

# The Future of **AGRICULTURE & FOOD PRODUCTION** in a **DRYING CLIMATE**

**PRESIDENTIAL  
ADVISORY  
COMMISSION  
REPORT**

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**THE UNIVERSITY  
OF ARIZONA**



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## Table of Contents

Executive Summary .....	4
Introduction.....	7
1. Threats .....	9
2. Solutions .....	12
3. UArizona Resources and Expertise.....	15
4. Recommended Actions .....	17
5. External Investments .....	22
6. Partnerships .....	24
7. Realizing the Vision: Timeline and Next Steps.....	26
List of Acronyms.....	27
Acknowledgments.....	28
Appendices .....	29
Appendix A: Commission Charge .....	30
Appendix B: Commission Biographies.....	31
Appendix C: Activity Summary for the Presidential Advisory Commission on the Future of Agriculture & Food Production in a Drying Climate.....	40

**Recommended citation:**

*Condon, L.E., J. Ruiz, P. Antin, J. Buizer, S. Collinge, N.L. Esquerra, L.A. Ikner, S.B. Megdal & K.J. Patten, "The Presidential Advisory Commission on the Future of Agriculture and Food Production in a Drying Climate." Final Report, August 2023.*



## Executive Summary

Located in one of the most arid portions of the country, Arizona’s food production systems are increasingly threatened by a drying climate, and there is growing concern that this trend poses an existential threat to food production in Arizona. In response to this urgent issue, UArizona President Dr. Robert C. Robbins created the Presidential Advisory Commission on the Future of Agriculture & Food Production in a Drying Climate. The Commission was tasked with assessing critical threats to agriculture and food production, identifying the most promising solutions, and determining how UArizona can best impact the future. This report reflects the Commission’s study and information gathering through listening sessions and surveys of community members across the University and the state of Arizona.

**Threats:** Sustainably producing food with decreasing water supplies in an already arid climate is a significant challenge. Decreased surface and groundwater supplies pose direct challenges to growing food with less water. Local threats are amplified by systemic threats to food production systems such as national and global food system disruptions and decreases in Colorado River allocations. These challenges contribute to socioeconomic and cultural concerns including the selloff of agricultural land and loss of the agricultural workforce. Furthermore, uncertain and inflexible policies create additional imped-

iments to adaptation that hinder long-term planning and holistic solutions.

**Solutions:** Given the complexity and far-reaching nature of the threats, any lasting solution must be multifaceted. Technical solutions like developing new heat- and drought-tolerant crops or improving soil moisture retention can sustain production with limited resources. However, technical solutions can only partially address the challenges. Policy and programmatic solutions to facilitate system-level changes and accelerate the application of technical solutions are greatly needed. Finally, no solution will be effective without human solutions that support cooperative decision making, bridge the gap from research to application, and support the next generation of farmers and ranchers.

**UArizona Resources and Expertise:** As Arizona’s land-grant university, UArizona is uniquely positioned to facilitate the development and implementation of solutions. UArizona has core strengths in food, water, energy, and community engagement. Through Cooperative Extension and the Arizona Experiment Station, UArizona already works directly with the agricultural community and operates a state-of-the-art network of laboratories, fields, and greenhouses. UArizona also has vast expertise in water issues and is ranked No. 2 in the U.S. and No. 6 in the world for water resources research.

### Core areas that UArizona can provide leadership:



**Research:** producing and providing research-based solutions



**Education & Training:** developing future leaders, thinkers and doers



**Extension & Community Connections:** engaging with stakeholders to jointly arrive at solutions



**Economic Development:** spearheading efforts to ensure resilience to future climate, economic, and policy shocks.

**The Commission recommends five actions:**

- 1 Create an Institute for Sustainable Food, Water and Agriculture Systems (ISFWAS):** The University lacks an integrated, interdisciplinary, and solutions-oriented unit that is centered at the intersection of food, water, and agriculture systems. The ISFWAS will be a flagship University Institute that spans the technical, policy, and human dimensions of agriculture, food, and water systems. Its purpose will be to realize synergies that occur when people work across disciplines and with diverse community and regional partners to develop system-level solutions.
- 2 Create a Center for Soil Health (CSH):** Maintaining and restoring soil health through regenerative practices is a critical issue facing the agriculture industry. The CSH will integrate current research capacity to address major research and development goals. A distinguishing feature of the CSH will be the integration of producers within the organizational and decision-making structure.
- 3 Create technology and innovation hubs at the Maricopa (MAC), Yuma (YAC) and Campus Agricultural Centers (CAC), and Biosphere 2 (B2):** The time periods between idea generation and solution implementation, and between solution implementation and adoption, are frequently problematic. UArizona can help reduce these lags in several ways. The proposed innovation hubs at MAC, YAC, CAC, and B2 will be places where University faculty work collaboratively with external partners including growers, ranchers, and industry to develop, evaluate, and advance innovative technologies toward commercial application. The innovation hubs will also provide significant educational opportunities for students through research, entrepreneurial activities, and internships to advance their workforce readiness.
- 4 Expand partnerships with Tribal agriculture:** Tribal communities have unparalleled knowledge of agriculture in our arid environment and bring highly valuable expertise in sustainable agriculture practices. It is critically important that UArizona works closely with Native Nations, honoring the fundamental principles of Tribal Consultation in accordance with University Tribal Consultation Policy. The Commission emphasizes the importance of building and maintaining reciprocal relationships that are focused on listening, building trust, and knowledge sharing.
- 5 Establish new and strengthen existing collaborations with institutions in arid regions around the world:** Drylands account for 40% of the world's land surface and 60% of its food production. Arizona's challenges are inextricably linked to drying regions worldwide and UArizona can enhance its global leadership in this area. The Commission recommends that UArizona develop and implement a high level, coordinated initiative to advance strategic partnerships with non-U.S. institutions focused on the critical issues of water, agriculture, and food sustainability.



PHOTO CREDIT: Sharon B. Megdal – Lettuce Field, Wellton, Arizona, 2023

**Investments:** To implement the recommended solutions, the allocation of existing resources and support must be optimized, new internal investments must be made, and additional external sources of funding must be secured. Existing University funding sources such as the Technology and Research Initiative Fund (TRIF), Provost’s Investment Fund (PIF) and Strategic Priorities Faculty Initiative (SPFI) can be amplified by investing in seed grants and other multipliers. The recommended actions are structured to foster direct engagement and pursuit of funding opportunities from a wide range of partners including government, industry, and philanthropic organizations. Given the strong focus on producing science-based solutions, “non-traditional” funding sources (e.g., industry and philanthropy) must be aggressively pursued.

**Partnerships:** Partnership is a central theme across all recommendations. Government, industry, and Tribal partners should be integral in the proposed centers and programs to accelerate innovation, and bridge the gap from research to implementation. Deliberate engagement is needed with municipal governments, and enhanced

collaborative efforts with county and state government agencies [including Arizona Department of Agriculture (ADA) and Arizona Department of Water Resources (ADWR)], the Governor’s office, and the State Legislature are essential. Close connections with philanthropic groups, other educational institutions, and civil society are also required. The UArizona Cooperative Extension service can play a critical role in achieving community engagement and should be strengthened and expanded. Further, to have a global impact, robust and purposeful partnerships should be forged and strengthened with other research, implementation, and funding entities around the world.

**Realizing the Vision:** Given the urgency of the threats, it is important that the University responds with agility. Efforts toward all recommendations should be initiated as soon as possible. Following the issuance of the report, the Commission recommends the appointment of an Implementation Team, who will convene over the next six months to develop a timeline and action plan for implementing these recommendations.



PHOTO CREDIT: Rosa Bevington – Wellton canal, Wellton, AZ, 2020



## Introduction

Agricultural production is a vibrant part of Arizona’s history, economy, and culture. Likewise, the arid climate and year-round growing conditions of Arizona make it a critical contributor to national food security. Agricultural producers across the state are highly diverse. Farming activities include large corporate-owned operations, Tribal farms, and small family farms. Arizona farmers and ranchers produce a broad array of food and non-food crops such as leafy greens, wheat, cattle, dairy, cotton, citrus, and wine. Many producers in the state operate at the cutting edge of precision agriculture and technical integration. Arizona also has an unparalleled history of Indigenous agriculture and a growing interest in regenerative practices and native crops. Some growers use groundwater exclusively or depend on local surface water sources. Others have senior Colorado River rights or rely on deliveries from the Central Arizona Project (CAP). Farmers and ranchers in Arizona contribute to a much broader food processing and distribution system that provides food for the state and the nation. Every member of this diverse community has a common commitment to the land and their ability to produce food and other crops in Arizona’s arid climate.

Unfortunately, this community is also increasingly connected by the threat of a drier future with greater competition for already-limited water supplies. Irrigated agriculture accounts for 72% of the state’s<sup>1</sup> water use. As water becomes increasingly scarce it is projected that agriculture will absorb some of the most significant cuts in water supply. The western U.S. is currently experiencing a historically unprecedented megadrought. This has strained local water supplies and reduced the Colorado River to historic low flows. Already, users of CAP water have experienced significant cuts, and nearly all Colorado River users can expect future curtailments. Groundwater in many parts of the state is already stressed by historical pumping, and low recharge rates challenge sustainable use. As water levels decline and urban areas expand, increased competition is likely between agricultural and municipal sectors. Concerns are prevalent that decreased water supplies will lead to the abandonment of agriculture, and ultimately, the decline of many rural communities. The need for agility and resilience in the face of mounting water stress has critical implications for agricultural production, food security, and the economic vitality of Arizona’s rural, Tribal, and urban communities.

In response to the rapidly expanding threats posed by a drying climate, UArizona President Dr. Robert C. Robbins created the Presidential Advisory Commission on the Future of Agriculture & Food Production in a Drying Climate in December 2022, with the knowledge that UArizona is uniquely positioned to rise to this challenge. As he stated, “With the mandates of our land-grant mission, and hundreds of expert researchers and a multitude of world-renowned programs that can be brought to bear to address this challenge, the University of Arizona is uniquely positioned to address this critical problem for Arizona’s agricultural production system and, by extension, for other arid regions around the world.”

The Commission is comprised of UArizona faculty and staff from a cross-section of pertinent fields including agriculture, Tribal agriculture and relations, climate change, water resources, and water quality (commissioner bios are provided in Appendix B). The Commission was charged with providing a set of recommendations with concrete steps that will position the University, in partnership with the desert agriculture industry, as a global leader in the creation and application of transformational technologies and climate-resilient sustainable agriculture and food production practices in arid regions across the globe. To do this, the Commission was tasked with:

- Summarizing the threats of drought and climate change to Arizona’s agricultural production systems, with an emphasis on food and a robust agriculture economy.
- Conducting a comprehensive and constructive review of the expertise and resources that can be brought to bear on the problem.
- Providing recommended actions for UArizona to address the issue and convert threats into opportunities.
- Identifying stakeholders who will support and grow these efforts on a continuous basis.

Since its formation in December 2022, the Commission gathered a large and diverse set of viewpoints on (1) the most significant threats facing food production in Arizona, (2) the most promising solutions, and (3) how the University can positively impact the future of agriculture in Arizona. An online survey was distributed through several



UArizona newsletters, including the Water Resources Research Center (WRRC) Weekly Wave (3500+ subscribers) and The Current, the Research Development Services newsletter (6500+ subscribers) to gather stakeholder input. The survey link was also publicly available on the Commission webpage and was distributed by members of the Commission to relevant individual contacts. In addition, the Commission conducted multiple in-person listening sessions with agricultural groups from across the state as well as international groups. An analysis of the data helped to formulate the recommendations in this report. Additional information on the Commission’s charge and activities can be found in [Appendix A](#) and [Appendix C](#).

In this report, we summarize the largest threats to food production in Arizona ([Section 1](#)), the most promising solutions ([Section 2](#)), and the existing resources at UArizona that can be brought to bear on the problem ([Section 3](#)). The core of the report is a series of five concrete recommended actions that the University can take ([Section 4](#)). We also provide guidance on potential investments to support our recommendations ([Section 5](#)) and strategic partnerships to sustain our activities ([Section 6](#)). This report contains our preliminary recommendations. We envision additional work to refine these recommendations and the transition to implementation. A timeline and next steps for realizing the vision are provided at the end of the report ([Section 7](#)).



PHOTO CREDIT: Sharon B. Megdal — Lettuce Field, Wellton, Arizona, 2023



## 1. Threats

It is likely that the future of Arizona will be drier and hotter. According to the latest National Oceanic and Atmospheric Administration (NOAA) climate summary, average temperatures in Arizona have risen by approximately 2.5°F since 1900, and the period from 2000-2021 was the warmest two-decade period on record for the state<sup>2</sup>. The increase in both day- and night-time temperatures, and the greater frequency of extreme events like drought pose serious hazards to agricultural productivity in an already arid climate. There is also consensus among scientists that the risk of intense precipitation and associated flooding in addition to longer and more intense heat waves is increasing. Therefore, farmers must be prepared for risks at both ends of the spectrum. Furthermore, impacts to agriculture and food production will cause complex and serious ripple effects on a wide range of economic, social, and cultural dimensions throughout the state.

We identify **four** major types of threats to agriculture:

### A. Challenges of growing food with less water in a hotter climate

A drying climate will decrease local water supplies, impact Colorado River allocations, and add strain to already taxed groundwater resources. Unchecked, the combination of decreased water supply, increased demand, and plant stress caused by warmer temperatures can lead to:

- **Reduced availability of and increased competition for water:** With dwindling water supplies and continued population growth, competition is increasing across the region among agricultural producers and between agriculture and urban/residential users. Watersheds that are internal to the state are stressed by increased temperatures and changes in precipitation. At the same time water allocation agreements made decades ago among Colorado River basin states are being challenged by the ongoing megadrought. The availability of groundwater, a common water source for agriculture often viewed as a substitute for diminished surface water supplies, is also limited, and competition for groundwater across sectors is increasing as aquifer levels drop.
- **Decline in soil quality and biodiversity:** Maintaining soil health is critical to ensuring a productive and sustainable future for the agriculture industry in Arizona. Rising temperatures, reduced water availability and increasing atmospheric CO<sub>2</sub> levels can negatively impact soil structure and biodiversity, organic carbon quality and abundance, as well as water quality and water retention.
- **Decline in product yield and quality:** With less water and higher temperatures, crops grow less efficiently and may have lower nutritive quality. Stressed crops are more susceptible to insect pests, disease, and invasive species. Heat and drought are detrimental to livestock and other animal species such as pollinators. Furthermore, the occurrence of large-scale mortality events impacting agricultural crops and trees caused by pests, pathogens, and wildfire are likely to increase.



## B. Systemic threats to food production systems

Statewide water supplies and food production systems are also threatened by external changes to the broader systems that Arizona producers rely on. These include:

- **Food system disruptions:** Food production exists within the context of a broader food system, which includes production, distribution, processing, marketing, consumption, and waste. Because the food system is so tightly interconnected, reductions in productivity or loss of one crop or resource can impact other crops as well as other elements of the food system. For example, food distribution can be impeded by supply disruptions and rising energy costs for cold storage and transport.
- **Decreases in Colorado River deliveries:** Colorado River deliveries are threatened by the ongoing megadrought in the western U.S. Already, CAP deliveries have been significantly curtailed, with the greatest impact experienced by agriculture in Central Arizona. More recently, Arizona farmers have proposed significant voluntary cuts, for which they will receive compensation, over the next three years. The future stability of Colorado River deliveries will depend on federally approved agreements between the seven basin states, Tribal users, municipal users, and agricultural users. It is unclear how much Arizona will be impacted in the long-term, but the envisioned curtailments are significant and further cuts can be anticipated.
- **Unresolved water rights:** Unresolved water rights add uncertainty to water supplies. Many unresolved water rights persist in Arizona and future adjudication of these claims can impact water availability for many uses, including water for agriculture. To date, 11 of the 22 Native Nations in Arizona have unresolved issues regarding water rights.

## C. Socioeconomic and cultural threats

Concerns regarding decreased water availability for agriculture and food production also threaten the economic vitality of Arizona's rural communities and a wide range of economic, social, and cultural dimensions throughout the state. Some of the biggest challenges are:

- **Loss of agricultural workforce:** Although the demand for highly skilled agriculture technology workers and industry leaders has never been higher, few young Arizonans view agriculture as a viable and desirable career. This situation is particularly acute for Arizona's Tribes, many of whom regard agriculture as integral to cultural practices and traditions.
- **Selling-off of agricultural land and water rights:** Decreased agricultural production and loss of institutional knowledge can lead to permanent resource depletion, including land and water, for agricultural production.
- **Decline of rural communities:** The selling-off of agricultural land and water rights can result in cascading losses to rural communities. Arizona's rural areas could experience out-migration to cities and possible out-of-state relocations.
- **Insufficient resources for Tribal agriculture:** Tribal food producers face all of the same challenges listed above, including difficulty in maintaining an agricultural workforce. Further exacerbating the challenges, Native Nations have unique concerns related to water availability and water quality for agriculture. Water quality has been impaired in many locations due to chemical contaminants from mining and other industries, and the lack of wastewater infrastructure has elevated concerns regarding the risk of illness from microbiological contaminants.



## D. Impediments to adaptation

Arizona's ability to be agile and resilient is critical to the long-term sustainability and vitality of our food production systems. Unfortunately, significant structural issues limit our ability to adapt quickly to changing conditions including:

- **Uncertain regulatory and government policies regarding water availability:** The changing landscape of water policies and regulations introduces additional uncertainties for farmers and ranchers. Reduced availability of Colorado River water and possible changes to groundwater regulations affect agricultural activities. These uncertainties make planning for the future difficult.
- **Inflexible policies:** Once policies are enacted, they can be difficult to change. Existing water and land use policies make it difficult to incentivize new behaviors or to easily explore potential solutions that don't align with our current regulatory framework.
- **Siloed policies within the food-water-energy nexus:** The connections between food, water, and energy are well known but also complex and often fall between the gaps of our existing regulatory structures. These gaps make it difficult to develop scalable holistic solutions.
- **Public perception:** Limited public understanding of Arizona agriculture and water supplies affects attitudes toward agricultural policies related to water pricing, water availability, and climate adaptation.
- **Challenges of long-term planning by farmers:** Farmers and ranchers often do not own the land that they use for production. Large amounts of farmland are owned by developers and government agencies, with land leasing common. The disconnect between land ownership and farming/ranching activities often make it difficult for producers to engage in long-term planning and on-farm investments.
- **Lack of systems thinking and investment in research and development:** The challenges associated with food sustainability in a drying climate are complex and constantly evolving. Traditional approaches that focus on a single aspect of the problem are inherently limited and will not produce the systems level solutions that are needed. Significant investments in cross-disciplinary research and development (R&D) are needed to connect industry and community partners with academia.



## 2. Solutions

The threats to food production in Arizona are complex and multifaceted; as such, no single approach will solve these issues. Successful solution(s) must embrace a broad array of interrelated technical, policy, and human approaches. Although not exhaustive, the following list includes some of the most promising ideas for addressing the previously listed threats. An inclusive approach to actively identify sustainable solutions is an important priority for the Commission.

### A. Technical solutions to do more with existing resources

Technical solutions can increase the quantity and quality of food produced with finite resources. They can be broadly characterized as approaches to:

- **Develop new heat- and drought-tolerant crops:**

Switching to crops that have lower water use requirements and developing more drought and heat tolerant crop varieties can decrease water demand. However, this issue is complicated by economic considerations that can drive crop choice decisions since farmers naturally strive to maximize profit for a given water allocation. When taking into consideration nutritive value and other factors, water intensive crops are not always “worse” than less water intensive crops.

- **Improve soil health:** Soil health is fundamental to the productivity of lands, and declining soil health is a concern across Arizona. Regenerative agricultural practices which focus on soil health are evolving in Arizona and have the potential to improve productivity over time. Additionally, no-till practices, cover cropping, and soil treatments that increase the moisture retention of soils are promising. Technology innovations that contribute to a better understanding of how the soil microbiome impacts soil, plant, and animal

health have the potential to sustain and improve agricultural productivity.

- **Improve irrigation efficiency:** Drip irrigation and pressurized spray systems can decrease water losses in irrigation systems. Similarly, lining or covering canals can decrease the amount of water lost to seepage and evaporation, respectively. However, increased irrigation efficiency does not lead to less total water usage if farmers switch to more water intensive crops or expand the acreage planted. Adoption of improved irrigation practices will not necessarily translate to conserved water at the watershed or groundwater basin level. Also, efficiency gains that decrease recharge or tail water from farming operations can lead to hypersalinity issues in soils that must be mitigated. Hypersaline soils can negatively impact both agricultural production as well as ecosystems that rely on field runoff or seepage. Irrigation efficiency is still an important solution, but it must be applied in conjunction with appropriate policies and programs which take a systems level approach to the issue.
- **Developing alternative water supplies:** Non-traditional water sources including recycled water are anticipated to increase in volume and can be made available for

crops. Recycled water has been used for agricultural irrigation principally in Central and Eastern Arizona. Because this solution requires that urban centers and water treatment facilities be located close to agricultural production, it is not feasible for all parts of the state. Brackish groundwater, which is saltier than drinking water, could also be a water source for some crops such as tomatoes. Treatment of brackish groundwater using membrane-based desalination technologies can facilitate the development of new water sources for agriculture (and communities). Innovative decentralized water treatment systems can further facilitate on-site agricultural water reuse.

- **Integrated solutions in the food-water-energy nexus:** Synergistic solutions that simultaneously address food, water, and energy challenges are promising. For example, when crops are grown under solar panels (a practice called agrivoltaics), panel efficiency is improved due to cooling from the crops, while

increases in crop yields are attributed to shading from the panels. Similarly, pilot projects to build solar panels over canals show promise. Canal water is used to cool the panels, and the panels decrease evaporative losses from the canal. This option is being implemented by the Gila River Indian Community.

- **Enhanced data tools to improve decision making:** The availability and use of Earth systems monitoring tools and the generation of agricultural production data are increasing. Remote sensing coupled with geographic information system (GIS) data tools can improve the efficiency of precision agriculture, leading to better monitoring and prediction of water and nutrient requirements. At the regional scale, enhanced forecasting and long-term models can improve planning and decision making. UArizona is distinguished in its capacity for big data acquisition, storage, management, and use (e.g., the newly established Arizona Institute for Computation and Data-Enabled Insight).

## **B. Policies and programs for resilient systems**

Technical solutions alone cannot address the multifaceted challenges of food production in a drying climate. Technical innovations are most effective when paired with policies or programs that incentivize adoption and accelerate application at scale. The best policies and management practices are those based on sound science, including model projections of future climate and weather events that Arizona will experience in the face of climate change.

- **Policy solutions for food production:** Policy solutions are greatly needed and have the potential to be far reaching. It is beyond the scope of the Commission to identify specific policy solutions, but many options should be explored. For example, tax policy can influence whether landowners choose to keep land in agricultural production or not. Similarly, land use and zoning policies influence development patterns and can determine the feasibility of integrated solutions such as agrivoltaics. Likewise, water law and policy dictate potential approaches to conjunctive management of groundwater and surface water.
- **Policy solutions for food waste:** Policy solutions should not be limited to those directly related to agricultural production. Current estimates by the U.S. Department of Agriculture (USDA) place food waste at about 30-40% of the food produced. The USDA has a voluntary program for businesses and organizations to become “food waste champions” by reducing the amount of food waste generated, but there are limited policies at both the federal and state level in Arizona to motivate actions to decrease losses in the food system. Policies at the state level aimed at decreasing food loss or utilizing food waste in creative ways could contribute to more sustainable and resilient food systems.
- **Incentive programs and water pricing:** Incentive programs are another way to influence behavior. Farmers respond to the demand for products in relation to production costs. For example, water intensive alfalfa is a crop of choice for many in Central Arizona because it is highly profitable. Incentive structures can support farmers interested in converting to less water intensive crops. Incentives have also been used for water conservation programs. For example, at the federal level, the Farm Bill includes incentives and funding for water conservation practices. At the state level, a program that began in 2022 incentivizes installation of water-saving irrigation approaches. Also related to economic considerations, water pricing influences behavior. For example, pricing by water utilities impacts the feasibility of water use for different applications, such as urban farms. In all cases, a rigorous systems analysis of the potential externalities impacting any incentives program is needed.



### C. Human solutions to support communities and build capacity

All the proposed solutions will benefit from strong communities of practice and enhanced cooperation across sectors. Mechanisms are needed to bring communities together to evaluate their needs, identify solutions, and develop the requisite workforce. Such mechanisms include:

- **Supporting cooperative decision making:** Collaborative processes to facilitate resource sharing and agreements related to water policy have been shown to be very effective in avoiding extended legal battles and developing community-supported solutions.
- **Decreasing the gap from research to application:** Many technical solutions require significant research and development. Close collaboration between producers and researchers is needed to accelerate the development cycle, advance promising solutions, and avoid wasted efforts on impractical or infeasible solutions.
- **Learning from Indigenous agricultural practices:** Most Indigenous agricultural communities practice community-based agriculture, often with a commitment to traditional practices. Indigenous farmers have a long history of climate change adaptation and production of drought-resistant crops. Farmers in some Tribes in Arizona are dry-land farmers and produce crops without irrigation systems, using only the moisture provided by nature.
- **Human capacity development:** Programs to increase the workforce at every level in the food supply system are greatly needed. This must include many approaches such as: a) formal and informal agricultural education and programs to increase the number of farmers for future generations; b) training for researchers to develop innovative technological solutions, and c) preparation of policy makers to work on systems level issues.
- **Consumer education:** Public awareness can be increased through consumer education programs that are geared toward fostering a better understanding of food production, water resources, and the associated challenges. Consumer education can also help decrease food waste.



### 3. UArizona Resources and Expertise

UArizona has core strengths in the areas of food and water and has long been recognized as an institution that excels in interdisciplinary research. The low barriers for cross-campus collaboration and capacity to work across colleges encourages UArizona faculty and staff to work together across traditional structures to ensure that impactful work can be accomplished. This is demonstrated by UArizona’s rank as 20th in research expenditures for public institutions in FY21<sup>3</sup> and a total economic impact exceeding \$8.3 billion per year in Arizona.

As Arizona’s land-grant university, UArizona has strong connections to agricultural communities throughout the state. Cooperative Extension offices are located in each of Arizona’s 15 counties and in five of the 22 Native Nations. UArizona also has vast expertise in water issues directly and indirectly related to agriculture and is ranked No. 2 in the U.S. and No. 6 in the world for water resources research. Further, the University has significant strengths in multi-disciplinary Earth observations, including the Earth Dynamics Observatory (EDO) research groups, and the Climate Dynamics and Hydrometeorology Collaborative (CDHC) which brings together ten academic units across five colleges to focus on the basic science and applications relating to climate variability and change.

It is beyond the scope of this report to list all programs and departments across campus that address issues of water and food. However, we highlight here some key programs to illustrate the breadth and depth of UArizona resources. Some notable programs that are not discussed in detail include, Biosphere 2 (B2), the Bio5 Institute, the Udall Center for Studies in Public Policy, the Natural Resource

Users Law and Policy Center, the OneHealth Initiative (an integration with the recently established College of Veterinary Medicine), the Arizona Lab for Emerging Contaminants (ALEC), and the Arizona Institute for Resilience (AIR). The collective strength of the University of Arizona is our ability to incorporate business and professional degrees with our basic research programs to provide solutions for the state of Arizona, the region, and the world.

- **Arizona Experiment Station** includes the Maricopa and Yuma Agricultural Centers (MAC and YAC) that are University field research sites located in high intensity agricultural regions. MAC includes approximately 2,100 acres in Pinal County while YAC encompasses approximately 500 acres in Yuma. Each has significant farm and technology infrastructure, plus laboratory, meeting, and administrative space. MAC is co-located with the USDA ARS Arid Lands Agricultural Research Center and is home to the world’s largest robotic field scanner.
- **Economic and Business Research Center** provides Arizona’s citizens, educators, business leaders, and decision makers with applied economic research, forecasts, and analysis of trends that impact business success and quality of life in Arizona. This includes the Arizona-Mexico Economic Indicators that focus on the trade relationships with Mexico and provide economic data on imports and exports (including agricultural) in the region.
- **Indigenous Resilience Center (IRes)** aims to position the University of Arizona as a world leader in Indigenous



resilience research, education, and outreach. It supports collaborative projects with Extension as well as research projects focused on regenerative agriculture among many others.

- **Natural Resource Users Law & Policy Center and Clinic** provides scholarly legal and policy analysis, and addresses the underrepresented law and policy needs of the natural resource communities of Arizona and the West. The Center is a partnership between the James E. Rogers College of Law and Cooperative Extension. The Clinic was developed to provide law students with practical field experience in environmental and natural resources law while being supervised by a practicing attorney.
- **Water & Energy Sustainable Technology (WEST) Center** is a leading research facility at UArizona where microbiologists and engineers work collaboratively to address current and future regional, national, and global water issues including water quality, scarcity, and reuse. WEST Center is uniquely poised to tackle the challenges of developing alternative high-quality water resources for agriculture producers in a drying climate. The expansive research labs at WEST allow for the assessment of water treatment technologies that can potentially be deployed for decentralized on-site water reuse efforts in agricultural settings.
- **Water Resources Research Center (WRRC)** is a Cooperative Extension center and a research unit in the

College of Agriculture, Life and Environmental Sciences (CALES). It is the designated state water resources research center established under the 1964 Federal Water Resources Research Act. The WRRC conducts water policy and management research and analysis and disseminates information through publications, conferences, lectures, and seminars.

- **Yuma Center of Excellence for Desert Agriculture (YCEDA)** is an innovative public-private partnership that connects top scientists with the desert agricultural industry to develop solutions to the challenges of arid land crop production. The work focuses on high-priority issues identified by industry stakeholders, including but not limited to increased production efficiencies through disease and water management, crop yield maximization, food safety, and technology utilization.

Beyond the research assets, UArizona has several innovation and translation assets that are largely embodied within the Office for Research, Innovation, and Impact (RII). This includes FORGE (Finding Opportunities and Resources to Grow Entrepreneurs), the entrepreneurial-training branch of RII; Tech Launch Arizona, the tech transfer unit for University developed intellectual property, and the Tech Parks, including the UArizona Center for Innovation which is the landing site for University and regional start-ups. Each of these provides services for transitioning research to the marketplace to ensure that the University of Arizona maximizes its economic impact on the region and the world.



PHOTO CREDIT: Eric Jewett – Cattle Cup, Las Cienegas National Conservation Area, Sonoita, AZ, 2021

## 4. Recommended Actions

UArizona plays a unique and critical role in addressing the challenges of a drying climate in an already arid landscape. Contributions toward a sustainable future are central to UArizona’s land-grant mission and are strategically aligned with existing areas of excellence within the institution. The establishment of the Commission for the Future of Agriculture & Food Production in a Drying Climate is an opportunity for UArizona to distinguish itself as a leader nationally and globally. Because Arizona is home to a productive and diverse agricultural economy, the solutions we put forth can set the standard for sustainable agriculture and food production in arid climates worldwide.

UArizona can provide leadership in four core areas:

- **Research:** producing and providing research-based solution options
- **Education & Training:** developing future leaders, thinkers and doers in the food and agriculture sectors
- **Extension & Community Connections:** engaging with stakeholders to jointly arrive at implementable solutions
- **Economic Development:** helping make Arizona resilient to future climate, economic, and policy shocks in the food and agricultural production sector

We have developed five recommended actions aligned with these areas that range from a university level Institute to targeted outreach and partnership building. These recommendations are not centered around individual technical solutions but are designed to build infrastructure within the University to accelerate a broad range of integrative solutions and strengthen UArizona connections to the community.

### A. Create the Institute for Sustainable Food, Water and Agricultural Systems

UArizona is globally recognized for its strength in the areas of agriculture, food production, and water, including research excellence and a strong community presence through Cooperative Extension, Agricultural Research Centers, and numerous college level initiatives. However, efforts are widely distributed across the University and frequently lack the coordination needed to collaboratively address large-scale problems. Given the complexity of the challenges we face and the diversity of potential solutions, we see a great need for a more holistic and visible approach within the University.

The ISFWAS will be a flagship University Institute that spans technical, policy, and human solutions. ISFWAS will build on existing University capacity in education, research, Cooperative Extension, and economic development, incentivizing efforts at the interface of research and action. Its purpose will be to realize the synergies that can only occur by working across disciplines and aligning diverse resources to address systems level challenges. As a University Institute, we anticipate that ISFWAS will be a part of the Office of RII. It will partner with departments, schools, colleges, Cooperative Extension, centers, institutes, and external partners to collaboratively advance its mission. The Institute will lead some



programs and support others, forging collaboration and leading University-wide initiatives to secure funding to advance common goals.

By leveraging existing strengths, ISFWAS can ensure that UArizona is a global leader in arid lands sustainability for agriculture, food, and water systems. Our Desert Southwest location is an opportunity for UArizona to lead the way in providing viable solutions to other regions of the U.S. and the world that are facing aridification. While the focus of this Commission is on agriculture and food production, concerns about water were some of the most common responses during our listening sessions. Our arid environment is a distinguishing factor of agriculture in Arizona. It is impossible to have a sustainable food production system without sustainable water supplies. The proposed Institute therefore extends beyond agricultural production to encompass water, food, and agricultural systems in a holistic way.

The goals of the Institute will necessarily be broad, and at a minimum will include:

- **Building partnerships:** External partners (e.g., farmers, ranchers, water resource managers, policy makers, industry) will be integrated into the organizational structure of ISFWAS to ensure a grounding in end-user needs and concerns.
- **Accelerating use-inspired research and scalable solutions:** UArizona has vast expertise in water, agriculture, and food production. The Institute will bring researchers together to tackle large problems and create innovative solutions that require multidisciplinary approaches. The Institute will also identify priorities for capacity building. In collaboration with external partners, the Institute will develop and scale innovative technologies and systems for efficient water use practices and climate-resilient agriculture. The Institute will lead efforts to secure large-scale funding opportunities that require University-level coordination.
- **Performing policy analysis:** Because governmental policies can accelerate or hinder movement toward more sustainable agricultural and food production systems, ISFWAS will work with university partners to better understand the implications of current policies or those under consideration and co-develop policy-centered solutions.
- **Strengthening Cooperative Extension:** UArizona Cooperative Extension has a long history of supporting Arizona’s food and agriculture producers through science, training, and knowledge sharing. ISFWAS can support and expand Cooperative Extension’s impact and assist with the co-development of system-level solutions in the areas of agriculture and food production, and water sustainability.
- **Providing workforce development:** ISFWAS will partner with CALES, College of Engineering (COE), College of Social and Behavioral Sciences (SBS), and the Office of Native American Advancement and Tribal Engagement (NAATE), among others, to develop intentional approaches for increasing enrollment in agriculture-related educational programs, including agriculture technology and engineering, water quality and resources, data science, food studies, business, and resource economics. Recognizing that many jobs in the sector do not require a four-year degree, ISFWAS will also work with community colleges and other education and training providers to advance programs that focus on agricultural workforce development.
- **Sharing knowledge:** Innovative approaches for connecting stakeholders and delivering information beyond traditional dissemination and outreach are needed. Through ISFWAS, University constituents will co-create, share knowledge, and communicate with members of the agricultural community through collaborative workshops, issue forums, and networks of alumni and local experts who can connect with the agricultural community. ISFWAS will also support public facing programs to inform and educate consumers regarding the environmental, economic, and health benefits of climate-smart agriculture.
- **Serving as a community convener:** UArizona is generally viewed as a neutral party that employs a full-system approach to framing challenges. The Institute can serve as a convener of community and policy making groups to arrive at solutions.

**University Units Involved:** As envisioned, the Institute would be inclusive and collaborative, bringing together experts in agriculture, food, water systems, engineering, social sciences, law, policy, and others from across campus. To advance its mission, it is recommended that the Institute be formed by and housed in RII, and that it partners with academic units, centers and institutes, and Cooperative Extension to advance its mission.



**Investments and Returns:** Although the land-grant mission is highlighted in Pillar 3 of the UArizona Strategic Plan, Arizona Advantage, minimal funding was included in the original allocation of Strategic Initiative Funds (SIF) for initiatives specifically addressing the foundational land-grant endeavors of animal and plant agriculture, food production, and water resources. For many decades, financial responsibility for advancing agriculture and food has fallen largely to the Division of Agriculture, Life and Veterinary Sciences, and Cooperative Extension (ALVSCE) and its constituent units of CALES, the Arizona Experiment Station and Cooperative Extension. However, numerous other colleges have also invested in these areas, including the Colleges of Science, Education, SBS, and the James E. Rogers College of Law.

With climate change threatening water supplies and a sustainable future for agriculture and food production in Arizona, this Commission strongly recommends that UArizona provide core funding to establish and sustain ISFWAS. This new Institute will drive educational outcomes impacting tuition revenue and will develop and support major research initiatives. A primary goal is to sustain and advance the agricultural and food production industries in Arizona that are of direct benefit to its citizens. In the long run, we envision that University funding will support core Institute personnel and administration, with a vibrant mix of funding from numerous sources supporting the Institute's mission objectives. The Institute will lead large-scale federal, regional, and state funding initiatives and is expected to be an attractive philanthropic naming opportunity.

## **B. Create the Center for Soil Health**

Internal and external partners have highlighted that maintaining and restoring soil health is a critical issue facing the agriculture industry that UArizona is well positioned to address given our exceptional collective strengths in soil science and soil health. The CSH will coalesce current research capacity to address major research and development goals including understanding abiotic and biotic soil attributes, soil assessment, carbon sequestration, optimizing nutrient use, reducing greenhouse gas emissions, developing decision support tools, and working with producers to develop and implement soil health plans. Through the harboring of pathogens and the presence microbial toxins and contaminants, soil health is also relevant to plant, animal, and human health.

A distinguishing feature of CSH will be the integration of agricultural producers into its organizational and decision-making structure. This is critical since producers will be responsible for adopting the new strategies and will shoulder the economic risk. Through collaborations with internal and external partners, CSH will help to evaluate the business case for new approaches to soil health, oversee research and development, develop and scale statewide soil health assessments and the impact of soil health implementation plans, coordinate education and training, and, as a trusted partner, provide accurate scientific information to best inform policy.

**University Units Involved:** To best align with the institutional expertise and capacity, we recommend that CSH be established within the Division of ALVSCE. It is anticipated that faculty from the COE, Mel & Enid Zuckerman College of Public Health (MEZCOPH), and from across the University will participate in this new Center. Several ongoing programs and projects related to soil health can be organized within and/or partner with CSH.

**Investments and Returns:** The Commission recommends a modest permanent institutional investment to cover the core personnel and administrative costs of CSH. Because the goals of CSH align with those of National Institute of Food and Agriculture (NIFA), ALVSCE could provide additional Center support through its allocation of Federal Capacity Funding. It is anticipated that the Center will garner significant project support from federal agencies and private foundations. Additional support may come from state entities including the Arizona Department of Agriculture (ADA). Soil health is of interest to a number of philanthropic foundations, and CSH is a potential philanthropic naming opportunity.



### **C. Create technology innovation hubs at the Maricopa (MAC), Yuma (YAC) and Campus Agricultural Centers (CAC), and Biosphere 2 (B2)**

While many potential technical solutions are evolving, the time periods between idea generation and solution implementation, and between implementation and adoption, are frequently problematic. UArizona can help accelerate the pace of technological development in arid land agriculture. The existing farm technology and laboratory infrastructure at MAC, YAC, CAC and B2 are exceptional resources that should be enhanced to foster closer partnerships with agricultural producers and the agricultural technology industry, develop field ready solutions, and train the next generation of producers, researchers, and technologists.

The proposed innovation hubs will be places where University faculty collaborate with agricultural producers and industry to develop and evaluate innovative technologies and practices. Example technologies may include irrigation and other water conservation approaches, water quality monitoring, robotics, precision agriculture/real-time field monitoring, soil amendments, novel fertilizers, soil health plans, and pathogen control. The innovation hub

concept is founded on close partnerships between industry and research and is designed to accelerate the adoption of new technologies. These innovation hubs will also provide significant educational opportunities for students through research, entrepreneurial activities, and internships to advance their workforce readiness.

**University Units Involved:** Innovation hubs will involve faculty from colleges across the University including but not limited to CALES, COE, COS, MEZCOPH and Cooperative Extension.

**Investments and Returns:** The Commission recommends a one-time institutional investment to help establish innovation hubs and recurring funding for four faculty positions to advance innovation hub goals. Innovation hubs will partner with and attract industry partners, resulting in significant new grants and contracts, anchor tenant opportunities, startup companies and small business development, and education and internship opportunities.

### **D. Expand partnerships with Tribal farmers and agriculture**

Arizona is fortunate to have a large presence of Tribal farmers and agriculture. Indigenous communities have been stewarding this land for millennia and have unparalleled knowledge of agriculture in Arizona’s arid environment. More than half of the producers in the state are Indigenous<sup>4</sup> and they bring significant expertise in regenerative and sustainable agriculture practices that are integral to the potential solutions. It is critical that UArizona work closely with Native Nations honoring the fundamental principles of Tribal Consultation in accordance with University Tribal Consultation Policy. The Commission emphasizes the importance of reciprocal relationships focused on listening to Indigenous communities, building trust, learning from Indigenous practices, and supporting advanced farming practices. Leaders of Native Nations have expressed a desire to work with the Commission to find ways to avoid the loss, for any reason, of agricultural heritage in the Native Nations within Arizona and across the nation.

Working with Indigenous communities should not be treated as a separate activity from the rest of the recommendations, and we emphasize that Indigenous partners should be a part of each of the proposed efforts. In

addition, a special focus on building relationships to better understand the needs of Indigenous communities is vital to the overall success of the proposed solutions. The Indigenous Resilience Center (IRes) is a successful, established program that has positioned the University of Arizona as a world leader in Indigenous resilience research, education, and outreach. The office of Native American Advancement & Tribal Engagement (NAATE) works to increase Native American awareness and increase the health and well-being of Native American students, faculty, staff, and Tribal nations. It is essential that NAATE and IRes are included in development efforts to determine the best approaches to engage Tribal agricultural producers in meaningful ways.

**University Units Involved:** The Commission will work with IRes and NAATE during the next phase to identify the appropriate partners for this activity.

**Investments and Returns:** It is critical that the proposed solutions are developed in partnership with Indigenous communities. In the near term, the Commission will require funding to invite Indigenous leaders to co-develop plans for their partnership and involvement.



## **E. Establish new and strengthen existing collaborations with institutions in arid regions around the world**

Although the Commission's charge is to recommend actions to ensure the future of agriculture, food production and water resources in Arizona, challenges in Arizona are inextricably linked to drying regions worldwide. Drylands are the largest biome on earth covering 40% of the land surface and supplying 60% of global food production<sup>5</sup>. Much can be learned from agriculture in other arid regions around the world and Arizona has much to share. Strategic partnerships have already been developed with several international universities and government organizations to jointly address the challenges of diminishing water supplies, reduced agricultural productivity and food insecurity. Recently, a long-term University-level collaboration was established with the French National Center for Scientific Research (CNRS), and a Memorandum of Understanding (MOU) regarding specific research initiatives with Mohamed VI Polytechnic University (UM6P) in Morocco is being finalized. Discussions have also begun with King Abdullah University of Science and Technology (KAUST) in Saudi Arabia and Ben Gurion University in Israel. Although the CNRS relationship was established at the University level, other relationships have developed through individual colleges, centers, and faculty.

The Commission recommends that UArizona develop and implement a high level, coordinated initiative to advance strategic partnerships with international institutions around the critical issues of water, agriculture, and food sustainability. Existing relationships should be strengthened, and new ones forged with international partners (e.g., Mexico, Israel, Australia, Morocco, France, UAE) that are innovating novel approaches and technological solutions to produce food in increasingly arid regions around the world. This aligns with Pillar 4 of the UArizona Strategic Plan, Arizona Global, and specifically initiative 4.1. Global Projects.

**University Units Involved:** International projects will include faculty and staff from numerous UArizona colleges, including but not limited to CALES, COS, COE, and SBS.

**Investments and Returns:** The Commission recommends that strategic research partnerships with institutions in arid regions around the world become a core function of RII and Arizona International as it undergoes structural reorganization.



## 5. External Investments

To implement the recommendations outlined in Section 4, the allocation of existing resources and support must be optimized, new investments must be made, and additional external sources of funding must be secured. Existing University funding sources such as the TRIF and the PIF can be used to create increased cohesiveness among existing programs and to leverage external funds. Opportunities should be pursued through the SPFI that enables academic departments to hire additional full-time, tenure-track faculty or continuing-track academic professionals who will enhance UArizona’s distinctive strengths in advancing inclusive excellence.

In addition to garnering new funds, solutions can be achieved by partnering with existing programs at other universities such as Arizona State University, Northern Arizona University, the University of California system, as well as academic institutions located in other neighboring states. UArizona is engaged in conversations with counterpart land-grant universities in California, Utah, Nevada, and New Mexico to coordinate research activities at the regional level. Also, UArizona is the lead institution on a regional innovation engine that brings together the state land-grant institutions from California, Utah, Nevada, New Mexico, and Arizona to advance technology solutions toward the integrated issues of agriculture, water, and energy sustainability.

Examples of sources of possible external investments are:

- **Government:** Given the importance of Arizona agriculture to the nation, federal funding opportunities should be aggressively pursued. These include: a) USDA, including Sustainable Agriculture Research and Education, National Institute of Food and Agriculture, Agriculture and Food Research Initiative, Agricultural Research Service, Climate-Smart Agriculture, Natural Resources Conservation Service, Conservation Improvement Specialty Crop Research Initiative, and Smart Agriculture and Commodities; b) NSF Technology Innovation and Partnerships and Regional Innovation Engines Program; c) Department of Energy (DOE) Earth Shot Program, and d) U.S. Departments of Interior and Defense programs related to agriculture. State, Tribal, county, and local funding should also be sought, particularly for implementation and scaling of pilot programs in specific locales. MAC and YAC can serve as key locations for such pilots.
- **Industry:** The private-sector production, storage, distribution, and consumption components of the food industry have financial interests in achieving a more sustainable food system in Arizona. As such, they should be approached to contribute to funding, especially to produce novel and innovative solutions that can improve their bottom line. These can include: a) farmers, ranchers, beef, dairy, and poultry producers; b) agribusiness, especially innovators such as Nature-Sweet, Wholesum, OnePointOne, Corteva, Bayer Crop Sciences, and Syngenta, among others; c) agricultural associations, such as the Arizona Farm Bureau, the Arizona Grain Research and Promotion Council, the



Family Farm Alliance, and the Agribusiness & Water Council of Arizona, and d) ranching associations, such as Dairy Council of Arizona, Beef Council of Arizona, Arizona Cattle Growers Association, Southern Arizona Cattleman’s Protective Association (SACPA), and Arizona State Cowbelles.

- **Philanthropy:** Partnerships with philanthropic foundations and private philanthropists interested in this challenge should be fostered to complement funding provided by governmental agencies, industry, and other entities. Intentional and sustained communication and trust-building with foundation program officers, fine-tuning of the message to fit their aspirations, and above all, investment of time, are key to successfully establishing fruitful relationships with philanthropic foundations.

A growing number of these foundations are focused on community-based sustainable approaches to agriculture to combat climate change, improve food quality and access, health and nutrition, advocacy for

public policy, and support for Indigenous and historically underserved communities. In collaboration with the UArizona Foundation, discussions are underway with the Rockefeller Foundation and the Foundation for Food & Agriculture for work in Arizona Native agricultural practices. Colleagues at the UArizona Foundation are supporting efforts to develop relationships with other philanthropic foundations with an interest in food, including the Gordon & Betty Moore Foundation, Walton Family Foundation, Waverley Street, and the Robert Wood Johnson Foundation. FY24 strategies are in place to cultivate relationships with additional foundations including the Howard G. Buffett Foundation, The Schmidt Family Foundation 11th Hour Project, The David & Lucille Packard Foundation, and Mars Wrigley Foundation. An additional group of foundations who prioritize food security, regenerative agriculture, healthy communities, and resilience will be approached beginning in January 2024. In addition, the UArizona Foundation is working diligently to identify and engage in conversations with individual philanthropists who are a potential source of complementary funding.



## 6. Partnerships

UArizona must strengthen its existing relationships, and forge and maintain both strategic and operational partnerships with organizations and individuals beyond the University. Specific recommendations were provided in Section 4 for focused measures to build relationships with Tribes and international partners. In addition to these targeted efforts, partnerships should be pursued with government, industry, philanthropic, academic, and civil society as described below:

- **Government:** Federal, state, Tribal, county, and local governments can support innovation through economic incentives as well as water management and land use policies that encourage the implementation of new technologies and approaches by producers and consumers. Government agencies can also play a critical role by supporting both formal and informal educational programs, expanding UArizona’s Extension function, and advancing local, Tribal, and statewide economic development goals. At the federal level, agencies such as the USDA, DOE, DOI, NOAA, NIH and the NSF should be engaged. At the Tribal level, leadership and agricultural entities should be approached both at the individual nation level, and through inter-Tribal organizations. State legislators, the ADA, the ADWR, Arizona Department of Environmental Quality (ADEQ), water municipality leaders and resource planners, and other relevant entities and individuals at county and municipal levels should be heavily involved. Many opportunities for direct engagement are envisioned through the proposed ISFWAS activities.
- **Industry:** Potential industry investors were described in Section 5. All of the groups that participate in agricultural food and water systems listed above are potential partners as well as investors. The recommended ISFWAS, CSH, and innovation hubs are all envisioned to have industry partners as part of their governing boards. A strong commitment to user-centered design will enhance the ability to rapidly develop, test, and scale toward real world solutions.
- **Philanthropic Organizations:** Philanthropic organizations were discussed in Section 5 as potential investors, but they should also be viewed as partners. Many opportunities are available to collaborate with existing foundation-funded programs that align with the recommended actions. Philanthropic organizations often directly fund local community organizations, frontline/grassroots organizations, and Indigenous farmers. In addition, many private foundations work with intermediaries such as ClimateWorks, Arizona Community Foundation, and Silicon Valley Community Foundation to distribute philanthropic support to local organizations.
- **Education:** The breadth of expertise required for both the creation and use of innovations must be tapped beyond UArizona. A resilient and secure food and agricultural production system in Arizona’s drying climate requires that other academic institutions are fully engaged to complement UArizona’s excellent research and educational capacity. These include other public and private colleges and universities both in Arizona and in neighboring southwestern states,



Arizona Tribal colleges, community colleges, and technical, trade, and K-12 schools. Through robust and ongoing partnerships with these entities, a pipeline of trained solution-oriented experts can be established.

- **Civil Society:** Not-for-profit organizations, community groups, and garden clubs are all examples of civil society groups that are critical to educating, communicating, and influencing communities. Such groups are necessary for advocacy, support, and adoption of proposed solutions. Through partnerships, UArizona

can engage in educational and communications campaigns to raise public awareness about the significance of the economic and social value that Arizona agriculture brings to communities and to the region, as well as the threats of a drying climate. Importantly, UArizona can help individuals understand how they can contribute to solutions. Cooperative Extension provides helpful publications and videos, but more capacity is needed so that Extension faculty and staff have the capacity to answer inquiries and interact with the public.



## 7. Realizing the Vision: Timeline and Next Steps

It is crucial that the University act with a level of urgency commensurate with the rapidly evolving threats facing food production in Arizona. The Commission was given six months to develop the preliminary recommendations summarized in this report. Our proposed actions encompass activities that can be accomplished in the near term, such as creating the CSH and dedicating resources to global partnerships, as well as longer term undertakings like creating the Institute for Food, Water and Agricultural Sustainability (ISFWAS) and developing the technology innovation hubs. Regardless of the overall timeline, progress toward all recommendations can and should start as soon as possible.

The Commission recommends the appointment of an Implementation Team who will work over the six months following the distribution of the report to develop a timeline and action plan for implementing the recommendations. This will include:

- Continuing to learn about related activities on campus and engaging with relevant groups to identify specific opportunities for engagement in the proposed recommendations.
- Connecting with Tribal leaders, government agencies, and industry partners to better understand their needs and refine the proposed external engagement structures.
- Working with the UArizona Foundation to develop options for philanthropic support.

- Identifying funding opportunities external to and within the University for the initial support needed to seed activities.
- Developing an implementation plan for the final recommendations, including the identification of leadership teams and structure for each recommendation.

We propose a transition from planning to implementation during the year following the distribution of this report. Because each recommendation is unique, the implementation processes and timelines will differ depending on the recommendation. We envision that most of the recommendations will be implemented by groups outside the initial Commission. Therefore, detailed plans and timelines will be developed by the groups who assume responsibility for the implementation of the solutions.

<sup>1</sup>Presson, Luke and Susanna Eden. "Arizona's Agricultural Outlook." Arroyo. Tucson, AZ: University of Arizona Water Resources Research Center, 2023. <https://wrrc.arizona.edu/arroyo-2023>

<sup>2</sup>Frankson, R., K.E. Kunkel, L.E. Stevens, D.R. Easterling, T. Brown, N. Selover, and E. Saffell, 2022: Arizona State Climate Summary 2022. NOAA Technical Report NESDIS 150-AZ. NOAA/NESDIS, Silver Spring, MD, 5 pp.

<sup>3</sup>As reviewed by the National Science Foundation Higher Education Research and Development Survey

<sup>4</sup>Presson, Luke and Susanna Eden. "Arizona's Agricultural Outlook." Arroyo. Tucson, AZ: University of Arizona Water Resources Research Center, 2023. <https://wrrc.arizona.edu/arroyo-2023>

<sup>5</sup>Wang, L., Jiao, W., MacBean, N. et al. Dryland productivity under a changing climate. *Nat. Clim. Chang.* 12, 981–994 (2022). <https://doi.org/10.1038/s41558-022-01499-y>



## List of Acronyms

<b>ARS</b>	Agricultural Research Service	<b>NAATE</b>	Native American Advancement & Tribal Engagement
<b>CAC</b>	Campus Agricultural Centers	<b>NEON</b>	National Ecological Observatory Network
<b>CALES</b>	College of Agriculture, Life and Environmental Sciences	<b>NIFA</b>	National Institute of Food and Agriculture
<b>CAP</b>	Central Arizona Project	<b>NOAA</b>	National Oceanic and Atmospheric Administration
<b>CDC</b>	Centers for Disease Control and Prevention	<b>NSF</b>	National Science Foundation
<b>CSH</b>	Center for Soil Health	<b>PI</b>	Principal Investigator
<b>CNRS</b>	Centre national de la recherche scientifique/ French National Center for Scientific Research	<b>PIF</b>	Provost’s Investment Fund
<b>COE</b>	College of Engineering	<b>R&amp;D</b>	Research and Development
<b>COS</b>	College of Science	<b>RII</b>	Research, Innovation and Impact
<b>DOE</b>	Department of Energy	<b>SACPA</b>	Southern Arizona Cattleman’s Protective Association
<b>DOI</b>	Department of the Interior	<b>SBS</b>	Social and Behavioral Sciences
<b>EPA</b>	Environmental Protection Agency	<b>SIF</b>	Strategic Initiative Funds
<b>FASEB</b>	Federation of Societies for Experimental Biology	<b>SPFI</b>	Strategic Priorities Faculty Initiative
<b>FORGE</b>	Finding Opportunities and Resources to Grow Entrepreneurs	<b>TRIF</b>	Technology and Research Initiative Fund
<b>GIS</b>	Geographic Information System	<b>UArizona</b>	University of Arizona
<b>ISFWAS</b>	Institute for Sustainable Food, Water and Agriculture Systems	<b>USDA</b>	U.S. Department of Agriculture
<b>KAUST</b>	King Abdullah University of Science and Technology	<b>WEST</b>	Water & Energy Sustainable Technology Center
<b>MAC</b>	Maricopa and Yuma Agricultural Centers	<b>WRRC</b>	Water Resources Research Center
<b>MEZCOPH</b>	Mel & Enid Zuckerman College of Public Health	<b>YAC</b>	Yuma Agricultural Center
<b>MOU</b>	Memorandum of Understanding	<b>YCEDA</b>	Yuma Center of Excellence for Desert Agriculture



## Acknowledgments

The Commission expresses its deep gratitude to the countless UArizona experts and community members who provided valuable input to this report through presentations, focus group discussions, the stakeholder survey, and in one-on-one conversations.

We are particularly grateful to Jane Hunter, Lori Tochiara, Daniel Moseke, and Meaghan Miller of the UArizona Office of Strategic Initiatives, who provided valuable logistical and administrative support to the Commission.

We also recognize Connie Collins of the UArizona Foundation for her excellent contribution to the writing of the External Investments Section, and the UArizona “Readers” who provided constructive critiques, significantly improving the content of the final report.

We are very thankful for Dr. Jane Zavisca and Dr. Jessica Martinez, who provided analysis of the stakeholder survey, and to Mingyoung An and Danielle Soza for their contributions to its analysis.

We are deeply grateful for the leadership of Paul Brierley, who led the Yuma Center of Excellence for Desert Agriculture and was the initial Commission Chair until June 2023, when he was appointed to serve on Arizona Governor Katie Hobbs’ cabinet as Director of the Arizona Department of Agriculture (ADA).

Last, but not least, we are very appreciative of the UArizona Office of Research Development for the operational funds they provided. These covered costs related to the analysis of the stakeholder survey, copy editing, and a small amount of local travel for outreach to community members.

Without these contributions this report would not have been possible.

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# Appendices



THE UNIVERSITY  
OF ARIZONA



*Appendix A: Commission Charge*

## **Presidential Advisory Commission on the Future of Agriculture and Food Production in a Drying Climate**

*Dec. 8, 2022*

*Robert C. Robbins*

As a rapidly drying climate threatens food and agriculture systems around the globe, Arizona’s agriculture industry will need innovative solutions to continue producing food and other goods year-round for the state and beyond. From leveraging transformative agricultural practices to enhanced data tools for rapid analysis of challenges and changes within agriculture and food production, research-based solutions will be critical.

Our ability to be agile and resilient in the face of this challenge affects not only agricultural production and food security, but also the economic vitality of our rural communities. The imminent Colorado River crisis, for example, offers a window into the severity of the damage wrought by a drying climate. Without the economic activity based on the Colorado River and other rapidly dwindling water sources, Arizona’s rural areas could experience mass out-migration to cities, creating major social upheaval for the state’s most underserved.

With the mandates of our land-grant mission, and hundreds of expert researchers and a multitude of world-renowned programs that can be brought to bear to address this challenge, the University of Arizona is uniquely positioned to address this critical problem for Arizona’s agricultural production system, and by extension, for other arid regions around the world.

With this in mind, I have formed a **Presidential Advisory Commission on the Future of Agriculture and Food Production in a Drying Climate** to provide recommendations on concrete steps the University can take to make our state a global leader in creating and applying transformational technologies and climate-resilient sustainable agricultural and food production practices, in partnership with the desert agriculture industry.

Paul Brierley, Executive Director of the Yuma Center of Excellence for Desert Agriculture, will chair the Commission which will include Dr. Joaquin Ruiz, Dr. Parker Antin, Assoc. Vice President Kim Patten, Dr. Sharon Megdal, Prof. Jim Buizer, Dr. Laura Condon, Dr. Sharon Collinge, Dr. Luisa Ikner, and Senior Vice President N. Levi Esquerra.

Drawing from experts across the University, and from the agriculture, food production, and water industries throughout the state and beyond, the Commission will:

- 1.** Summarize the threats of drought and climate change to Arizona’s agricultural production systems, with an emphasis on food and a robust agriculture economy
- 2.** Conduct a comprehensive and constructive review of the expertise and resources that can be brought to bear on the problem
- 3.** Provide recommended actions for the University of Arizona to take to address the issue and turn the threats into opportunities, and
- 4.** Identify stakeholders who will support and grow these efforts on an ongoing basis

To do its work, the Commission will establish and convene ad hoc subgroups of UArizona faculty and staff, as well as external experts and stakeholders, to inform it on specific aspects of the Future of Agriculture and Food Production in a Drying Climate.

I am very excited about this initiative and its potential. By providing research-based, scalable solutions to address this critical issue for Arizona, we can not only ensure the continued productivity of our agricultural and food producers and keep rural economies vibrant, but also help other arid regions around the world facing similar threats.

*Appendix B: Commission Biographies*



## **Parker Antin**

*Associate Vice President for Research, Agriculture – Life, Environmental and Veterinary Sciences / Cooperative Extension*

Dr. Parker Antin is Professor of Cellular and Molecular Medicine in the College of Medicine, Associate Vice President for Research for the Division of Agriculture, Life and Veterinary Medicine, and Cooperative Extension, and Associate Dean for Research in the College of Agriculture, Environmental and Life Sciences. In his positions of Associate Vice President and Associate Dean, he is responsible for developing and implementing the research vision for the College of Agriculture, Life and Environmental Sciences and the Division that includes Cooperative Extension and the Arizona Experiment Station. His responsibilities include oversight of research strategy and portfolio investment, grants and contracts pre award services, research intensive faculty hires and retentions, research communication and marketing, research facilities, and research compliance services. In collaboration with Division and College leadership teams, he has shared responsibilities for philanthropy, budgets, and information technology.

Dr. Antin is a vertebrate developmental biologist whose research is concerned with vertebrate embryonic development, genomics, and bioinformatics. His research has been supported by NIH, NSF, NASA, USDA, and the DOE, as well as several private foundations. From 2015-2021, he was Principal Investigator of CyVerse, a \$115M NSF funded cyberinfrastructure project whose mission is to design, deploy and expand a national cyberinfrastructure for life sciences research ([cyverse.org](http://cyverse.org)).

Dr. Antin is also active nationally in the areas of science policy and funding for science. He is a past President of the Federation of Societies for Experimental Biology (FASEB), an umbrella science policy and advocacy organization representing thirty scientific societies and 130,000 scientists.



## Jim Buizer

*Senior Strategy Advisor, Office of Research, Innovation, and Impact; Professor, School of Natural Resources and the Environment; Associate Director, Aegis Consortium for a Pandemic-Free Future*

Prof. Jim Buizer serves as Senior Strategy Advisor, Office of the Senior Vice President for Research, Innovation, and Impact (RII). He is a Professor of Climate Adaptation in the School of Natural Resources and the Environment and Associate Director of the Aegis Consortium for a Pandemic Free Future. He was the founding director of the Arizona Institute for Environments and Societies (now AIR).

Prof. Buizer serves as senior advisor to the RII Faculty Foresight Committee, is a member of the steering committee for the France-Arizona Institute for Global Grand Challenges and provides leadership on the Biosphere 2 board of directors, among other roles at UArizona. He has served as Chairman on numerous national and environmental and higher education nonprofit boards, including the Global Council for Science and the Environment and Second Nature, Inc. He has also served in lead authorship roles for U.S. National Climate Assessments and as contributor for the Inter-governmental Panel on Climate Change.

From 2003-2011, Prof. Buizer served as Senior Advisor for Institutional Transformation to the president at Arizona State University, where he led the establishment of the Global Institute of Sustainability. Prior, Jim was director of the Climate and Societal Interactions Division at NOAA in Washington, D.C., where he was responsible for designing and leading climate applications research programs.

He has worked in over 20 countries throughout his career and has published extensively on institutionalizing the science-to-action interface, integrating climate information into decision processes, and climate assessments. His degrees are in Oceanography, Marine Policy and Economics from the University of Washington, Seattle.



## Sharon Collinge

*Director, Arizona Institute for Resilience*

Dr. Sharon Collinge directs the Arizona Institute for Resilience (AIR) at the University of Arizona, which is an interdisciplinary institute housing 15 centers and programs focused on developing tools and solutions to promote environmental and societal resilience in response to environmental change.

During her tenure as a Professor at the University of Colorado, Dr. Collinge developed and delivered graduate and undergraduate courses that explored the sustainability of food production and procurement systems, and mentored students in capstone projects focused on food and the environment.

Dr. Collinge is a landscape ecologist whose interdisciplinary research focuses on the consequences of environmental change for species and ecosystems. Her expertise in human-environment interactions includes the impacts of habitat loss and fragmentation on wildlife disease dynamics, ecological restoration of riparian woodlands and ephemeral wetlands, and population declines of species due to land conversion.

Dr. Collinge formerly served as Professor and Chair of the Environmental Studies Department at the University of Colorado, Chief Scientist and Observatory Director for the NSF-funded National Ecological Observatory Network (NEON), and as the Vice President for Public Affairs for the Ecological Society of America. Dr. Collinge currently serves as President of the Ecological Society of America.



## Laura Condon

*Associate Professor, Hydrology and Atmospheric Sciences*

Dr. Laura Condon is an Associate Professor in the Department of Hydrology and Atmospheric Sciences. She studies groundwater surface water interactions and large-scale water availability and sustainability. Growing up on a farm in Colorado, Dr. Condon has a particular interest in agricultural water use and has spent much of her career focusing on water issues in the western U.S.

Before joining UArizona she worked at the Bureau of Reclamation where she worked primarily on regional water availability studies. Dr. Condon is currently leading multiple federally funded research projects to study innovations at the food energy water nexus and national groundwater availability. She is the lead PI of a \$6M NSF convergence accelerator project to develop a national groundwater forecasting platform.

Dr. Condon has won multiple awards for her work including the American Geophysical Union Hydrology Section Early Career Award, University of Arizona Early Career Award, University of Arizona Galileo Circle Curie Award and NSF CAREER Award. She is an author on the Fifth National Climate Assessment Water Chapter and serves on multiple national and international committees on data stewardship, cyberinfrastructure, and large-scale modeling. More information on Dr. Condon's work can be found at [condonlab.org](http://condonlab.org).



## Levi Esquerra

*Senior Vice President of Native American Advancement and Tribal Engagement*

N. Levi Esquerra is currently the Senior Vice President of Native American Advancement and Tribal Engagement for the University of Arizona. He continues to work with the various Native Nations and bring UArizona resources to the Tribes. Prior to this, he was employed at the Alliance Bank Economic Policy Institute on the campus of Northern Arizona University. He is responsible for increasing entrepreneurship and economic and community development activities within Tribal communities.

He has served as Tribal Chairman of the Chemehuevi Indian Tribe and has been elected to serve three additional terms on Tribal Council. During this time, he was an active member of the Colorado River Ten Tribes/7 State Partnership. He currently has allotted land which is used for agricultural purposes.



## Luisa A. Ikner

*Assistant Professor, Environmental Science*

Dr. Luisa A. Ikner is an Assistant Professor and environmental microbiologist in the Department of Environmental Science at the Water & Energy Sustainable Technology (WEST) Center. Dr. Ikner collaborates with academic, government, industry, and community partners on a broad spectrum of research ventures performed under biosafety level-2 and biosafety level-3 conditions. She works collaboratively with engineers and public health experts on research projects funded by the U.S. Department of Agriculture (USDA), the Environmental Protection Agency (EPA), the Centers for Disease Control and Prevention (CDC), and the U.S. Army Corps of Engineers in the areas of soil health, microbiological water quality, and advanced water treatment to increase water resiliency and security in arid environments. Of key interest are decentralized water treatment technologies capable of removing chemical and microbiological contaminants that can potentially be deployed to agricultural settings for on-site water reuse.

Dr. Ikner serves on the Arizona Department of Environmental Quality (ADEQ) Technical Advisory Group for Pathogen Control during rulemaking for the implementation of direct potable reuse as water scarcity concerns continue to mount. On behalf of The WEST Center and UArizona, she also collaborates with the City of Tucson and Pima County to provide the Citizen Water Academy, a public outreach and educational effort that focuses on local water resources and challenges. Dr. Ikner prioritizes providing intensive research experiences and focused mentorship to undergraduate and graduate students who have career aspirations in the areas of water quality and reuse.



## Sharon B. Megdal

*Director of the University of Arizona Water Resources Research Center*

Dr. Sharon B. Megdal is Director of the University of Arizona Water Resources Research Center (WRRC), Professor in the Department of Environmental Science, C.W. & Modene Neely Endowed Professor, and Distinguished Outreach Professor. She bridges the academic, practitioner, and civil society communities through water policy and management research, education, and engagement programs. The geographic scope of Dr. Megdal’s work ranges from local to international. Applied research projects include analysis of water management, policy, and governance in water-scarce regions, groundwater recharge, and transboundary aquifer assessment. Recent engagement initiatives include Indigenous Water Dialogues and Diversifying Voices in Water Resources. Dr. Megdal teaches the multi-disciplinary graduate course “Water Policy in Arizona and Semi-arid Regions.” In 2020, she was awarded the Warren A. Hall Medal for lifetime achievement in water resources research and education by the Universities Council on Water Resources.

Dr. Megdal serves on the Board of Governors for the Kasser Joint Institute for Food, Water, and Energy Security, is an ex officio member of the Leadership Team for the Colorado River Basin Water & Tribes Initiative, and is a member of the Governor’s Water Policy Council. Dr. Megdal holds a Ph.D. in Economics from Princeton University. Sharon Megdal’s full CV, along with her policy columns and Reflections essays, can be found at [wrrc.arizona.edu/director](http://wrrc.arizona.edu/director).



## Kim J. Patten

*Associate Vice President for Research Development*

Kim Patten is Associate Vice President for Research Development at the University of Arizona. She leads a team of research development professionals that excel in supporting faculty in their pursuit of extramural funding from federal, corporate, and foundation sponsors resulting in more than \$600 million in awards to campus since 2014. Part of this success is based on a holistic view of research development and the research lifecycle with an emphasis on the societal impacts of research such as the incorporation and promotion of undergraduate research experiences, core community partnerships, and inclusive practices.

Prior to joining UArizona, Patten managed projects and programs in conservation, renewable energy, and distributed data systems both nationally and internationally. As Associate Director at the Arizona Geological Survey (AZGS) she managed and conducted research on a more than \$30m portfolio, including Co-PI on a \$3.6m NSF project and project manager of a \$22m U.S. DOE project. Prior to her work at AZGS, she was Programs Director at a science-based nonprofit organization where she helped develop the organization's research portfolio resulting in the organization's first NSF funding.



## Joaquin Ruiz

*Vice President of Global Environmental Futures, [Thomas R. Brown Endowed Chair](#), Director of [Biosphere 2](#), Executive Director of the [Gem and Mineral Museum](#), Co-Director of the [France-Arizona Institute](#), and Professor of Geosciences.*

Dr. Joaquin Ruiz' research addresses societal grand challenges related to water, environment and energy through large-scale experimentation and research at Biosphere 2 to seek critical solutions so that Earth can support future generations. Under his leadership, Dr. Ruiz and his team at Biosphere 2 are transforming the facility into a collaborative and inclusive hub within a network that provides education, ideas, research, and innovations for sustainability from the UArizona campus to the entire globe.

Dr. Ruiz is a Fellow of the Society of Economic Geologists, and a member of the American Geophysical Union, the American Chemical Society, the Geochemical Society, the National Research Council of the National Academies of Science, and the Mexican Academy of Sciences. He was named a National Researcher by the Mexican government where he was recognized for his outstanding scientific contributions and efforts to enhance Mexico's scientific and technological capacity through collaborations with the UArizona and research institutions in Mexico. In 2018, the Mexican Secretary of State named Dr. Ruiz as one of forty distinguished Mexican citizens living abroad who have brought distinction to the country.



### *Appendix C: Activity Summary for the Presidential Advisory Commission on the Future of Agriculture & Food Production in a Drying Climate*

The Presidential Advisory Commission on the Future of Agriculture & Food Production in a Drying Climate was formed in December of 2022. The Commission was charged with evaluating (1) the greatest threats facing food production in Arizona, (2) the most promising solutions, and (3) how the University can positively impact the future of agriculture in Arizona (See Appendix A for the official Commission charge). The Commission is composed of ten members from across the University (see Appendix B for commissioner bios). Paul Brierley, who led the Yuma Center of Excellence for Desert Agriculture, was the initial Commission Chair until June 2023, when he was appointed to serve on Arizona Governor Katie Hobbs’ cabinet as Director of the Arizona Department of Agriculture (ADA). Joaquin Ruiz and Laura Condon assumed leadership roles as Co-Chairs of the Commission at this point. Administrative and technical support for the Commission was provided by the Office of Strategic Initiatives.

The Commission dedicated significant resources to information gathering and listening to ensure that recommendations were based on community interest and need. An eight-question survey (Table 1) was developed to obtain broad input from a range of voices and perspectives pertaining to the three areas of the Commission’s charge. Due to the diversity of respondents, the different ways in which responses were obtained, and the desire to receive as much input as possible, the survey was designed to provide qualitative, not quantitative, results. The survey was distributed through several UArizona newsletters including the WRRRC Weekly Wave (3500+ subscribers) and The Current, the Research Development Services newsletter (6500+ subscribers). The survey link was also publicly available on the Commission website and was distributed to relevant individual contacts by members of the Commission. The Commission also conducted multiple in-person listening sessions with agricultural groups across the state and international groups. At each listening session, the survey questions were used as a guide for breakout group discussions led by commissioners.

Overall, the Commission received seventy-three valid responses to the survey; 60 responses are from individuals, and 13 responses consist of summaries of group discussions facilitated by commissioners. Most responses were from UArizona affiliates and agricultural

producers. Survey responses were aggregated and summarized by Jane Zavisca, Minyoung An, Danielle Soza, and Jessica Martinez in the College of Social and Behavioral Sciences. Survey responses helped to inform the Commission recommendations as well as our evaluation of the biggest threats and most promising solutions.

The Commission met roughly weekly from January 20, 2023 to July 10, 2023. Guest presenters were invited to offer expert viewpoints and information regarding water resources and management, the food production system in Arizona, economic factors influencing farming practices and crop choices, and UArizona resources. This report was developed jointly by Commission members, and six internal UArizona readers provided comments on a report draft.

#### **Table 1: Commission survey questions**

- 1.** What are the threats of a drying climate to Arizona’s agriculture and food production systems?
- 2.** Given these threats, how do you expect agriculture and food producers will respond?
- 3.** What big picture ideas would have the most impact on agriculture and food producers in the short and/or long-term?
- 4.** What expertise and resources (i.e., specific research, innovations, technologies, infrastructure, practices) can UArizona provide to help agriculture and food producers be as productive as possible in the face of these challenges?
- 5.** What actions by UArizona can bring these resources to bear on the threats to agriculture and food production in a drying climate?
- 6.** What funding and partnering opportunities are there to support these actions?
- 7.** Who else should we get input from on any of these questions?
- 8.** Do you have any additional comments or suggestions?



PHOTO CREDIT: David Quanrud – Chasing a Rainbow, Sulphur Springs Valley, AZ, 2010



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