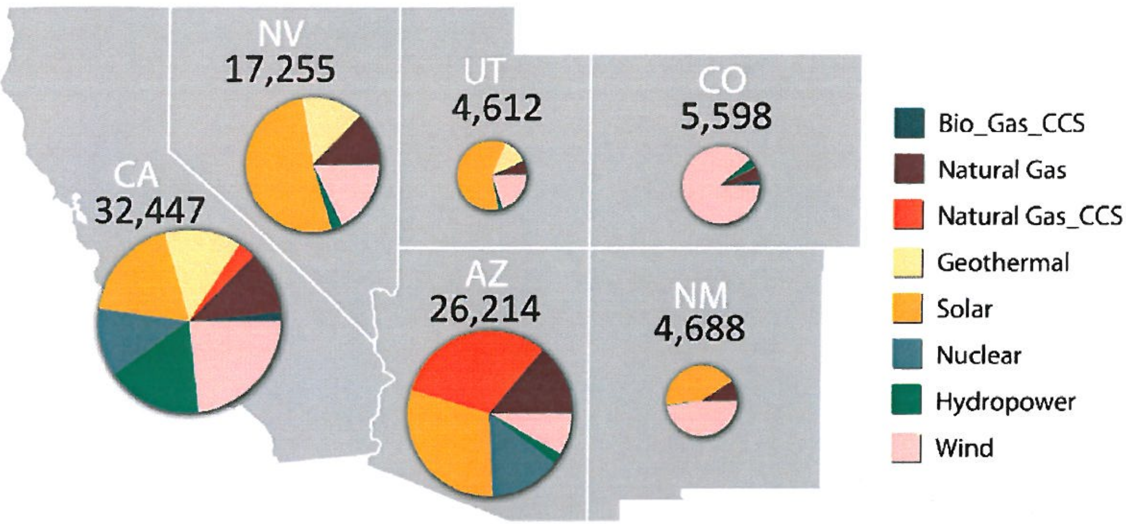

Figure 20.3. Major shifts in how electricity is produced can lead to large reductions in heat-trapping gas emissions. Shown is an illustrative scenario in which different energy combinations could, by 2050, achieve an 80% reduction of heat-trapping gas emissions from 1990 levels in the electricity sector in the Southwest. For each state, that mix varies, with the circle representing the average hourly generation in megawatts (the number above each circle) from 10 potential energy sources. CCS refers to carbon capture and storage. (Data from Wei et al. 2012, 2013[38,40]).

Key Message 2: Threats to Agriculture

The Southwest produces more than half of the nation's high-value specialty crops, which are irrigation-dependent and particularly vulnerable to extremes of moisture, cold, and heat. Reduced yields from increasing temperatures and increasing competition for scarce water supplies will displace jobs in some rural communities.

Farmers are renowned for adapting to yearly changes in the weather, but climate change in the Southwest could happen faster and more extensively than farmers' ability to adapt. The region's pastures are rain-fed (non-irrigated) and highly susceptible to projected drought. Excluding Colorado, more than 92% of the region's cropland is irrigated, and agricultural uses account for 79% of all water withdrawals in the region.[44,45,46] A warmer, drier climate is projected to accelerate current trends of large transfers of irrigation water to urban areas,[47,48,49] which would affect local agriculturally dependent economies.

California produces about 95% of U.S. apricots, almonds, artichokes, figs, kiwis, raisins, olives, cling peaches, dried plums, persimmons, pistachios, olives, and walnuts, in addition to other high-value crops.[50] Drought and extreme weather affect the market value of fruits and vegetables more than other crops because they have high water content and because sales depend on good visual appearance.[51] The combination of a longer frost-free season, less frequent cold air outbreaks, and more frequent heat waves accelerates crop ripening and maturity, reduces yields of corn, tree fruit, and wine grapes, stresses livestock, and increases agricultural water consumption.[52,53] This combination of climate changes is projected to continue and intensify, possibly requiring a northward shift in crop production, displacing existing growers and affecting farming communities.[54,55]

Winter chill periods are projected to fall below the duration necessary for many California trees to bear nuts and fruits, which will result in lower yields.[56] Warm-season vegetable crops grown in Yolo County, one of California's biggest producers, may not be viable under hotter climate conditions.[54,57] Once temperatures increase beyond optimum growing thresholds, further increases in temperature, like those projected for the decades beyond 2050, can cause large decreases in crop yields and hurt the region's agricultural economy.

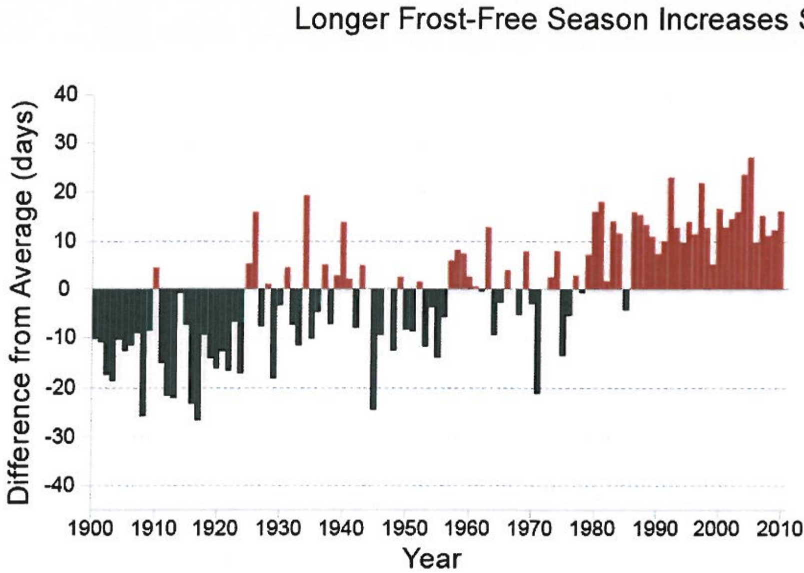

Figure 20.4. The frost-free season is defined as the period between the last occurrence of 32°F in spring and the first occurrence of 32°F in the subsequent fall. The chart shows significant increases in the number of consecutive frost-free days per year in the past three decades compared to the 1901-2010 average. Increased frost-free season length, especially in already hot and moisture-stressed regions like the Southwest, is projected to lead to further heat stress on plants and increased water demands for crops. Higher temperatures and more frost-free days during winter can lead to early bud burst or bloom of some perennial plants, resulting in frost damage when cold conditions occur in late spring (see Ch. 6: Agriculture); in addition, with higher winter temperatures, some agricultural pests can persist year-round, and new pests and diseases may become established.[47] (Figure source: Hoerling et al. 2013[4]).

Key Message 3: Increased Wildfire

Increased warming, drought, and insect outbreaks, all caused by or linked to climate change, have increased wildfires and impacts to people and ecosystems in the Southwest. Fire models project more wildfire and increased risks to communities across extensive areas.

Fire naturally shapes southwestern landscapes. Indeed, many Southwest ecosystems depend on periodic wildfire to maintain healthy tree densities, enable seeds to germinate, and reduce pests.[58] Excessive wildfire destroys homes, exposes slopes to erosion and landslides, threatens public health, and causes economic damage.[59,60] The $1.2 billion in damages from the 2003 Grand Prix fire in southern California illustrates the high cost of wildfires.[60]

Beginning in the 1910s, the Federal Government developed a national policy of attempting to extinguish every fire, which allowed wood and other fuels to over-accumulate[61] and urban development to encroach on fire-prone areas. These changes have also contributed to increasing fire risk.

Increased warming due to climate change,[3] drought, insect infestations,[62] and accumulation of woody fuels and non-native grasses[63,64] make the Southwest vulnerable to increased wildfire. Climate outweighed other factors in determining burned area in the western U.S. from 1916 to 2003,[65] a finding confirmed by 3000-year long reconstructions of southwestern fire history.[66,67,68] Between 1970 and 2003, warmer and drier conditions increased burned area in western U.S. mid-elevation conifer forests by 650% (Ch. 7: Forests, Key Message 1).[8]

Drought and increased temperatures due to climate change have caused extensive tree death across the Southwest.[7,69] In addition, winter warming due to climate change has exacerbated bark beetle outbreaks by allowing more beetles, which normally die in cold weather, to survive and reproduce.[70] Wildfire and bark beetles killed trees across 20% of Arizona and New Mexico forests from 1984 to 2008.[62]

Numerous fire models project more wildfire as climate change continues.[64,71,72,73,74] Models project a doubling of burned area in the southern Rockies,[73] and up to a 74% increase in burned area in California,[74] with northern California potentially experiencing a doubling under a high emissions scenario toward the end of the century. Fire contributes to upslope shifting of vegetation, spread of invasive plants after extensive and intense fire, and conversion of forests to woodland or grassland.[63,75]

Historical and projected climate change makes two-fifths (40%) of the region vulnerable to these shifts of major vegetation types or biomes; notably threatened are the conifer forests of southern California and sky islands of Arizona.[71]

Prescribed burning, mechanical thinning, and retention of large trees can help some southwestern forest ecosystems adapt to climate change.[68,76] These adaptation measures also reduce emissions of the gases that cause climate change because long-term storage of carbon in large trees can outweigh short-term emissions from prescribed burning.[61,77]

Key Message 4: Sea Level Rise and Coastal Damage

Flooding and erosion in coastal areas are already occurring even at existing sea levels and damaging some California coastal areas during storms and extreme high tides. Sea level rise is projected to increase as Earth continues to warm, resulting in major damage as wind-driven waves ride upon higher seas and reach farther inland.

In the last 100 years, sea level has risen along the California coast by 6.7 to 7.9 inches.[78] In the last decade, high tides on top of this sea level rise have contributed to new damage to infrastructure, such as the inundation of Highway 101 near San Francisco and backup of seawater into the San Francisco Bay Area sewage systems.

Although sea level along the California coast has been relatively constant since 1980, both global and relative Southwest sea levels are expected to increase at accelerated rates.[78,79,80] During the next 30 years, the greatest impacts will be seen during high tides and storm events. Rising sea level will allow more wave energy to reach farther inland and extend high tide periods, worsening coastal erosion on bluffs and beaches and increasing flooding potential.[18,81,82,83,84]

The result will be impacts to the nation's largest ocean-based economy, which is estimated at $46 billion annually.[85,86] If adaptive action is not taken, coastal highways, bridges, and other transportation infrastructure (such as the San Francisco and Oakland airports) are at increased risk of flooding with a 16-inch rise in sea level in the next 50 years,[5] an amount consistent with the 1 to 4 feet of expected global increase in sea level (see Ch. 2: Our Changing Climate, Key Message 10). In Los Angeles, sea level rise poses a threat to groundwater supplies and estuaries,[82,87] by potentially contaminating groundwater with seawater, or increasing the costs to protect coastal freshwater aquifers.[88]

Projected increases in extreme coastal flooding as a result of sea level rise will increase human vulnerability to coastal flooding events. Currently, 260,000 people in California are at risk from what is considered a once-in-100-year flood.[82] With a sea level rise of about three feet (in the range of projections for this century – Ch. 2: Our Changing Climate, Key Message 10)[78,80] and at current population densities, 420,000 people would be at risk from the same kind of 100-year flood event,[85] based on existing exposure levels. Highly vulnerable populations

Coastal Risks Posed by Sea Level Rise and High Tides

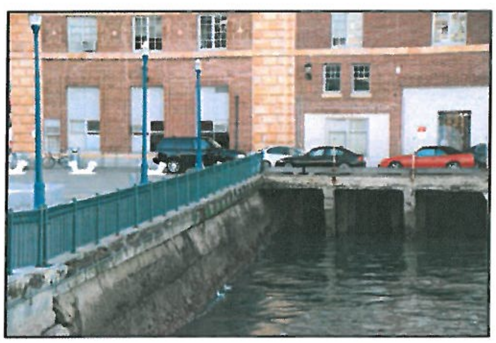

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Figure 20.5. King tides, which typically happen twice a year as a result of a gravitational alignment of the sun, moon, and Earth, provide a preview of the risks rising sea levels may present along California coasts in the future. While king tides are the extreme high tides today, with projected future sea level rise, this level of water and flooding will occur during regular monthly high tides. During storms and future king tides, more coastal flooding and damage will occur. The King Tide Photo Initiative encourages the public to visually document the impact of rising waters on the California coast, as exemplified during current king tide events. Photos show water levels along the Embarcadero in San Francisco, California during relatively normal tides (top), and during an extreme high tide or "king tide" (bottom). (Photo credit: Mark Johnsson).

– people less able to prepare, respond, or recover from natural disaster due to age, race, or income – make up approximately 18% of the at-risk population (Ch. 25: Coasts).[85,89]

The California state government, through its Ocean and Coastal Resources Adaptation Strategy, along with local governments, is using new sea level mapping and information about social vulnerability to undertake coastal adaptation planning. NOAA has created an interactive map showing areas that would be affected by sea level rise (http://www.csc.noaa.gov/slr/viewer/#).

Key Message 5: Heat Threats to Health

Projected regional temperature increases, combined with the way cities amplify heat, will pose increased threats and costs to public health in southwestern cities, which are home to more than 90% of the region's population. Disruptions to urban electricity and water supplies will exacerbate these health problems.

The Southwest has the highest percentage of its population living in cities of any U.S. region. Its urban population rate, 92.7%, is 12% greater than the national average.[90] Increasing metropolitan populations already pose challenges to providing adequate domestic water supplies, and the combination of increased population growth and projected increased risks to surface water supplies will add further challenges.[91,92] Tradeoffs are inevitable between conserving water to help meet the demands of an increasing population and providing adequate water for urban greenery to reduce increasing urban temperatures.

Urban infrastructures are especially vulnerable because of their interdependencies; strains in one system can cause disruptions in another (Ch. 11: Urban, Key Message 2; Ch. 9: Human Health).[16,93] For example, an 11-minute power system disturbance in September 2011 cascaded into outages that left 1.5 million San Diego residents without power for 12 hours;[94] the outage disrupted pumps and water service, causing 1.9 million gallons of sewage to spill near beaches.[95] Extensive use of air conditioning to deal with high temperatures can quickly increase electricity demand and trigger cascading energy system failures, resulting in blackouts or brownouts.[14,15]

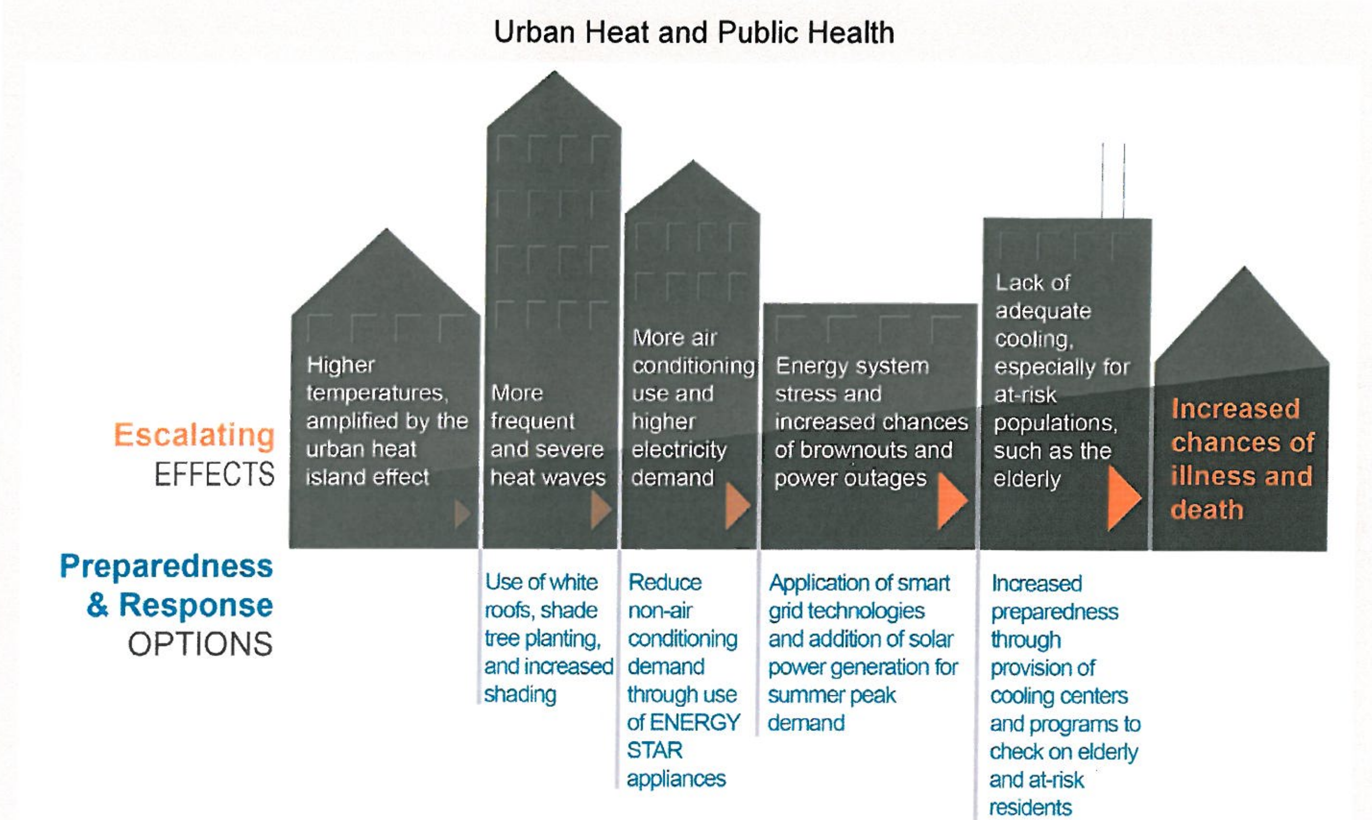

Figure 20.6. The projected increase in heat waves in Southwest cities (Ch. 2: Our Changing Climate, Key Message 7) increases the chances that a chain of escalating effects could lead to serious increases in illness and death due to heat stress. The top of the figure provides some of the links in that chain, while the bottom of the figure provides adaptation and improved governance options that can reduce this vulnerability and improve the resilience of urban infrastructure and community residents.

Heat stress, a recurrent health problem for urban residents, has been the leading weather-related cause of death in the United States since 1986, when record keeping began[96] – and the highest rates nationally are found in Arizona.[97] The effects of heat stress are greatest during heat waves lasting several days or more, and heat waves are projected to increase in frequency, duration, and intensity,[11,13,98] become more humid,[11] and cause a greater number of deaths.[99] Already, severe heat waves, such as the 2006 ten-day California event, have resulted in high mortality, especially among elderly populations.[100] In addition, evidence indicates a greater likelihood of impacts in less affluent neighborhoods, which typically lack shade trees and other greenery and have reduced access to air conditioning.[101]

Exposure to excessive heat can also aggravate existing human health conditions, like for those who suffer from respiratory or heart disease.[99] Increased temperatures can reduce air quality, because atmospheric chemical reactions proceed faster in warmer conditions. The outcome is that heat waves are often accompanied by increased ground-level ozone,[102] which can cause respiratory distress. Increased temperatures and longer warm seasons will also lead to shifts in the distribution of disease-transmitting mosquitoes (Ch. 9: Human Health, Key Message 1).[97]

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SUPPLEMENTAL MATERIAL
TRACEABLE ACCOUNTS

Process for Developing Key Messages
A central component of the assessment process was the Southwest Regional Climate assessment workshop that was held August 1-4, 2011, in Denver, CO with more than 80 participants in a series of scoping presentations and workshops. The workshop began the process leading to a foundational Technical Input Report (TIR) report.[103] The TIR consists of nearly 800 pages organized into 20 chapters that were assembled by 122 authors representing a wide range of inputs, including governmental agencies, non-governmental organizations, tribes, and other entities. The report findings were described in a town hall meeting at the American Geophysical Union's annual fall meeting in 2011, and feedback was collected and incorporated into the draft.

The chapter author team engaged in multiple technical discussions through more than 15 biweekly teleconferences that permitted a careful review of the foundational TIR[103] and of approximately 125 additional technical inputs provided by the public, as well as the other published literature and professional judgment. The chapter author team then met at the University of Southern California on March 27-28, 2012, for expert deliberation of draft key messages by the authors. Each key message was defended before the entire author team prior to the key message being selected for inclusion. These discussions were supported by targeted consultation with additional experts by the lead author of each message, and they were based on criteria that help define "key vulnerabilities, which include magnitude, timing, persistence and reversibility, likelihood and confidence, potential for adaptation, distribution, and importance of the vulnerable system."[104]

Key message #1 Traceable Account

Snowpack and streamflow amounts are projected to decline in parts of the Southwest, decreasing surface water supply reliability for cities, agriculture, and ecosystems.

Description of evidence base
The key message was chosen based on input from the extensive evidence documented in the Southwest Technical Input Report[103] and additional technical input reports received as part of the Federal Register Notice solicitation for public input, as well as stakeholder engagement leading up to drafting the chapter.

Key Message 5 in Chapter 2, Our Changing Climate, also provides evidence for declining precipitation across the United States, and a regional study[17] discusses regional trends and scenarios for the Southwest.

Over the past 50 years, there has been a reduction in the amount of snow measured on April 1 as a proportion of the precipitation falling in the corresponding water-year (October to September), which affects the timing of snowfed rivers. The implication of this finding is that the lower the proportion of April 1 snow water equivalent in the water-year-to-date precipitation, the more rapid the runoff, and the earlier the timing of center-of-mass of streamflow in snowfed rivers.[26,27] For the "recent decade" (2001 to 2010), snowpack evidence is from U.S. Department of Agriculture (USDA) Natural Resources Conservation Service snow course data, updated through 2010. One study[4] has analyzed streamflow amounts for the region's four major river basins, the Colorado, Sacramento-San Joaquin, Great Basin (Humboldt River, NV), and the Rio Grande; data are from the U.S. Department of the Interior – Bureau of Reclamation, California Department of Water Resources, U.S. Geological Survey, and the International Boundary and Water Commission (U.S. Section), respectively. These data are backed by a rigorous detection and attribution study.[10] Projected trends[18] make use of downscaled climate parameters for 16 global climate models (GCMs), and hydrologic projections for the Colorado River, Rio Grande, and Sacramento-San Joaquin River System.

Based on GCM projections, downscaled and run through the variable infiltration capacity (VIC) hydrological model,[105] there are projected reductions in spring snow accumulation and total annual runoff, leading to reduced surface water supply reliability for much of the Southwest, with greater impacts occurring during the second half of this century.[18,28]

Future flows in the four major Southwest rivers are projected to decline as a result of a combination of increased temperatures, increased evaporation, less snow, and less persistent snowpack. These changes have been projected to result in decreased surface water supplies, which will have impacts for allocation of water resources to major uses, such as urban drinking water, agriculture, and ecosystem flows.

New information and remaining uncertainties

Different model simulations predict different levels of snow loss. These differences arise because of uncertainty in climate change warming and precipitation projections due to differences among GCMs, uncertainty in regional downscaling, uncertainty in hydrological modeling, differences in emissions, aerosols, and other forcings, and because differences in the hemispheric and regional-scale atmospheric circulation patterns produced by different GCMs produce different levels of snow loss in different model simulations.

In addition to the aforementioned uncertainties in regional climate and hydrology projections, projection of future surface water supply reliability includes at least the following additional uncertainties: 1) changes in water management, which depend on agency resources and leadership and cooperation of review boards and the public;[106] 2) management responses to non-stationarity;[107] 3) legal, economic, and institutional options for augmenting existing water supplies, adding underground water storage and recovery infrastructure, and fostering further water conservation (for example, Udall 2013[108]); 4) adjudication of unresolved water rights; and 5) local, state, regional, and national policies related to the balance of agricultural, ecosystem, and urban water use (for example, Reclamation 2011[43]).

Assessment of confidence based on evidence

There is **high** confidence in the continued trend of declining snowpack and streamflow in parts of the Southwest given the evidence base and remaining uncertainties.

Confidence Level
Very High
Strong evidence (established theory, multiple sources, consistent results, well documented and accepted methods, etc.), high consensus
High
Moderate evidence (several sources, some consistency, methods vary and/or documentation limited, etc.), medium consensus
Medium
Suggestive evidence (a few sources, limited consistency, models incomplete, methods emerging, etc.), competing schools of thought
Low
Inconclusive evidence (limited sources, extrapolations, inconsistent findings, poor documentation and/or methods not tested, etc.), disagreement or lack of opinions among experts

For the impacts on water supply, there is **high** confidence that reduced surface water supply reliability will affect the region's cities, agriculture, and ecosystems.

KEY MESSAGE #2 TRACEABLE ACCOUNT

The Southwest produces more than half of the nation's high-value specialty crops, which are irrigation-dependent and particularly vulnerable to extremes of moisture, cold, and heat. Reduced yields from increasing temperatures and increasing competition for scarce water supplies will displace jobs in some rural communities.

Description of evidence base

Increased competition for scarce water was presented in the first key message and in the foundational Technical Input Report (TIR).[103] U.S. temperatures, including those for the Southwest region, have increased and are expected to continue to rise (Ch. 2: Our Changing Climate, Key Message 3). Heat waves have become more frequent and intense and droughts are expected to become more intense in the Southwest (Ch. 2: Our Changing Climate, Key Message 7). The length of the frost-free season in the Southwest has been increasing, and frost-free season length is projected to increase (Ch. 2: Our Changing Climate, Key Message 4). A regional study[17] discusses the trends and scenarios in the Southwest for moisture, cold, heat, and their extremes.

There is abundant evidence of irrigation dependence and vulnerability of high-value specialty crops to extremes of moisture, cold, and heat, including, prominently, the 2009 National Climate Assessment[109] and the foundational TIR.[103] Southwest agricultural production statistics and irrigation dependence of that production is delineated in the USDA 2007 Census of Agriculture[45] and the USDA Farm and Ranch Irrigation Survey.[46]

Reduced Yields. Even under the most conservative emissions scenarios evaluated (the combination of SRES B1emissions scenario with statistically downscaled winter chill projections from the HADCM3 climate model), one study[56] projected that required winter chill periods will fall below the number of hours that are necessary for many of the nut- and fruit-bearing trees of California, and yields are projected to decline as a result. A second study[54] found that California wheat acreage and walnut acreage will decline due to increased temperatures. Drought and extreme weather may have more effect on the market value of fruits and vegetables, as opposed to other crops, because fruits and vegetables have high water content and because consumers expect good visual appearance and flavor.[51] Extreme daytime and nighttime temperatures have been shown to accelerate crop ripening and maturity, reduce yield of crops such as corn, fruit trees, and vineyards, cause livestock to be stressed, and increase water consumption in agriculture.[53]

Irrigation water transfers to urban. Warmer, drier future scenarios portend large transfers of irrigation water to urban areas even though agriculture will need additional water to meet crop demands, affecting local agriculturally-dependent economies.[55] In particular areas of the Southwest (most notably lower-central Arizona), a significant reduction in irrigated agriculture is already underway as land conversion occurs near urban centers.[48] Functioning water markets, which may require legal and institutional changes, can enable such transfers and reduce the social and economic impacts of water shortages to urban areas.[47] The economic impacts of climate change on Southwest fruit and nut growers are projected to be substantial and will result in a northward shift in production of these crops, displacing growers and affecting communities.

New information and remaining uncertainties

Competition for water is an uncertainty. The extent to which water transfers take place depends on whether complementary investments in conveyance or storage infrastructure are made. Currently, there are legal and institutional restrictions limiting water transfers across state and local jurisdictions. It is uncertain whether infrastructure investments will be made or whether institutional innovations facilitating transfers will develop. Institutional barriers will be greater if negative third-party effects of transfers are not adequately addressed. Research that would improve the information base to inform future water transfer debates includes: 1) estimates of third party impacts, 2) assessment of institutional mechanisms to reduce those impacts, 3) environmental impacts of water infrastructure projects, and 4) options and costs of mitigating those environmental impacts.

Extremes and phenology. A key uncertainty is the timing of extreme events during the phenological stage of the plant or the growth cycle of the animal. For example, plants are more sensitive to extreme high temperatures and drought during the pollination stage compared to vegetative growth stages.

Genetic improvement potential. Crop and livestock reduction studies by necessity depend on assumptions about adaptive actions by farmers and ranchers. However, agriculture has proven to be highly adaptive in the past. A particularly high uncertainty is the ability of conventional breeding and biotechnology to keep pace with the crop plant and animal genetic improvements needed for adaptation to climate-induced biotic and abiotic stresses.

Assessment of confidence based on evidence

Although evidence includes studies of observed climate and weather impacts on agriculture, projections of future changes using climate and crop yield models and econometric models show varying results depending on the choice of crop and assumptions regarding water availability. For example, projections of 2050 California crop yields show reductions in field crop yields, based on assumptions of a 21% decline in agricultural water use, shifts away from water-intensive crops to high-value specialty crops, and development of a more economical means of transferring water from northern to southern California.[47] Other studies, using projections of a dry, warmer future for California, and an assumption that water will flow from lower- to higher-valued uses (such as urban water use), generated a 15% decrease in irrigated acreage and a shift from lower- to higher-valued crops.[49]

Because net reductions in the costs of water shortages depend on multiple institutional responses, it is difficult as yet to locate a best estimate of water transfers between zero and the upper bound. Water scarcity may also be a function of tradeoffs between economic returns from agricultural production and returns for selling off property or selling water to urban areas (for example, Imperial Valley transfers to San Diego).

Given the evidence base and remaining uncertainties, confidence is **high** in this key message.

KEY MESSAGE #3 TRACEABLE ACCOUNT

Increased warming, drought, and insect outbreaks, all caused by or linked to climate change, have increased wildfires and impacts to people and ecosystems in the Southwest. Fire models project more wildfire and increased risks to communities across extensive areas.

Description of evidence base

Increased warming and drought are extensively described in the foundational Technical Input Report (TIR).[103] U.S. temperatures have increased and are expected to continue to rise (Ch. 2: Our Changing Climate, Key Message 3). There have been regional changes in droughts, and there are observed and projected changes in cold and heat waves and droughts (Ch. 2: Our Changing Climate, Key Message 7) for the nation. A study for the Southwest[17] discusses trends and scenarios in both cold waves and heat waves.

Analyses of weather station data from the Southwest have detected changes from 1950 to 2005 that favor wildfire, and statistical analyses have attributed the changes to anthropogenic climate change. The changes include increased temperatures,[3] reduced snowpack,[27] earlier spring warmth,[30] and streamflow.[10] These climate changes have increased background tree mortality rates from 1955 to 2007 in old-growth conifer forests in California, Colorado, Utah, and the northwestern states[7] and caused extensive piñon pine mortality in Arizona, Colorado, New Mexico, and Utah between 1989 and 2003.[69]

Climate factors contributed to increases in wildfire in the previous century. In mid-elevation conifer forests of the western United States, increases in spring and summer temperatures, earlier snowmelt, and longer summers increased fire frequency by 400% and burned area by 650% from 1970 to 2003.[8] Multivariate analysis of wildfire across the western U.S. from 1916 to 2003 indicates that climate was the dominant factor controlling burned area, even during periods of human fire suppression.[65] Reconstruction of fires of the past 400 to 3000 years in the western U.S.[66] and in Yosemite and Sequoia National Parks in California[67,68] confirm that temperature and drought are the dominant factors explaining fire occurrence.

Four different fire models project increases in fire frequency across extensive areas of the Southwest in this century.[71,72,73,74] Multivariate statistical generalized additive models[64,72] project extensive increases across the Southwest, but the models project decreases when assuming that climate alters patterns of net primary productivity. Logistic regressions[74] project increases across most of California, except for some southern parts of the state, with average fire frequency increasing 37% to 74%. Linear regression models project up to a doubling of burned area in the southern Rockies by 2070 under emissions scenarios B1 or A2.[73] The MC1 dynamic global vegetation model projects increases in fire frequencies on 40% of the area of the Southwest from 2000 to 2100 and decreases on 50% of the areas for emissions scenarios B1 and A2.[71]

Excessive wildfire destroys homes, exposes slopes to erosion and landslides, and threatens public health, causing economic damage.[59,60] Further impacts to communities and various economies (local, state, and national) have been projected.[74]

New information and remaining uncertainties

Uncertainties in future projections derive from the inability of models to accurately simulate all past fire patterns, and from the different GCMs, emissions scenarios, and spatial resolutions used by different fire model projections. Fire projections depend highly on the spatial and temporal distributions of precipitation projections, which vary widely across GCMs. Although models generally project future increases in wildfire, uncertainty remains on the exact locations. Research groups continue to refine the fire models.

Assessment of confidence based on evidence

There is **high** confidence in this key message given the extensive evidence base and discussed uncertainties.

KEY MESSAGE #4 TRACEABLE ACCOUNT

Flooding and erosion in coastal areas are already occurring even at existing sea levels and damaging some California coastal areas during storms and extreme high tides. Sea level rise is projected to increase as Earth continues to warm, resulting in major damage as wind-driven waves ride upon higher seas and reach farther inland.

Description of evidence base

The key message and supporting text summarizes extensive evidence documented in the Technical Input Report.[103] Several studies document potential coastal flooding, erosion, and wind-driven wave damages in coastal areas of California due to sea level rise (for example, Bromirski et al. 2012; Heberger et al. 2011, and Revell et al. 2011[81,82]). Global sea level has risen, and further rise of 1 to 4 feet is projected by 2100 (Ch. 2: Our Changing Climate, Key Message 10).

All of the scientific approaches to detecting sea level rise come to the conclusion that a warming planet will result in higher sea levels. In addition, numerous recent studies[78,80] produce much higher sea level rise projections for the rest of this century as compared to the projections in the most recent report of the Intergovernmental Panel on Climate Change[83] for the rest of this century.

New information and remaining uncertainties

There is strong recent evidence from satellites such as GRACE[110] and from direct observations that glaciers and ice caps worldwide are losing mass relatively rapidly, contributing to the recent increase in the observed rate of sea level rise.

Major uncertainties are associated with sea level rise projections, such as the behavior of ice sheets with global warming and the actual level of global warming that the Earth will experience in the future.[78,80] Regional sea level rise projections are even more uncertain than the projections for global averages because local factors such as the steric component (changes in the volume of water with changes in temperature and salinity) of sea level rise at regional levels and the vertical movement of land have large uncertainties.[78] However, it is virtually certain that sea levels will go up with a warming planet as demonstrated in the paleoclimatic record, modeling, and from basic physical arguments.

Assessment of confidence based on evidence

Given the evidence, especially since the last IPCC report,[83] there is **very high** confidence the sea level will continue to rise and that this will entail major damage to coastal regions in the Southwest. There is also **very high** confidence that flooding and erosion in coastal areas are already occurring even at existing sea levels and damaging some areas of the California coast during storms and extreme high tides.

KEY MESSAGE #5 TRACEABLE ACCOUNT

Projected regional temperature increases, combined with the way cities amplify heat, will pose increased threats and costs to public health in southwestern cities, which are home to more than 90% of the region's population. Disruptions to urban electricity and water supplies will exacerbate these health problems.

Description of evidence base

There is excellent agreement regarding the urban heat island effect and exacerbation of heat island temperatures by increases in regional temperatures caused by climate change. There is abundant evidence of urban heat island effect for some Southwest cities (for example, Sheridan et al.[98]), as well as several studies, some from outside the region, of the public health threats of urban heat to residents (for example, Ch. 9: Human Health, Ostro et al. 2009, 2001[99,100]). Evidence includes observed urban heat island studies and modeling of future climates, including some climate change modeling studies for individual urban areas (for example, Phoenix and Los Angeles). There is wide agreement in Southwest states that increasing temperatures combined with projected population growth will stress urban water supplies and require continued water conservation and investment in new water supply options. There is substantial agreement that disruption to urban electricity may cause cascading impacts, such as loss of water, and that projected diminished supplies will pose challenges for urban cooling (for example, the need for supplemental irrigation for vegetation-based cooling). However, there are no studies on urban power disruption induced by climate change.

With projected surface water losses, and increasing water demand due to increasing temperatures and population, water supply in Southwest cities will require greater conservation efforts and capital investment in new water supply sources.[92] Several southwestern states, including California, New Mexico, and Colorado have begun to study climate impacts to water resources, including impacts in urban areas.[91]

The interdependence of infrastructure systems is well established, especially the dependence of systems on electricity and communications and control infrastructures, and the potential cascading effects of breakdowns in infrastructure systems.[16] The concentration of infrastructures in urban areas adds to the vulnerability of urban populations to infrastructure breakdowns. This has been documented in descriptions for major power outages such as the Northeast power blackout of 2003, or the recent September 2011 San Diego blackout.[94]

A few references point to the role of urban power outages in threatening public health due to loss of air conditioning[14] and disruption to water supplies.[94]

New information and remaining uncertainties

Key uncertainties include the intensity and spatial extent of drought and heat waves. Uncertainty is also associated with quantification of the impact of temperature and water availability on energy generation, transmission, distribution, and consumption – all of which have an impact on possible disruptions to urban electricity. Major disruptions are contingent on a lack of operator response and/or adaptive actions such as installation of adequate electricity-generating capacity to serve the expected enhanced peak electricity demand. Thus a further uncertainty is the extent to which adaptation actions are taken.

Assessment of confidence based on evidence

The urban heat island effect is well demonstrated and hence projected climate-induced increases to heat will increase exposure to heat-related illness. Electricity disruptions are a key uncertain factor, and potential reductions in water supply not only may reduce hydropower generation, but also availability of water for cooling of thermal power plants.

Based on the substantial evidence and the remaining uncertainties, confidence in each aspect of the key message is **high.**

ORDINANCE NO. 2014-___

AN ORDINANCE OF PIMA COUNTY, ARIZONA RELATING TO DROUGHT: AMENDING PIMA COUNTY CODE CHAPTER 8.70 DROUGHT RESPONSE PLAN AND WATER WASTING ORDINANCE, SECTIONS 8.70.020 (A)(D)(J) DEFINITIONS; 8.70.040 (B(7))(D(1)(3))DROUGHT STAGES-REQUIRED DROUGHT CONSERVATION MEASURES; 8.70.050 (B) TABLE 8.70.050 DECLARATION OF DROUGHT STAGE.

WHEREAS, pursuant to A.R.S § 11-251.05, the Pima County Board of Supervisors is authorized to adopt, amend and repeal all ordinances necessary or proper to carry out the duties, responsibilities and functions of the County which are not otherwise limited by §11-251 or any other law or in conflict with any rule or law of the State of Arizona; and

WHEREAS, pursuant to A.R.S section 45-401, the State of Arizona declares it is necessary to conserve, protect and allocate the use of groundwater resources; and

WHEREAS, pursuant to A.R.S § 11-251(17), the Pima County Board of Supervisors is authorized to adopt provisions necessary to preserve the health of the County; and

WHEREAS, the Board of Supervisors has determined the need to amend certain sections of Chapter 8.70 Drought Response Plan and Water Wasting Ordinance,

BE IT ORDAINED BY THE BOARD OF SUPERVISORS OF PIMA COUNTY, ARIZONA:

SECTION 1. That Pima County Code, Chapter 8.70, Sections 8.70.020, 8.70.040 and 8.70.050 are amended to read as follows:

8.70.020 Definitions.

A. "Arizona Drought Monitoring Report" means the long-term drought status report issued by the Arizona Department of Water Resources' Monitoring Technical Committee (MTC), created by the Governor's Drought Task Force, which is responsible for gathering drought, climate, and weather data and disseminating that information to land managers, policy-makers, and the public. The MTC determines drought conditions based on monitoring data, tracks changes in weather and physical conditions, forecasts likely future conditions, and provides early detection of changes in drought severity. The MTC will also assess local area impact assessment information provided by the Pima County Local Drought Impact Group ~~citizens throughout the state~~.

B. "Department" means the Pima County Health Department.

C. "Director" means director of the health department.

D. "Pima County Local Drought Impact Group" ~~"Drought Monitoring Committee"~~ means a drought monitoring and assessment group comprised of individuals skilled in monitoring climate, area water supplies, ecosystems, and economic and social impacts as a result of drought and facilitates the role of a Local Area Impact Assessment Group prescribed in the Arizona Drought Preparedness Plan.

E. "Economic hardship" means a threat to an individual's or business' primary source of income.

F. "Notification to the public" means notification through local media, including interviews and issuance of news releases.

G. "Person" means a government or government subdivision or agency, the county, a municipality, district or other political subdivision, a cooperative, association, corporation, company, firm, partnership, individual, or other legal entity.

H. The term "pool" applies to all pools regulated by Pima County's adopted building or technical codes, regardless of whether the pool is installed above- or below-ground or whether it is a temporary or permanent structure.

I. "Water" means potable or reclaimed water from all sources.

J. "Rainwater harvesting system" means a system or series of components or mechanisms that are designed to provide for the collection and storage of rainwater for use of the collected water on the same property.

8.70.040 Drought Stages—Required Drought Conservation Measures.

Following the declaration of a drought stage, no person may make, cause, use, or permit the use of water for residential, commercial, industrial, agricultural, governmental or any other purpose in a manner contrary to any provision of this section, or in an amount in excess of that use permitted by the drought management stage. The water use restrictions in each less restrictive stage apply to all more restrictive stages unless the higher stage has a more stringent requirement on the same subject.

A. Stage 1, Water Alert. During a Water Alert, the department shall issue one or more notifications to the public. The department shall ask all persons to implement voluntary reductions in water use, ask restaurants to provide water only upon request, urge hotels and motels to conserve water, and engage in a campaign to increase public education to promote awareness about water conservation issues.

B. Stage 2, Water Warning. During a Water Warning, the following additional conservation measures will be implemented:

   1. Persons may only irrigate landscaping between the hours of 7 p.m. and 7 a.m.
   2. Persons working in or operating restaurant-type uses may provide water only upon request.
   3. No person may operate outdoor misters;
   4. No person may operate or use public fountains or water features;
   5. No natural person may wash a car except with use of a bucket and a shut-off nozzle;
   6. No charity car washes may occur except at commercial car washes that recycle water; and
   7. No person may overseed turf areas. Areas to be irrigated exclusively by a rainwater harvesting system are exempt from this measure.

C. Stage 3, Water Emergency. During a Water Emergency, the following additional conservation measures will be implemented:

   1. No person may fill a newly constructed residential pool. Pool permits will remain in active status for 3 months after Stage 3 is downgraded to Stage 2;
   2. No person may operate a car wash unless it is equipped with a water recirculation system; and
   3. A person may top off a pool only to maintain water level; no person may refill a pool.

D. Stage 4, Water Crisis. During a Water Crisis, the following additional conservation measures will be implemented:

1. Landscape irrigation is restricted to only trees and shrubs; a ~~no~~ person may irrigate turf or ground cover with harvested rainwater only;
2. No person may fill a newly constructed pool. Pool permits will remain in active status for 3 months after Stage 4 is downgraded to Stage 2;
3. No person may use water to wash a car except for water captured by a rainwater harvesting system;
4. No person may use water to clean a parking lot or street; and
5. No person may use potable water in construction projects, either for dust control or toward the erection of new improvements or structures.

(Ord. 2007-47 § 1 (part), 2007; Ord. 2006-43 § 1 (part), 2006)

8.70.050 Declaration of Drought Stage.

A. Drought Stage Trigger - The triggers defining each drought stage are listed in Table 8.70.050.

B. Declaration of Drought - A drought stage for all or any area of the county may be declared by the Board of Supervisors upon a recommendation from the county administrator and information developed by the Local Drought Impact Group ~~Drought Monitoring Committee~~. A declaration by the U.S. Secretary of the Interior of either a shortage on the Colorado River or a curtailment of water delivered through the Central Arizona Project canal to any local water provider may increase the drought level by one stage. If the severity of the drought lessens, the Board of Supervisors may downgrade the drought stage to a lower stage.

Table 8.70.050

Indicator	Arizona Drought Monitor Report[1] Based on Findings Related to Pima County
Stage 1 Alert	~~Abnormally Dry~~Moderate-Severe
Stage 2 Warning	~~Moderate~~Severe-Extreme
Stage 3 Emergency	~~Severe~~Extreme-Exceptional
Stage 4 Crisis	~~Extreme~~Exceptional

SECTION 2. The various County officers and employees are authorized and directed to perform all acts necessary or desirable to give effect to this Ordinance.

SECTION 3. If any provision of this Ordinance or the application thereof to any person or circumstances is invalid, that invalidity shall not affect other provisions or applications of this Ordinance which can be given effect without the invalid provision or applications, and to this end the provisions of this Ordinance are severable.

SECTION 4. This Ordinance shall become effective 31 days after its adoption.

PASSED AND ADOPTED by the Board of Supervisors, Pima County, Arizona, this _____ day of _______________, 2014.

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Chairperson, Pima County Board of Supervisors

ATTEST:

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Clerk of the Board

APPROVED AS TO FORM:

Deputy County Attorney
CHARLES WESSELHOFT