Sonorensis
ARIZONA-SONORA DESERT MUSEUM

Desert Harvest

HERITAGE AND FUTURE

Sonorensis
ARIZONA-SONORA DESERT MUSEUM 2016

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The Arizona-Sonora Desert Museum
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Visit us at www.desertmuseum.org

Cover: A Kino Heritage Sonoran white pomegranate *(Punica granatum)* in the Mission Garden. The Desert Museum currently is doing research on pomegranates. Photo by L. M. Brewer.

Back cover: A variety of local tomatoes for sale at a farmers' market in Tucson, Arizona. Photo by Kim Franklin.

We gratefully acknowledge all the authors, photographers, and organizations who contributed articles, photos, or maps for this issue of *Sonorensis*.

Photos on this page, above: Prickly pear fruit in batter; Tarahumara serape corn and Hopi red dye amaranth.

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INTRODUCTION

Linda M. Brewer
Editor, Sonorensis,
Arizona-Sonora Desert Museum

Food. It is essential for survival. It is the basis of health, a source of sensual pleasure and endless creativity, as well as an integral part of our economy. Last year, the City of Tucson, the University of Arizona's [UA] Southwest Center and College of Social and Behavioral Sciences, with the support of *Edible Baja Arizona* magazine and other contributors, submitted an application to UNESCO for designation of Tucson as a "City of Gastronomy" in the United Nations Creative Cities Network. You might ask, Why? What good is it? And how does Tucson merit this title?

The application they put together under Jonathan Mabry's pen says it all. Here are a few short excerpts from that document:

• *Tucson has the longest [continuous] agricultural history in the [United States]. Its distinctive cuisine has developed from more than 4,000 years of farming, a culturally layered history, a variety of heritage food ingredients, and continuity of traditional food preparation techniques unique to the U.S./Mexico borderlands. A thriving contemporary culinary scene is led by award-winning chefs and independently owned restaurants creating traditional and contemporary dishes using local foods, and is celebrated by film and book festivals and popular media. Innovative City programs, policies, and regulations support food security and sustainability, and the fast-growing culinary economic sector. The University of Arizona is a world leader in research on agriculture, nutrition, biodiversity conservation, and cultural foodways, and engages the community with many food-education programs. Non-profit groups and libraries conserve and disseminate heritage seeds and plants. Higher education institutions, vocational schools, business associations, and incubators support entrepreneurship and employment in the culinary industry. A community garden network and many school and home gardens play important roles in food security and the informal food economy. Numerous farmers' markets and two-dozen annual food festivals occur year-round and offer tastes of local foods and living food traditions to residents and visitors.*

Above, and clockwise: Las Milpitas, an urban community farm run by the Community Food Bank of Southern Arizona; Bumble bee *(Bombus sonorus)*; Mesquite experts Dr. Richard Felger and Clifford Pablo at 2014 Mesquite Conference; Cattle watering, Sonora, Mexico; Tomato rows in a UA CEAC greenhouse; Local produce at farmers market. Cut out: carrots.

"To be interested in food and not in food production is clearly absurd." – *Wendell Berry*

• *[This region] also has a 300-year tradition of vineyards, orchards, and livestock ranching. More heritage foods listed on the Slow Food International Ark of Taste are grown within 100 miles of Tucson than any other city in North America. These heritage foods are representative of many living traditions that thrive today."*

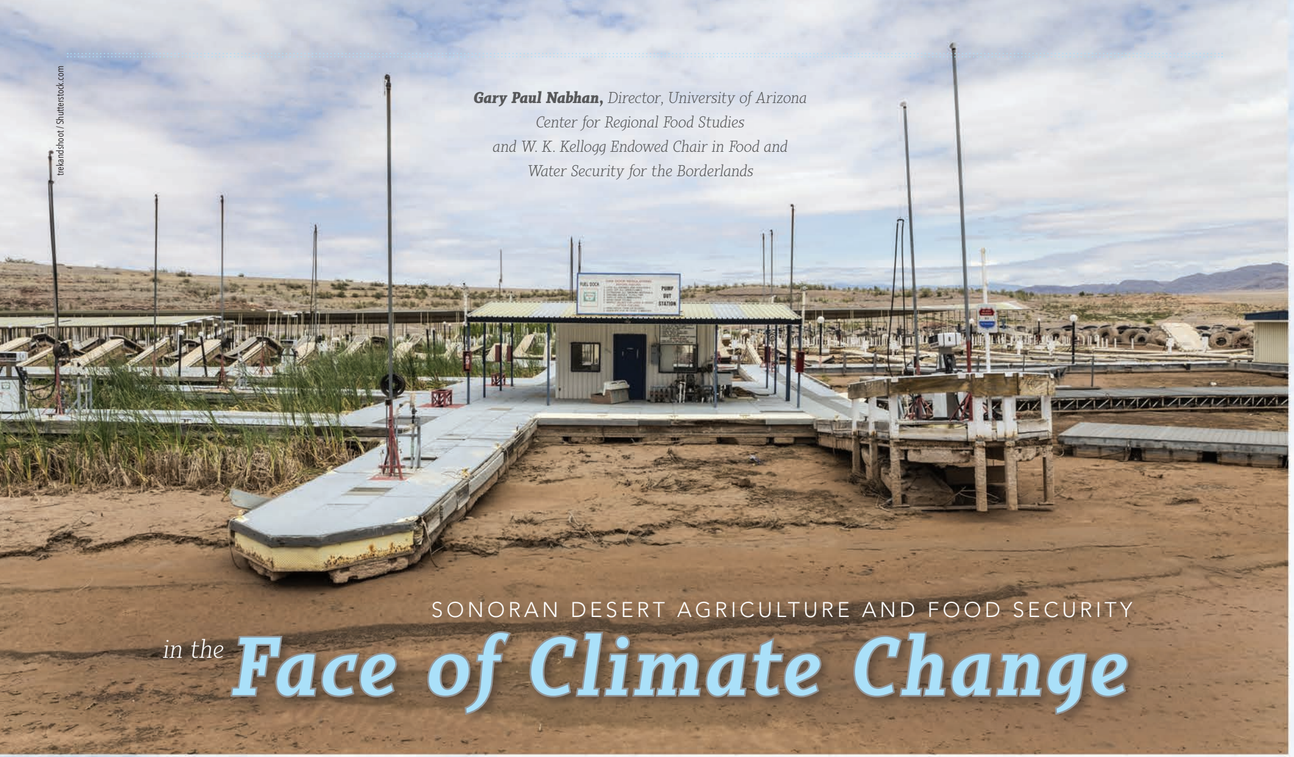
• *"[The designation of Tucson as a City of Gastronomy] will provide an economic boost to local food production and help us build a more sustainable, resilient, and secure food system based upon traditions, innovation, and food justice.*

It is worth noting that the Arizona-Sonora Desert Museum will be a partner in Tucson's first international initiative in UNESCO's Creative Cities Network, along with the UA, Pima County, Native Seeds/SEARCH, and other nonprofits. Together, we are organizing an international convention to work with other cities to develop resources and strategies for conserving and distributing heritage crops. We will share our knowledge and experience in seed banking, seed libraries, establishing native trees in urban areas, re-establishing historical fruit trees, and harvesting and preparing native wild foods. It is also worth noting that Tucson draws much of its food culture from the history, resources, and peoples of the whole Sonoran Desert Region.

According to Wikipedia, "Gastronomy is the study of the relationship between food and culture." According to *Webster's*, it's "the art or activity of cooking and eating fine food." This issue of *Sonorensis* looks at both, from food cultivation to dishes on the table. Between these two definitions, there are countless worthy subjects we cannot fit between these covers, including the numerous community farms and educational/food resource networks in the region and a plethora of food security issues, like soil depletion and ground and water pollution. What we can offer is a look at a few aspects of the food chain of the Sonoran Desert Region, from desert or farm to table.

Farmers, scientists, poets, and others have been speaking out for decades—offering observations on the intimate relationships of the land, plants, animals, agriculture, our health, and the health of the planet. Today, we need agricultural wisdom for food security. We need engagement and action if we want our children and grandchildren to continue to enjoy delectable, nutritious foods.

Our *Sonorensis* authors offer perspectives on food and/or food production in the Sonoran Desert Region: agriculture in the face of climate change; precision controlled-environment agriculture; re-seeding lost food diversity; the resurgence and revisioning of Native American ancestral foods; mesquite, a desert superfood; the place of ranching, ranchers, and cattle; bees, champion pollinators; the Kino Heritage Fruit Tree Project; and Sonoran Desert seafood. We hope you will enjoy and learn from these articles, as we have.



trekandshoot / Shutterstock.com

Gary Paul Nabhan, *Director, University of Arizona Center for Regional Food Studies and W. K. Kellogg Endowed Chair in Food and Water Security for the Borderlands*

SONORAN DESERT AGRICULTURE AND FOOD SECURITY

in the Face of Climate Change

Above: Drought damage at Lake Mead's Echo Bay Marina, Nevada, May 9, 2015.

Welcome, desert eaters, drinkers, gardeners, orchard-keepers, hunters, and fishers, to the "New Normal"! That's one shorthand term that climate scientists use to signal "the end of stationarity"—in other words, we can no longer predict climate using past baselines for rain, temperature, extreme weather and other factors. Perhaps it's also the end of "agri-business as usual" as we have known it in the Southwest since the introduction of gas and electric pumps for extracting water for crop irrigation a century ago. While we would do well to draw upon the wisdom and technical knowledge of desert farming traditions around the world, the ways by which desert dwellers produce food in the future may not look much like how we have been farming in the Sonoran Desert, currently or historically! Without question, we can't afford to furrow irrigate in the desert.

Why might that be? As I write, just after the 2016 summer solstice, many of my Sonoran Desert neighbors are stunned by the news of two record-setting events:

- Lake Mead, the largest reservoir in the United States, declined to its lowest level since it was first filled in the 1930s, prompting hydrologists to predict that we have a 50-50 chance of mandated water rationing in Arizona by 2018, largely due to the last sixteen years of subnormal precipitation in the Colorado River watershed.
- Phoenix, Hermosillo, and other cities in low desert areas had already shouldered twenty days with temperatures over 110 degrees Fahrenheit by mid-summer.

Do these unusual weather events confirm that the deleterious consequences of long-term, human-influenced climate change on our food supplies are now palpably upon us? Well, *no* and, *tentatively, yes*.

No single weather event or even cluster of extreme events can be definitively tied to human-induced climate change, but multiple sophisticated climate models at the University of Arizona and other climate research institutions do predict a greater frequency and/or and intensity of catastrophic events. Moreover, temperatures and associated evaporation rates continue to rise, as they have over the last few decades, especially in cities such as Tucson, Hermosillo, and Phoenix, which suffer from urban heat-island effects. In other words, residents of our desert cities are being exposed to hotter temperatures and daunting aridity. Temperatures are increasing more rapidly in this region than in other terrestrial habitats.

And yet, predicting how heightened aridity might affect both residential and agricultural water use for Arizonans and Sonorans is a complex task because we are affected by global change, more specific changes in the watershed *above* our cities, as well as changes in the cities themselves. For instance, the depths of snowpack and durations of stream flows from the headwaters of the Colorado River, Rio Yaqui, and Rio Mayo are projected to decline, but rainfall patterns in the desert itself are likely to be far more variable. While water planners in the region as a whole will have to grapple with greater uncertainty, Phoenix, Yuma, Tucson, and Hermosillo still rely on multiple sources of groundwater and surface water that buffer their residents from the effects of this uncertainty over the short haul.

In fact, Las Vegas, Los Angeles, Las Cruces, El Paso/Juarez, and San Diego are at greater immediate risk of water scarcity than are the Sonoran Desert's largest cities. That may be why those California, Nevada, and Texas cities are already rationing urban and horticultural water use and Arizona is not (albeit Hermosillo is already rationing water). But it may also be the reason we are not yet exercising our "peripheral vision" enough to prepare for what's coming over the horizon!

As Arizona Department of Agriculture Director Mark Killian recently underscored at a statewide meeting on "food deserts" in early July, "our food security is clearly linked to our water security." And yet, he correctly observed that the challenge before us is really about the competition for available water among the various states and, within each state, their users (urban vs. agricultural), and wildlife. Both federal and state agencies legally mandate that society does its best to meet the minimum needs for the recovery of endangered species, their critical habitats, and the ecosystem services they provide. In Arizona, this may include legal protection of a minimum flow in certain streams.

Given the high probability that food production in Arizona and Sonora will be affected by meteorological drought (less rain and more evaporation), unpredictable and/or violent storms, or politically mandated drought (less water for off-reservation agriculture in favor of cities, wild habitats, and tribes), how is this apt to affect our food security?

First and foremost, there is a good chance that both Native nations ("tribes") and private farmers will increasingly opt to sell their allotted water supplies—once intended for local food security—to the highest bidder, which may be municipalities or industries. Or they may sell to high-water consumptive enterprises. For instance, a Saudi Arabian corporation has recently purchased more than 14,000 acres of irrigated croplands in the Sonoran Desert to grow alfalfa that is being sent more than half way around the world to feed dairy cows that produce a billion liters of milk in air-conditioned barns near Riyadh, Saudi Arabia! Such water transactions may be ecologically and ethically questionable because of their large water and energy "foodprint," but they are perfectly legal by federal laws passed during the days of the "Old Normal." What forces will push our society to revise antiquated laws that allow us to forfeit

chloe7992

Above: Hereford cattle graze in the open range.

Below: Mature pecan grove budding with new leaves during springtime.

Lindsay72


Rod Mondt

Above: A velvet mesquite tree flush with bean pods that produce nutritious flour.

Below: Englemann's prickly pear heavy with fruit.


M. A. Burgess

control over trillions of gallons of embedded water per year that supports the economies of other countries, but produces few multiplier effects that benefit our own region?

Secondly, some water intensive food crops like pecans may be "transitioned out" of production across large acreages of the Sonoran Desert, due to rising production costs, salinization of arable soils, heat limitations on crop yields, or better returns from less water-intensive but still high-value returns from vegetables or other tree crops.

Third, climate-induced range expansion of aggressively invasive weeds, pests and diseases is likely to cripple some crops (such as citrus) more than others. Climate change is already affecting the availability of crop pollinators as well, a food security issue that Desert Museum and University of Arizona researchers have been engaged with for two decades, just as they have been with invasive weeds.

Fourth, there will be intense societal debate over how much of our irrigated lands should be kept under forage crops for livestock versus food crop plants for direct human consumption. Although the best ranchers still may be able to produce range-fed beef in natural or restored grasslands in some years, year-round range carrying capacity will inevitably be compromised by drought conditions.

Fifth, more of our food will be produced in controlled environments such as vertical farms, window gardens, "agrivoltaic" plantings (using shade tolerant crops) under solar photovoltaic arrays, aquaponics, and upcoming cutting edge systems. (See "Complimentary Agriculture" page 24.)

At this point, some of you may well ask what such issues have to do with the explicit missions of the Desert Museum, the University of Arizona and other public institutions in our state. Well, if you scratch below the surface a little, you will see that both the museum and the university have been engaged in evaluating "new crops for desert agriculture" for well over forty years. Our early proposals for intentional production and consumption of some of these desert crops—such as mesquite pod flour, halophytic greens, tepary beans, cactus buds and fruit, and amaranth grain—seemed like "pie-in-the-sky" wishful thinking by critics within mainstream agricultural institutions in the 1970s and 1980s.

Ironically, six of the top ten desert crops proposed by Richard Felger, myself, and other ethnobiologists during that era are being used now in restaurants and grocery stores every day of the year, crops either wild-harvested or cultivated through rainwater-harvesting or other "permaculture" systems. (In addition to those noted above, the list included, agaves, chia, saltgrass grain, and buffalo gourds for the oil in their seed.) Pilot projects have also advanced the harvestability, consumer acceptability, and nutritional density of several dozen perennial desert food crops that can now be grown, processed and prepared with "disruptive technologies" (new technologies that have the potential to eventually disrupt and displace old systems) and in novel agro-ecosystems that were not available when such work was begun in Tucson nearly a half century ago.

With Tucson's recent designation as the first U.S. "City of Gastronomy" in the UNESCO Creative Cities Network, we will be looking to ensure the food security and inclusive well-being of desert dwellers on the both sides of the U.S.-Mexico border who currently suffer from the collateral damage from what has turned out to be an imprudent and wasteful industrial food system. We now need all Sonoran Desert dwellers to think of themselves as "co-designers" of a more energy- and water-efficient, just, and economically viable desert food system that has the "pre-silience" to anticipate and avert the deleterious consequences of climate change. Sonoran Desert institutions may need to be creatively redesigned to address human health, land health, and community well-being in order to contribute as proactive, innovators of climate-friendly solutions, rather than as passive victims of climate catastrophes. S

Suggested Readings and Resources:

Nabhan, Gary Paul. "Desert Prophet of New Food Crops," *Edible Baja Arizona,* March/April 2016. http://ediblebajaarizona.com/desert-prophet-new-food-crops

Nabhan, Gary Paul. *Growing Food in a Hotter, Drier Land: Lessons from Desert Farmers on Adapting to Climate Uncertainty,* foreword by Bill McKibben. White River Junction, VT: Chelsea Green Publishing, 2013.

United Nations Food and Agricultural Organization: http://www.fao.org/docrep/010/i0112e/i0112e00.htm


NSIS

RESEEDING

Lost Diversity in Food Crops

Martha Ames Burgess, *Ethnobotanist: Proprietor, Flor de Mayo LLC; former staff and board member Native Seeds/SEARCH*

The massive freezer door closes behind us with the solid sound of entombment—an airlock separating worlds. There before us, stacked floor to ceiling in this grocery-like walk-in, are a zillion glass jars of every size—baby-food- to gallon-size—each containing a separate set of colorful seeds. Our Native Seeds/SEARCH guide points out narrow aisles of amaranth, beans, chile, corn, gourd, squash, sunflower, a rainbow of native-food seeds they archive in Tucson. Alone in a passageway with jars-full of corn kernels—some purple, some red, blue, white, or yellow, some marked with star-burst stripes, some big and bulbous, others popcorn-size with a pearly sheen—I am mesmerized, no longer hearing the guide or fellow tour participants.

I'm in a room full of time—a cave filled with genetic success stories from the history and prehistory of agriculture in the Sonoran Desert Region! These seeds are silently singing long *corridos* of people caring for the plants that nurtured and clothed them, spanning the unseen past. I sense potential life in desert-adapted DNA encapsulated in thousands of miniature bio-chemical life-support packages. These jars hold **agricultural memory,** a diversity of life in suspended animation, waiting for the helping hands of humans. I am moved, and silently acknowledge the significance of this space, these seeds and seed savers past and present.

Cultures here and elsewhere have changed radically. As people relocated to cities, family farms have languished. (A hundred years ago 2 out of 5 people in America were farmers. Now, 1 in 50 Americans farm at all.) Governments imposed commodity food programs, altering Native agricultural practices and diets. In the latter half of the 20th century public tastes shifted to fast food made with products grown on megafarms or foods outsourced from distant rainforests. No longer were people growing traditional crops and saving their seeds; no longer was the genetic diversity of landraces, crop varieties adapted to particular local conditions, being preserved by their original stewards. Fortunately, the far-sighted founders of Native Seeds/SEARCH, a grassroots model for regional seed conservation, stepped in thirty-five years ago. It now stewards over 1,800 traditional crop-seed varieties from the Southwest, a treasure-trove of arid-adapted food for a warming world.

The precipitous loss of time-tested seeds was—and still is—occurring in many regions, as global cultures continue to set new taste standards around the world, obliterating traditional food crops in favor of mass production

Left: Intern, Julius Badoni at the NS/S Conservation Farm harvesting Tohono O'odham cowpeas. Isolation cages in background prevent cross-pollination of varieties. Right: Benjamin Gonzales, NS/S Farm Tech, hand pollinating a Yoeme Kama squash blossom to ensure seeds breed true to type.

and monoculture. Since 1900, 75% of crop diversity has been lost. Worldwide, diets now depend primarily on only a *dozen* or so food plants, species now primarily determined by agribusiness. As Simran Sethi notes in her book *Bread, Wine, Chocolate: The Slow Loss of Foods We Love,* choice in the supermarkets is superficial. With more than 1,000 varieties of bananas in the world, only one can be found in most American markets. And it isn't just plants. She observes that "more than 90% of every container of yogurt, milk, and ice cream [in most U.S. supermarkets] is made with milk from one breed of cow," and while more choices of fruits and vegetables are available now than in the recent past, the new produce is overwhelmingly determined by global transport, while "local and regional crops have become scarce or disappeared altogether" from the shelves. In addition, pesticides and herbicides continue to be used heavily in vast monocultural agricultural fields.

Fortunately, there is a groundswell of awareness about both the carbon footprint of distant food transport and the environmental hazards from widespread use of toxic chemicals on food-plants; the movement back to heirloom varieties and organic foods is gaining momentum. Sonoran Desert residents are growing their own again. Native O'odham farmers are cultivating traditional tepary beans again at San Xavier and on farms like Ramona's in Sacaton, Arizona. *Native Seeds/SEARCH's seed distribution almost tripled from 2011 to 2013.* The University of Arizona's Cooperative Extension is abuzz with questions from backyard gardeners, and the Community Food Bank of Southern Arizona teaches free backyard gardening, cooking, and seed-saving to packed classes.

Support of local organic growers through farmers' markets has burgeoned, with Arizona boasting 77 markets in the summer of 2016, where there were but a handful 10 years ago. Young people are learning how to grow their own heirloom foods in dozens of Tucson's schoolyard gardens, as well as on the Tohono O'Odham Nation. Pima County Public Library's seed-lending program, providing free open-pollinated and heirloom seed, has exploded in popular use. This demand for local and diverse foods directly supports genetic diversity. And the pages of *Edible Baja Arizona* magazine are bursting with mouth-watering endorsements of the diversity that made Tucson a World City of Gastronomy.

Currently, however, most big agricultural producers still prefer monocrops, standard crop genes and for certain crops, genetically modified varieties, to assure pest control and market predictability. Natural diversity is difficult to deal with, and complicated. Industry wants straightforward parts and plans. But diversity—and we're talking genetic diversity—provides both Nature and human "manipulators" an array of options. Think of diversity as an adaptable insurance plan for adjusting to environmental challenges like increasing soil salinization or regional warming; or for dealing with problems like the corn blight of 1970-71 that wiped out most of the genetically uniform hybrid corn in the United States; or for satisfying increasing cultural desires for increased flavor and vitamin content.

Nature itself isn't static; populations of earthly creatures in the Game of Reproductive Chance need a diversity of genes to successfully readjust to ever-changing patterns—be they gradual or sudden—of weather, winds, soil, nutrients, water availability, alkalinity/acidity, cover, exposure, competition, solar pulses, asteroid impacts. A plethora of gene options for "ecological testing" with each change provides the raw material for species survival and evolution through time.

Just as we are learning that cultural diversity among people makes life richer and deserves our respect, so too are we beginning to notice, appreciate, and respect the biological diversity on our home planet. But diversity awareness requires re-actions and pro-actions.

Left: A Native Seeds/SEARCH storage vault. Middle: Proofing squash seeds at NS/S. Right: Students seed sorting at NS/S.

Our Sonoran Desert Region (on both sides of the biologically divisive political Border) is blessed with scientists, volunteers, citizen field scientists, students, and nature enthusiasts, including those at the Desert Museum, who share an awareness of Nature's genetic diversity, and who engender action. Saving genetic diversity will take more than just seed banks; saving habitat for wild genetic diversity goes hand in hand with domestic seed diversification. By promoting food-crop diversity using renewable-energy technologies in combination with innovations in sustainability (like controlled environment farming) and land-respecting traditional practices (such as Tohono O'odham *ak chin* farming), we might arrive at a new and long-lasting, multi-cultural inhabitation of our beloved Sonoran Desert.

Rich genetic diversity is nothing without human participation. Seed banks, like the Native Seeds/SEARCH collection that so moved me, represent only potential life-energy, potential food-energy. Thankfully, many families, community garden groups, churches, tribal groups are again growing and saving their seeds. Let's all jump in. Borrow some seed from the library or the NS/S freezer bank, grow them out, eat the food you grow, clean and save some seed to share with neighbors, save some to grow again next year with a child, then return some seed to the library or vault for a temporary rest. As Sethi reminds us, "agrobiodiversity shapes—and is shaped by—every meal we eat."

> *We depend on seeds—even the animals that provide us meat and dairy depend on seeds.* – Simran Sethi

Suggested Readings and Resources:

Buchanan, David. *Taste, Memory*. White River Junction, VT: Chelsea Green Publishing, 2012.

Chaskey, Scott. *Seedtime*. New York, NY: Rodale Publishing, 2014.

Fowler, Cary. *Shattering: Food, Politics, and the Loss of Diversity*. Tucson: University of Arizona Press, 1990.

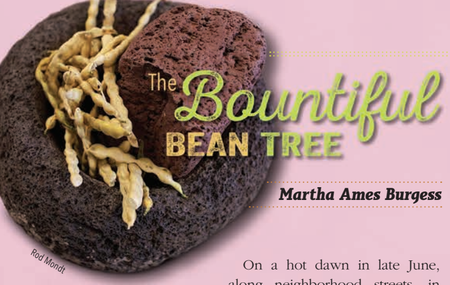
Sethi, Simran. *Bread, Wine, and Chocolate: The Slow Loss of Foods We Love*. HarperCollins Publishers, NY, New York, 2015.

TOP FIVE SEED BANKS

(from http://blogs.worldwatch.org/five-global-seed-banks-that-are-protecting-biodiversity/)

- Kew's Millennium Seed Bank Project, Wakehurst, England – 40 years.
- Navdanya, Uttrakhand, India (1987).
- Svalbard Global Seed Vault, Svalbard, Norway (2008) – the largest secure seed storage vault.
- National Center for Genetic Resources, Fort Collins, Colorado (mid-1900s) Part of the U.S. Department of Agriculture's Agricultural Research Service - saving seeds and germplasms, including plants, animals, insects, and microorganisms.
- Vavilov Research Institute, Russia (1924).

REGIONAL SEED BANKS *(including distribution, gardening/farming support, education, and/or research):*
Native Seeds/SEARCH, Tucson, Arizona www.nativeseeds.org
Gila River Indian Irrigation Drainage District, Sacaton, Arizona. Contact snieto@griidd.com.



Rod Mondt

The Bountiful BEAN TREE

Martha Ames Burgess

On a hot dawn in late June, along neighborhood streets, in golf courses and parks, and along riverways in southern Arizona, it's not surprising to see two-leggeds reaching into mesquite trees, busily browsing for... yes, you got it: they are bean hunters! Straw-colored pods hang like Christmas tree tinsel from every branch—nutritious gifts to humans and desert creatures alike, from small bruchid beetles to deer, javelina, and coyotes. Tohono O'odham, the Desert People, have shown us how to safely gather and deliciously prepare the ripe pods for tortillas, biscuits, and cornbread (including O'Odham elders like Juanita Ahil and Stella Tucker, who have taught classes for innumerable Desert Museum members over the years). Nutritional analyses and medical tests affirm traditional knowledge that mesquite meal is a superfood with upwards of 29% protein and 55% complex carbs; it provides sustained energy for athletes and helps balance blood sugar, which helps deter diabetes.

Beyond its sweet, energy-boosting pod meal, mesquite is a super-tree. As if the gift of shade weren't enough, every part of this desert-surviving tree offers something. Bees gather its pollen, and humans enjoy their copious honey production. Its leaves and sap have been used by desert peoples in healing medicines for untold centuries. Its web of roots prevents soil erosion, and its root nodules restore the soil with renewed nitrogen. At one time, rope was made from its roots. Beyond the BBQ fire, mesquite wood continues to provide material for construction, cabinetry, and artistic craft. A rich dye is derived from its dark sap by Native weavers. Livestock feeds on its nutritious pods. Little wonder this tree is treated with such respect by those whose culture depended upon it before modern techno-fixes and supplements. Mesquite is the epitome of desert independence and inter-dependence. The trees grow successfully with no supplementary irrigation on sporadic, low rainfall, giving shelter and sustenance to countless birds, mammals, reptiles, insects, and microbes; mesquites, in turn, are pollinated and propagated by innumerable insects, birds, and mammals.

New uses of mesquite here in the Sonoran Desert include Hamilton Distillery's mesquite-malting of barley to produce mesquite-smoked spirits! Who needs peat when you can make a superb single-malt with mesquite? This new innovation was cited in the City of Tucson's application to UNESCO for designation as a World City of Gastronomy!

Food-safety is a concern with mesquite. Native People have known for millennia that pods should be harvested before the monsoon rains arrive. Pods are hygroscopic, attracting moisture. So when the rains arrive, fungi multiply on humid pods, producing an aflatoxin hazardous to humans, a toxin that cannot be de-natured. When humidity rises over 10%, harvesting is dangerous. Commercial ventures in mesquite-meal production should be carefully monitored, but interestingly, as yet, mesquite is not on the FDA radar. Thus far, our regional "mesquite industry" (with the help of multiple University of Arizona testing labs) is self-monitoring for *E. Coli (Escherichia coli),* bug parts, salmonella, and aflatoxin.

Creative technologies are being applied to mesquite products, such as solar drying of pods for more efficient milling and storage. Aflatoxin testing is becoming standard. An amazing orchardist in western Arizona, Mark Moody, is cultivating native velvet and screwbean mesquites—now nine years old—that produce more than 3000 pounds of meal seasonally for a growing market. He has repurposed a miner's ball-mill that grinds mesquite pods at a temperature cool enough to produce mesquite meal as a raw-food. His and other mesquite flours are sold in farmers' markets statewide. (For information on Moody's mesquite farming and processes from trees to flour see https://www.youtube.com/watch?v=FteM7aoXrqI.)

Southern Arizona's www.DesertHarvesters.org has spread the word about safe harvesting and user-friendly recipes to a growing grassroots audience of mesquite gatherers, eaters, and brewers. They also provide instruction and public millings at several venues for do-it-yourselfers—plus pancake breakfasts for "experiential learning." Aravaipa Heirlooms (www.aravaipa.com) has a market presence for wild-collected mesquite meal at several southern Arizona farmers' markets. Tucson-based Cheri's Desert Harvest features mesquite in a number of its products. The NativeSeeds/SEARCH store (www.nativeseeds.org) in Tucson features mesquite meal, as well as recipes and encouragement for the mesquite novice.

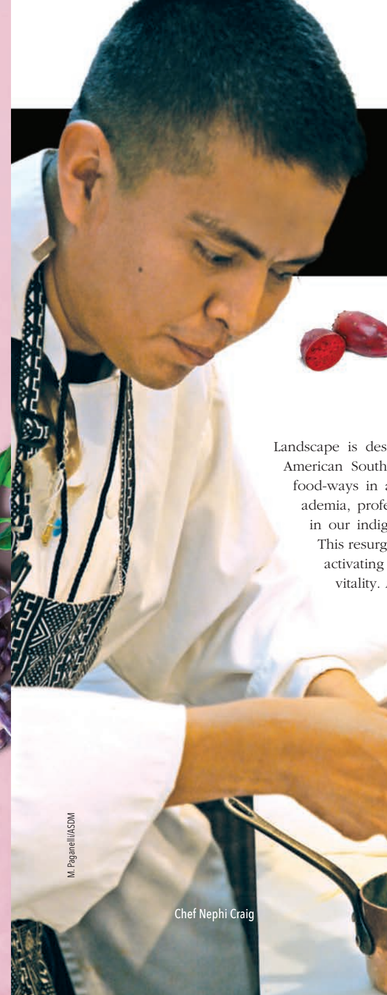
So when you see those mesquite pod gleaners out on the hottest mornings of the year, give them a bravo! They are bringing back a worthy desert tradition. S

M. A. Burgess

Prickly pear, mesquite, and white Sonora wheat coffeecake. For the recipe go to savorthesouthwest.wordpress.com/2016/08/12/mmmm-ihbhai-the-marvelous-monsoon-prickly-pear/

Cooking with Mesquite

Tasty mesquite recipes abound in the primo cookbook *Dining with the Desert Museum,* Arizona-Sonora Desert Museum Press, 2005; *Eat Mesquite!* published by www.desertharvesters.org; *Cooking the Wild Southwest: Delicious Recipes for Desert Plants* by Carolyn Niethammer, University of Arizona Press; *From I'itoi's Garden, Tohono O'odham Food Traditions,* Tohono O'odham Community Action, www.TOCAonline.org ; and *The Green Southwest Cookbook* by Janet E. Taylor, Rio Nuevo Press, Tucson, 2012. More information and recipes at www.savorthesouthwest.wordpress.com.



M. Paganie/UASDM

Chef Nephi Craig

Nephi Craig, *Executive Chef at Sunrise Park Resort & Founder of the Native American Culinary Association*

The Resurgence of Indigenous Food-Ways: BACK TO THE ROOTS

Landscape is destiny. In recent years, indigenous peoples in the American Southwest have witnessed a resurgence of traditional food-ways in agricultural teaching spaces, farm production, academia, professional kitchens, and, most importantly, at home in our indigenous communities—in our ancestral landscapes. This resurgence is revitalizing sacred ancestral knowledge and activating indigenous principles of intelligence, health, and vitality. As the world adapts to a changing climate and loss of biodiversity in our foods, it is more and more critical that we learn to share both ancient and newfound knowledge to manage and feed a growing population. We are living in an age of accountability and responsibility together.

Indigenous peoples of the Americas possess profound ancestral knowledge and an intimate relationship with the landscape, including those in the Sonoran Desert Region and Greater Southwest. Indigenous peoples have lived in this region since time immemorial and their deep spiritual connection to time and place resounds in oral histories, ancestral foodways, and awareness of our cosmological relationship with the universe. This emotional intelligence, reflecting the inter-connectedness and sacredness of all things, can drive and inform sustainability practices and food-security policies of the future in significant ways. In spite of many largely unrecognized layers of oppression of indigenous peoples, our foodways and culture continue to thrive and are teaching lessons that often validate Western science. For millennia, Native Americans have known how to farm strategically, as with corn, beans, and squash as companion plants, maximizing the land, shade, and water. They harvest wild foods mindfully, allowing them to continue to thrive.

Food is sacred. What you eat is a gift of a person's culture. It has love. It has thought. It has prayer. ~ Lois Ellen Frank, part-Kiowa, scholar and chef based in Santa Fe

Knowledge of drought-resistant crops, strategic agriculture, and expert botanical knowledge are ingrained in indigenous life, song, and ceremony. Native species such as the drought-resistant and protein-packed tepary bean have and

Cut outs above (from left to right): Prickly pear fruit; Cushaw squash; Flor del rio corn; Nopalitos; Tepary beans.

M. Paganelli/ASDM

M. Paganelli/ASDM

will continue to sustain peoples in arid regions. The tepary bean is just one example in a long list of wild and cultivated indigenous foods that are now being used in professional kitchens at the highest level, as well as in the homes of indigenous people. In professional kitchens, native flora and fauna—including but not limited to beans, corn, squash, mesquite, cactus pads, cactus fruits, roots, berries, wild grasses, agave, yucca blossoms, quail, rabbit, deer, and a wide range of edible nutritious wild seeds and greens—are used in both traditional and innovative preparations.

These foods are finding increasing appreciation with the greater public. And these foods and this culture provide opportunities for scientific study, learning, and practice as we enter an age of climate change. Ancestral knowledge is a source of health, not only for indigenous people, but also for our landscapes.

Just as our biodiversity of flora and fauna is at risk, so is the "biodiversity of thought." It is not enough for agricultural and food practitioners to simply interact and manage the landscape(s) as dictated by their discipline—be it farming, science, or cooking; it is just as important to have "biodiversity of thought." A curious and imaginative heart that senses themes of health, art, and indigeneity will help restore the health of both the land and all people. Landscape is the great educator of all people. This is the Ancestral Intelligence that must be protected, respected, sensitively utilized and supported by Native people, the original land advocates.

With that in mind, I, and other indigenous chefs across the country have been educating, demonstrating, promoting and serving our traditional and innovative dishes in restaurants and homes and at events and organizations. Soon after receiving my cook's certificate from Scottsdale Community College in 2000, I established the Native American Culinary Association, a network of Native American chefs, for this purpose, and in 2012 we held our first annual Indigenous Food Culture Conference where Native American chefs from Arizona, New Mexico, Utah, and other places demonstrated their fare and shared in public discussion on Native American culinary history. Last fall, the Arizona-Sonora Desert Museum hosted this event, entitled "Taste of Native Cuisine." This dinner and reception featured top chefs, including Dineh chef Walter Whitewater; James Beard award-wining author and chef Lois Ellen Frank; award-winning culinary historian Chef Loretta Barret Oden; myself, and others. The menu featured traditional and indigenous ingredients from across the Americas in nutritious and sophisticated dishes, and each chef spoke about their dishes. Each year, Desert Diamond Casino in Tucson also hosts a "Chef's Challenge," where several indigenous chefs compete for honors. While rare, Native American restaurants do exist: Desert Rain Café in Sells, Arizona; Kai, in Chandler, Arizona; Pueblo Harvest Café in Albuquerque, New Mexico, and Black Sheep Café in both Provo and Salt Lake City, Utah.

Native people are emerging from a great interruption in traditional foodways. Precontact, we were expert hunters, gatherers, fishermen, farmers, and cooks. Then came the reservations with high-fat, high-carbohydrate foods and a turn away from the most important ingredient in Native cuisine: healing. Native foods are not a trend—they are a way to recover our communities. ~ Nephi Craig, from *Edible Baja Arizona*, March 2014

As we look forward, we will see continued integration of indigenous foods in homes, community events, and in professional kitchens. We will see younger generations of indigenous land advocates emerge to carry out place-based expert work in food, science, medicine, and land management with the future of all people in mind. Right now, some of us are in a position of privilege to have access to education, safety, healthy food options or just food in general, but many of our Native people who are still oppressed spiritually, emotionally and physically by the bounds of colonialism do not have that food privilege. And, as our world struggles to meet the appetite of a growing population in a fragile global food system, we can all continue to benefit from the humble wisdom of indigenous food-ways, not only for physical health but also to invigorate the health of our minds and spirits. This is the power of respectful coexistence with landscape, people, and ancestral knowledge. S

Top left: Chef Neftali and Chef Sean preparing plates at the Taste of Native Cuisine event at the Desert Museum.
Lower left: Chef Arlie Doxtator in the Ocotillo Cafe , ASDM.
Cut outs above (from left to right): Yucca flowers; Pomegranate; Serrano chilies; Bellotas (acorns) pg 11. Bellota photo by Bill Steen.

N. Craig

M. Paganelli/ASDM

N. Craig

Evan Sung

IN MY *Dzilhga'a Kitchen*

Above left: Western Apache seed mix fritter.
Middle: Fruits of the land.
Above right: Dineh corn mush.

In my Dzilhga'a Kitchen on the Fort Apache Indian Reservation, we're an Apache team (with some Navajo/Dineh) producing food collaboratively in our sacred high mountains. We have a wide menu, based in a landscape from desert to mountain tops, including a wide choice of mindfully prepared local foods, like acorn stew and rack of rabbit. We have taken some things from the classical French culinary canon, but other things we've modified—for example, making our kitchen less hierarchical in a way that's more comfortable for us as Apaches. And we've sourced garden foods from The People's Garden, on the reservation.

We are focusing on the human aspect of food and cooking. A couple of years ago, we invited chefs from a culinary program on the Navajo Nation in New Mexico—from the same town that my late-father was from, the same place where I climbed the sandstones, threw rocks at my brothers and picked crystals out of the ground in amazement. The same places where Stinkbug speaks, where Monsters dwell in wait, where the darkness brings coyotes and trickery. This is Crownpoint, New Mexico. And we invited chefs from this program to come and be stagiers with us in the spirit of community building and revitalizing trade routes. They converged in our Dzilgha'a Kitchen for a few days in January. We talked about plate selection and intention. We talked about personalizing interpretation with indigenous foods and how we carry memory and embody culture. Our kitchen days were long and intense.

The following day our Apache culinary team and the Navajo chefs collaborated to produce our Chef's Table menu of 14 small courses—a plant-based menu with only small portions of salmon and rabbit. Often our Chef's Table dishes are a mixture of Family Style for sharing and individually plated dishes. We celebrate artistry of plating but also familial sharing of food among diners.

Suggested Readings and Resources:

Allen, Lee. "A New Spin on Native," *Edible Baja Arizona,* magazine. March 2014. ediblebajaarizona.com/a-new-spin-on-native

Craig, Nephi, blog: "Apaches in the Kitchen" apachesinthekitchen. blogspot.com/

Frank, Lois Ellen. *Foods of the Southwest Indian Nations*. Emeryville, CA: Ten Speed Press, 2002.

Neithammer, Carolyn. *American Indian Cooking*. Lincoln, NE: Bison Books, 1999

The Heritage of Ranching in the Sonoran Desert Region

Peter Warren, *Land Protection Specialist, The Nature Conservancy*

When we first took canoes down the Rio Bavispe in 1984, we never expected to meet someone like Enemecio. One day's paddle below the small farming community of Granados, Sonora, Enemecio's ranch borders the river above the mouth of the Rio Bacadehuachi. When we stopped to scout a route through a small rapid in front of his house, he came out and invited us up for coffee under his ramada. The original goal for our trip was to census bald eagles *(Haliaeetus leucocephalus)* and look for neotropical river otter *(Lutra longicaudis)* and other wildlife. But seeing Enemecio became the high point; he loves to share his knowledge of the land and wildlife. He also shares his love for his animals, the horses and cows on which he depends for his livelihood.

Enemecio Herrara is the steward of a way of life and of skills and knowledge that have developed for over 300 years in rural communities of the Sonoran Desert Region. In the later half of the 1600s Father Esuebio Kino and other Jesuit missionaries began moving into what is now the Sonoran border area, establishing a network of missions, along with herds of cattle and other livestock. By some estimates there were 100,000 head in the region by the late1690s, and cows, horses, goats and mules have been a cornerstone of the agricultural economy of the region ever since.

The skills that are needed for animal husbandry are remarkable, and traditionally, on small rural ranches, the tools of the trade were locally made. In fact, all of the gear Enemecio uses he made himself: his saddle, with wood from a local tree and leather from his cows; his reins and riata woven from rawhide; even his shoes and chaps. Using gear he made, on the horse he trained, he can gallop across steep, rocky hillsides that are difficult to walk on without falling on loose rocks, let alone catch a wild cow. Some of my fondest memories of our dozen or so Rio Bavispe trips are of visiting with him over coffee at the campsite. As a conservationist, however, I have a complicated relationship with Enemecio, as I do with the ranching community as a whole.

What makes the relationship between conservation and ranching complicated is that although there are parts of the Sonoran Desert where grazing does *not* belong, there are other places in the region where ranchers are our best conservation partners. The grasslands that ring the edge of the Sonoran Desert to the north and east are part of the North American grassland ecosystem that extends from here across the Great Plains. Our desert grasslands are some of the most intact in North America, with places such as the Big Chino Valley on the upper Verde River, the upper San Pedro Grasslands in Sonora, the San Rafael Valley on the Arizona/Sonora border, and the Animas Valley to the east providing a network of habitat for many grass-dependent species, like pronghorn *(Antilocarpa americana),* various rodents, and birds—especially migratory grassland species like Baird's sparrow *(Ammodramus bairdii),* Botteri's sparrow *(Peucaea botterii)* and loggerhead shrike *(Lanius ludovicianus).*

Worldwide, temperate grasslands, which include our desert grasslands, are the most depleted and least protected of any major ecosystem. As conservationists struggle to protect native grasslands, we have found that here, as well as throughout the West, ranchers are our most important partners in managing and restoring native grasslands. But ranchers make controversial partners.

Ranching is viewed by some in the conservation community as being incompatible with conservation of biodiversity. This is largely the result of its early history in the Southwest. When the big herds were brought here from Texas in the 1870s and '80s, southeast Arizona was described as a "sea of grass." By about 1890 there were an estimated 1.5 million cattle in Arizona, of which about one-third grazed in southern Arizona. Then, from 1891 to 1893 an intense drought hit, and as many as three-quarters of all cattle in the region starved to death. The early settlers were simply not prepared for a catastrophe of that scale, and damage to the land was severe. Livestock numbers have never been that high again, and the number of cattle on the range has declined steadily since the first formal census in the 1920s. Although the ranching community has made tremendous progress in learning how to manage grazing sustainably, the events of more than a century earlier still cloud public opinion.

In spite of the public controversy surrounding ranching, it remains a cornerstone of the rural economy in Arizona, and to an even greater extent in Sonora. The market value of cattle ranks third largest of all agricultural commodities in Arizona, accounting for almost twenty percent of Arizona's agriculture sales. And local beef and other meats are still a favored source of nourishment on millions of dinner tables. Sonora is recognized throughout Mexico as a major livestock producer, and is known especially for traditional Sonoran style *carne asada*. What changed is that ranchers increasingly see themselves as stewards of the natural resources and wildlife of the land.

Rancher-led community organizations are leading the way in the conservation of large landscapes. Organizations like the Malpai Borderlands Group and Altar Valley Conservation Alliance are bringing neighbors together to accomplish land protection and grassland restoration on a scale that no other conservation organization can approach. The Malpai Group is working to protect a million acres reaching east from the Chiricahua Mountains across the state line to the Animas Mountains in New Mexico.

Background photo: Grassland at the base of the Peloncillo Range, on the eastern edge of the Sonoran Desert Region.

Blake Gordon/TNC

Cut out: Enemicio Herrara, rancher/cowboy in Sonora, Mexico.

Peter Warren


Peter Warren

Above: Los Fresnos cienega Sonora, Mexico.

Below: Using prescribed fire to manage shrub encroachment on grassland on Los Fresnos Ranch.


Peter Warren

Their goal is to prevent subdivision of the valleys and to restore healthy grassland for ranching and wildlife. The Altar Valley Alliance has similar goals for the 600,000-acre watershed of the Altar Valley, which flows from the Mexico border at Sasabe to virtually the doorstep of the Arizona-Sonora Desert Museum. The view to Baboquivari Peak from the ASDM veranda is being protected by this partnership of ranchers.

Long-term conservation success at this scale requires two things: keeping the land whole and keeping the land healthy. Both of these groups are pursuing these goals. Faced with a trend toward the loss of ranches sold and subdivided for development, they are employing innovative land-use agreements called "conservation easements" that prevent subdivision. This keeps the land open for wildlife as well as for grazing rotations. Also, many years of fire suppression have stopped the natural cycle of fires that controlled shrub encroachment in the grassland, and grassland habitat continues to be lost to shrubs. Reversing this trend takes active intervention. So, the community groups are experimenting with different approaches to grassland restoration through prescribed burning and other shrub-control methods. It is no coincidence that the only places in the United States where jaguars have been seen recently are where groups like these have been working to keep landscape connections open and the land healthy. Cooperative ranchers in Sonora, near the Northern Jaguar Reserve, also participate in the protection of jaguar and other wildlife in wild lands.

As we face a future with unpredictable conditions due to changing climate, there are many things that we can learn from, and collaborate on, with ranchers in trying to adapt. Climate models predict that the Southwest is likely to get warmer and drier, which would make life more difficult for ranchers. But living close to the land, ranchers must observe and respond to shifting conditions, and even advise us of on-the-ground impacts of climate changes.

Looking to the future, it is clear that ranching will need to adapt to unforeseen economic and environmental conditions, with practices informed by new knowledge and consumer preferences. But it is also clear that ranching will remain an integral part of the heritage of the Sonoran Desert for years to come, sustained by people who love the land and who love a way of life that is close to the land.

Suggested Readings and Resources:

"Seeds of Change: The Legacy of Father Kino," *Sonorensis*. Tucson: Arizona-Sonora Desert Museum, 2007.

Sheridan, Thomas E., *Where the Dove Calls – The Political Ecology of a Peasant Corporate Community in Northwestern Mexico*. Tucson: University of Arizona Press, 1988.

"This area [5 southern Arizona counties around Tucson] . . . has 2,350 farms and ranches covering 930,000 hectares, including 49,000 hectares of irrigated cropland. Annually, these producers sell $122 million of crops and $73 million of livestock and products. The 43 community gardens, 12 school gardens, and thousands of home gardens in Tucson also play roles in the informal food economy." – excerpted from the City of Tucson's application for UNESCO designation as a City of Gastronomy, 2015.

Conservation Ranching in Sonora

Sergio Avila, *Conservation Research Scientist, ASDM*

In northwest Mexico, ranching is a land-based way of life with strong connections to Sonora's economy, culture, and cuisine. However, older generation ranchers are seeing that many in the younger generations don't want to continue ranching. They are moving to the cities, leaving some properties abandoned or understaffed and the ranches unable to maintain cattle production. Additionally, ranchers recognize that drought and extreme weather conditions are adversely affecting cattle grazing. For these reasons (climate change, lack of interest), they are looking for alternative sources of work and income to continue their ranching traditions. One of these alternatives is "voluntary land conservation"—a program in the Mexican government's protected lands system, in which landowners maintain stewardship of their land with certification from Mexico's national Commission of Natural Protected Areas. In Sonora, in addition to the effort of conservation organizations, there are a growing number of ranchers (including at El Aribabi) and *ejidatarios* (common land shareholders, including some in the Sierra Huerfana—Moctezuma and Pueblo de Alamos) who have voluntarily gone this route to protect their lands, simultaneously protecting a diversity of life living there, including jaguars *(Panthera onca),* ocelots *(Leopardus pardalis),* golden eagles *(Aquila chrysaetos),* military macaws *(Ara militaris),* and Sonoran cycads *(Dioon sonorense).*


Peter Warren

Above: Cattle watering at sunset in Rio Sahuaripa, Sonora.

Below: Grasslands in the Whetstone Mountains, Empire Valley, Arizona.


Peter Warren

THE VITAL LINK *between* BEES AND FOOD

Stephen Buchmann, Ph.D.
Adjunct Professor, Entomology Dept. and Research Associate, Ecology and Evolutionary Biology Dept., University of Arizona, and Research Associate, Arizona-Sonora Desert Museum

Photography by ***Jillian Cowles,*** *unless otherwise noted.*

Sweat bee *(Lasioglossum sisymbrii).*

The Sonoran Desert is home to rich communities of flowering plants and their pollinating animals. Tucson itself lies in a biodiversity hotspot where organisms from all directions converge on the floral resources of this unusual desert biome and its Sky Island archipelago. Bees are particularly diverse here: approximately 1,300 species of ground- and cavity-nesting native bees—a mix of mostly solitary but also social forms including native bumble bees and introduced Africanized honey bees—live in the state of Arizona, many of these species extending into northern Sonora, Mexico. (We have no good estimate of the number of bee species in the Sonoran Desert Region only, but it could easily be 700 species). Currently, research on native bees and other pollinators is being conducted at the University of Arizona in Daniel Papaj's and Judith Bronstein's laboratories as well as in my own. One avenue of our research addresses how bumble bees and other bees determine if pollen is present in flowers like deadly nightshades *(Solanum* spp.) and garden tomatoes, which must be buzz-pollinated (see page 18). In one project, researchers investigated whether a floral scent could "back up" a floral color signal attracting nectar-foraging bumble bees. (It did, but with plenty of caveats.) Daniel Papaj, Anne Leonard at University of Nevada Reno, and I are now working under a National Science Foundation grant on the evolution of multiple awards in flowers and learning behavior in bumble bees. At the Desert Museum, researchers are working to document and promote the diversity of native bees found in our urban habitats.

Here in the Sonoran Desert, several of our important desert bee plants bloom twice a year. At lower elevations the omnipresent creosote bush *(Larrea tridentata)* has both spring and summer blooming periods, and *about 120 different species of native bees make use of the creosote's bounty of pollen and nectar.* Our mix of spring- and summer-blooming annual, biennial, and perennial plants provides food and shelter for a plethora of flower-visiting birds, bats, and insects.

CHAMPION POLLINATORS

However, I consider bees the champion pollinators of our desert and home-garden plants. What makes them stand out? Diversity is a key consideration; taxonomists have described 21,000 species globally with many yet undiscovered. Bees have been around since the time of the dinosaurs, having diverged from a sphecid wasp ancestor at least 100 million years ago, and have co-evolved with flowering plants during this same period.

Distinguished from wasps by their pollen-capturing branched hairs, bees are pollen transporters par excellence, often aided by attractive electrostatic charges acquired during flight. Oily and spiny pollen sticks to bees as they forage. Before flying that haul of pollen back to the nest for their progeny, they will groom, and almost all pollen is swept from their bodies. Nevertheless, a tiny but key fraction lodges in "safe sites" (e.g. between the leg bases, under the proboscis, or midline of thorax) and later these grains are inadvertently rubbed off onto floral stigmas, resulting in pollination, and, thus, the formation of fruits, vegetables, legumes, and other edibles. Worldwide, bees help produce roughly one-third of the human diet. Bees and masarid wasps are the only animals that actively collect pollen to feed their brood.

Furthermore, Sonoran Desert bee species come in a multitude of sizes and lifestyles, from the diminutive *Perdita minima,* to the large black-and-yellow social bumble bees—at low elevations, *Bombus pennsylvanicus.* Although exact numbers for their full range are hard to estimate, we know that this bumble bee is only now recovering from abnormally low populations, at least within city limits, presumably due to competition for nesting substrates with high numbers of Africanized honey bees. (Imagine how difficult it would be to know how many ground or cavity-nesting bees emerge annually from even a single hectare of desert land. Thus, although there are likely billions of the various native bees living within the Sonoran Desert, we don't have good numbers on their populations, and whether they are stable or fluctuating.)

Of the Sonoran Desert bee species, some are generalists serving many flowers, while others specialize on just a few kinds. About 90% of these species are solitary, not social like bumble bees, honey bees, and some sweat bees. Our desert bumble bee *(B. sonorous)* is a large, elegant black and yellow hairy bee. Several species of shiny black carpenter bees are equally massive. They nest in dead wood, such as urban Chinaberry *(Melia azedarach)* trees, or in *Agave, Argemone, Dasylirion, Senna,* and *Yucca* in desert habitats. Carpenter bees will pollinate flowers of garden vegetables, including eggplant and other nightshades. Their pollinating activities outside of cities include *Argemone, Parkinsonia, Olneya* and *Passiflora,* among others, whose fruits provide food for mice, ground squirrels, and other animals. Other prominent species in the Sonoran Desert include: leafcutter bees *(Ashmeadiella, Megachile, Lithurgus),* mason bees *(Osmia),* sweat bees *(Agapostemon, Augochlorella, Dialictus, Halictus, Lasioglossum),* carder bees *(Anthidium),* plasterer or cellophane bees *(Colletes),* digger bees *(Anthophora, Centris)* and the squash and gourd bees *(Peponapis, Xenoglossa).* Mason bees are excellent pollinators of sweet cherries, while sweat bees may pollinate chile peppers and tomatillos. The squash and gourd bees are excellent pollinators of zucchini squash, various gourds, and pumpkins.

Digger bee *(Anthophora californica).*

Check out Pollinator Hotspots, the Desert Museum's bee-focused citizen science program, to see how you can contribute to a better understanding of the status of native bee populations in Tucson. *(https://www.desertmuseum.org/center/hotspots/)*

Keith Brust

GOOD, GOOD, GOOD VIBRATIONS!

Your tomato and eggplant crops benefit from female bees that literally turn themselves into living tuning forks; they produce sonic vibrations that eject pollen from flowers with small apical holes in their anthers instead of the usual larger slits (about 6% of the world's flowers have these small holes). Locally, female bumble bees *(Bombus* spp.) and *Anthophora* are the main species we see making morning visits to tomato and eggplant blossoms in our gardens. Their sonic vibrations eject the pollen, making these bees effective pollinators. Watch for them.

Research shows that bee-pollinated blossoms produce more consistently large tomatoes than those from hand-pollinated or wind-jostled and pollinated blossoms. If you grow zucchini, pumpkins, or gourds, their essential bee pollinators may be nesting underground beneath your pumpkin patch. Females of squash and gourd bees *(Peponapis, Xenoglossa)* only visit flowers of sundry cucurbits (the family of plants including squashes and gourds; some cucurbits are parthenocarpic, i.e., self-pollinating). Look for these bees flying from blossom to blossom in the early morning. Their amorous males search flowers for mates, and contribute greatly to overall pollination. Later in the day the flowers wilt, sometimes enshrouding a male squash bee sleeping within. Give the collapsed flowers a pinch. If it buzzes back, there's a male bee inside. Don't worry, male bees cannot sting.

LENDING A HAND

Dramatic losses of honey bee colonies worldwide have been a serious concern for ten years now, with significant costs for almond farmers and others. The most recent evidence indicates that neonicitinoid insecticides are having negative effects on honey bees, and may also affect other pollinators. Honey bees are also suffering from ever-dwindling areas of wildflower "bee pastures." And it isn't just honey bees that are losing ground. At least four species of bumble bees native to North America are also declining, although their demise is likely due to introduced European pathogens. Franklin's bumble bee *(Bombus franklini),* of the Pacific Northwest, may be the first bumble bee to become extinct.

However, we can take positive steps to help bees, the Sonoran Desert, and our gardens by doing a few simple things. (1) Plant for bees using low-maintenance, drought-adapted flowering desert plants, or heirloom varieties of flowers or vegetables (which often have more nectar and pollen than modern hybrids). (2) Don't use broad spectrum pesticides or herbicides if possible. (3) Most bees are ground-nesters, so leave patches of bare ground where females can nest. *(Diadasia* spp., which are dedicated pollinators of sunflowers, mallows, cacti, and a few other families, are among the most common ground-nesting bees in the Sonoran Desert.) Please don't mulch over everything; bees don't like thick surface mulch and cannot penetrate weed barrier or plastic. (4) A few mason bees *(Osmia* spp.) use mud as building materials, so a patch of mud would be great for them (justification for not fixing that outdoor drippy faucet). (5) Finally, you may be able to provide manmade nesting sites. Do you find little circles cut out of leaf edges especially on roses? These circular excisions are the work of female leafcutter bees *(Megachile* spp.), which preferentially visit and thereby pollinate palo verde and ironwood trees in the Sonoran Desert, along with some garden legumes. You can provide nesting sites for these fascinating bees by drilling 7–8 mm diameter and 5–7 cm deep holes in scrap lumber and nailing these "bee condos" under the eaves of your home or another building. Far better than reality television, the inhabitants of these mini bee domiciles make great watchable wildlife and "pollinator pets," as well as excellent student and scout projects. Leafcutter bees, while capable of stinging, don't come after people; they are among the gentlest of bees, and Africanized honey bees will not live in these structures. If you have a pair of close-focusing binoculars you can watch bees on flowers without disturbing them. Become a native bee advocate, or citizen scientist, and join one or more of these national bee conservation groups (www.pollinator.org, www.xerces.org, www.greatsunflowerproject.org). You'll be glad you did. ■

Suggested Readings and Resources:

Buchmann, S. *The Reason for Flowers: Their History, Culture, and Biology, and How They Change our Lives.* New York, NY: Scribner, 2016.

Buchmann, S. "Bees," in *A Natural History of the Sonoran Desert,* 2nd Edition, edited by M. A. Dimmitt, P. Comus, and L. M. Brewer. Tucson, AZ: Arizona-Sonora Desert Museum Press, 2015.

Chambers, N., Y. Gray, and S. Buchmann. *Pollinators of the Sonoran Desert: A Field Guide.* Tucson: AZ: Arizona-Sonora Desert Museum Press, the International Sonoran Desert Alliance, and The Bee Works, 2004.

Top left: Squash and gourd bee *(Peponapis* sp.).
Inset photo: Leaf-cutter bee *(Megachile inimica sayi)* on a creosote flower.
Lower left: Bumble bee *(Bombus)* buzzing pollen out of nightshade flower *(Solanum tridynamum)* in Dan Papaj's laboratory.

Top Right: Leaf-cutter bee *(Megachile centuncularis).*
Lower right: Cactus bee *(Diadasia rinconis)* one of many ground nesters.
Cut out: Sweat bee *(Agapostemon).*

KINO HERITAGE FRUIT TREES PROJECT

FROM HISTORICAL DOCUMENTATION TO A *Way of Life*

Jesús García, *Education Specialist, Arizona-Sonora Desert Museum*

Photography by ***Deena Cowan***

Above: Mission Garden Seville oranges.

When Jesuit missionary Eusebio Kino arrived in the arid northwest territories of New Spain in the late 17th century, he brought with him seeds, cuttings, and livestock from the Old World. As he established new missions he carried these for the indigenous people, lay folk and clergy to cultivate at each new mission. Other Jesuits and, later, Franciscans, followed suit, rooting stock of a wide variety of fruit trees and vines carried across the ocean from the Mediterranean region—including quince, pomegranate, grapes, sweet lime, figs, pears, peach, apricots, and apples. Some are distinctly different from those we are familiar with—a different color, flavor, sweeter, or less bitter—and these heritage varieties are not found in modern supermarkets. They were largely lost in abandoned orchards or backyards on both sides of the border.

Since its beginnings in 2004, the Kino Heritage Fruit Trees Project has focused on researching, locating, and re-establishing these colonial era trees from Spain and elsewhere around the Mediterranean. It helped re-establish the first heritage orchard at Tumacácori National Historical Park in 2007, then planted the orchards at Tucson's Mission Garden in 2012 (the Mission Garden now contains more than 120 trees and 2 dozen grapevines) and, more recently, a *huerta,* or orchard, at the Curley School in Ajo, Arizona.

Over the years, however, the project has expanded from an effort to document and recreate historical orchards to include the goal of enriching food and gardening choices for our communities and the taste for these fruits has been spreading as young and old sample them at local festivals and farmers' markets. With more exposure, demand for trees has grown and the small stock always sells out early at the Desert Museum's Fall Plant Sales—with the most popular being pomegranates, figs, and quinces. The proud caretakers of these trees are part of an ongoing horticultural experiment to refine propagation and maintenance techniques, and to find out which varieties do best in different microclimates and soils.

Even school children are in on the action. Students at Tucson's Manzo and Davis Bilingual Elementary Schools, as well as Mansfeld and Roskruge Middle Schools, have been testing different soil media and methods for propagating and cloning trees, and developing an appreciation for the wide array of fruit tastes and qualities not found in regular supermarket varieties. The variety of heritage pomegranate fruits we have harvested is less tart, soft seeded, and the arils (seeds) are white. The quince fruit is a little sweeter, and is good to eat raw.

Simultaneously, conservation work continues. Working with Organ Pipe Cactus National Monument and the El Pinacate Biosphere Reserve World Heritage Site, the Desert Museum is hoping to save heritage fruit trees that once flourished at Quitobaquito Springs in the Monument. Cuttings from the last remaining pomegranate and fig trees at Quitobaquito are being propagated at Desert Botanical Garden in Phoenix and at the Desert Museum, where they are being held in reserve for future restoration needs. A Quitobaquito pomegranate and fig were planted at the Mission Garden in Tucson last year, and are flourishing. Stock from both is scheduled for planting at Organ Pipe Cactus National Monument's visitor center.

The idea, the cultivars, and the tastes, are catching on. In the fall of 2015, staff from the Pinacate Biosphere Reserve made several trips to Magdalena de Kino and San Ignacio, Sonora, to collect seedlings for their new ethnobotanical garden. Heritage fruit trees (including, quince, pomegranate, peach, fig, and apricot) at their research station are now part of an educational tour on the history and value of ethnobotanical gardens, as well as the contribution of Padre Kino to regional cultures.

As more Kino trees become available, the fruits of this project are moving off the page of historical documents and onto people's taste buds. Sampling the variety of pomegranates that grow in this area alone (USDA holds stock of more than 200 varieties of pomegranate) and comparing them to mass-market varieties offers a visceral lesson in the value of biodiversity in both food systems and ecosystems more broadly. Should you want to bring some of this biodiversity home, you can purchase trees at the Desert Museum's next Fall Plant Sale or at the Mission Garden or Desert Survivors Nursery.

For background on Jesús's and ASDM efforts in the Kino Heritage Fruit Tree Project, see: "Seeds of an Era Long Gone" by Michael Tortorello in the *New York Times,* 11/21/15. *http://www.nytimes.com/2012/11/22/garden/in-tucson-a-search-for-fruit-the-missionaries-knew.html?_r=0*

For more project background see: *Seeds of Change: The Legacy of Father Kino.* "Tasting History: The Kino Heritage Fruit Trees Project" by Jesús M. García and Robert M. Emanuel. pg 37, Sonorensis 2007.

For Jesús's journey, see: Vimeo video "Tasting History," https://vimeo.com/52716148

Top: The Kino heritage fruit trees are mainly propagated as clones of the mother tree, generation after generation. By cutting off a section of branch, and planting it in the soil, a sapling will grow. Here, students and a volunteer (far right) from Manzo Elementary School propagate figs, pomegranates, and quinces with Jesús García (third from right).

Middle: Mission Garden with pomegranate trees in flower.

Bottom: Tumacácori Mission Orchard.

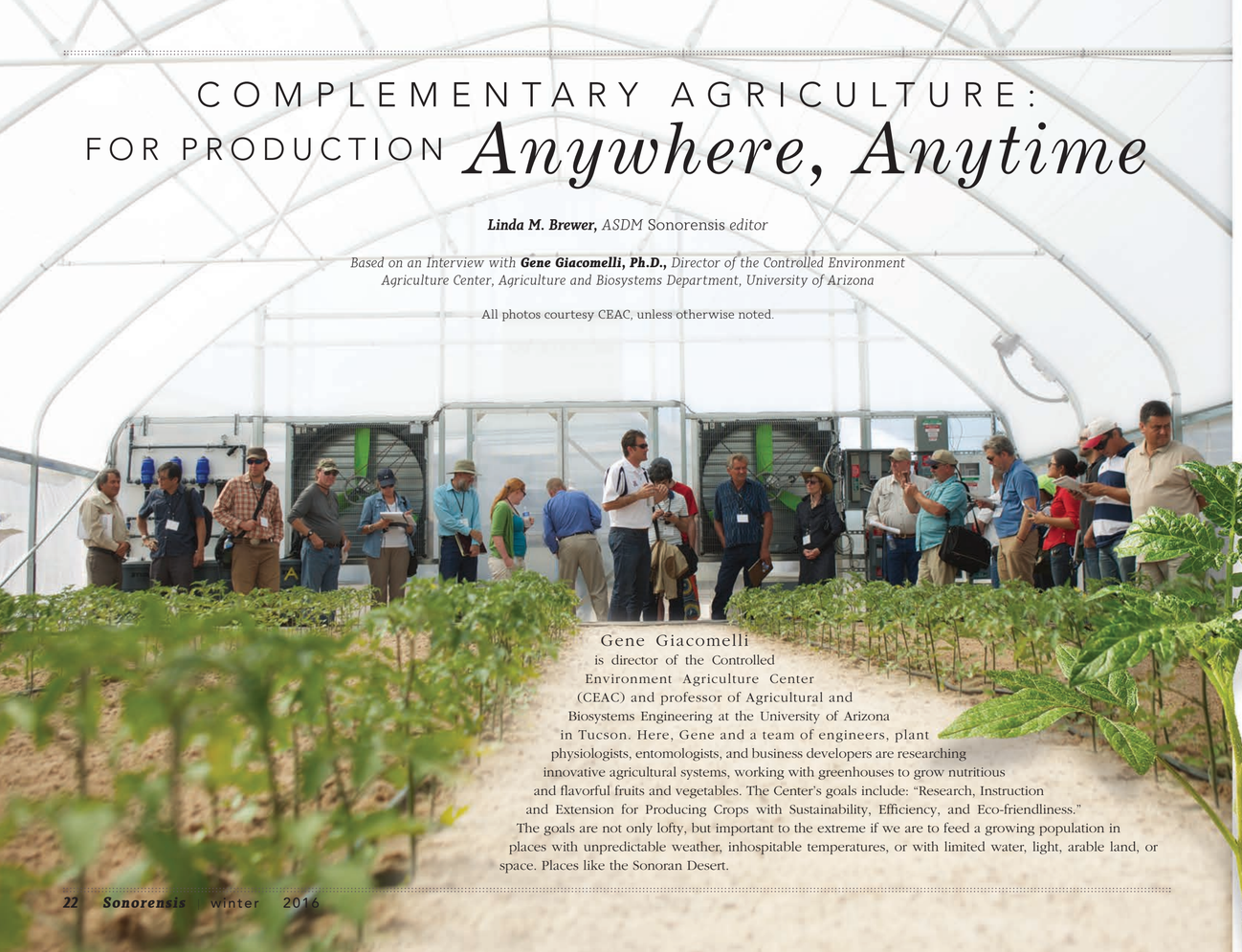
Cut out: Immature pomegranate fruits developing from the flowers.

COMPLEMENTARY AGRICULTURE: FOR PRODUCTION *Anywhere, Anytime*

Linda M. Brewer, *ASDM* Sonorensis *editor*

Based on an Interview with ***Gene Giacomelli, Ph.D.,*** *Director of the Controlled Environment Agriculture Center, Agriculture and Biosystems Department, University of Arizona*

All photos courtesy CEAC, unless otherwise noted.



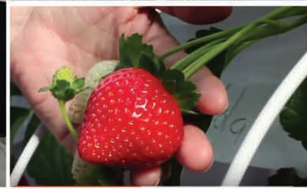
Gene Giacomelli is director of the Controlled Environment Agriculture Center (CEAC) and professor of Agricultural and Biosystems Engineering at the University of Arizona in Tucson. Here, Gene and a team of engineers, plant physiologists, entomologists, and business developers are researching innovative agricultural systems, working with greenhouses to grow nutritious and flavorful fruits and vegetables. The Center's goals include: "Research, Instruction and Extension for Producing Crops with Sustainability, Efficiency, and Eco-friendliness." The goals are not only lofty, but important to the extreme if we are to feed a growing population in places with unpredictable weather, inhospitable temperatures, or with limited water, light, arable land, or space. Places like the Sonoran Desert.

This summer, Gene spoke to me about the nature of controlled environment agriculture, where it came from and where it's going. "Traditional open-field production agriculture in the late 20th century used irrigation, big sprinklers, a lot of energy, and a lot of nitrogen fertilizer. People worried about it not being sustainable, or worse, that it would damage the environment." In response, agriculturalists and engineers developed "precision agriculture," still in the open field for staple crops (corn, soybean, etc), but with computers and sensors to monitor plants, water, and chemicals applied, with much more efficient use of resources and with improved crop production. Take that another step ahead, and today you will find "precision controlled environment agriculture," which complements field production for producing safe nutritional foods (such as leafy greens, tomatoes, sweet peppers) using greenhouses (with sunlight) or growth rooms (with electrical light) at greater annual production rates than in outdoor seasonal fields.

The simplest are inexpensive "hoop houses"—greenhouses constructed of bent piping spanning as little as 14 feet and covered with inexpensive clear plastic film at an overall cost of $5–6/sq ft of growing space—in which the crop is grown in soil (the Earth), and protected from harsh winds and rain. At the other extreme are glass greenhouses in which sensors and computers monitor and record details for future reference—increasing knowledge through "big data" analyses. In such higher-end greenhouses ($20–50/sq ft), computers automatically monitor ambient and plant conditions to operate hydroponic (soilless growing) and environmental systems as sensors detect plant needs—lights, water, humidity, fertilizer, air temperature, and even harmful plant disease—and, in combination, increasing food safety.

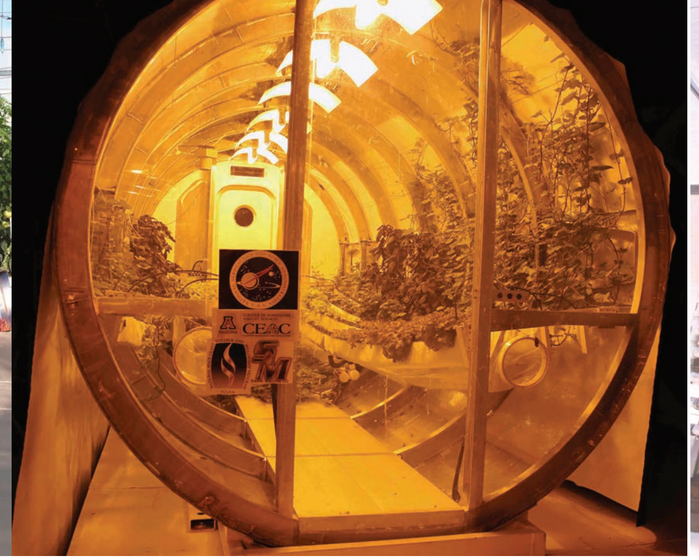
Today, a tiny, but growing share of indoor production uses hydroponic installations with vertically stacked rows of plants whose roots never touch soil, where workers wear gloves and hair nets to assure the produce remains free of human-carried microbes or outdoor contamination. In hydroponic farming, unused water can be collected and recycled; in some cases, Gene notes, requiring 90% less water to grow the crop than in traditional outdoor soil farming. And there are hydroponic/aquaponic installations where cultivating plants organically is complemented by fish farming. One current experiment at the CEAC involves direct re-use of drainage from the tomato greenhouse in the lettuce greenhouse. Lettuce, he informs me, is "less picky" than tomatoes about nutrients.

Re-using and recycling water, heat, plant waste, and such is a necessary goal. Efficiency in resource use, with the increased productivity that controlled environments offer, reduces environmental discharge and increases sustainability. A win-win-win.



Left hand page: Dr. Murat Kacira teaching greenhouse short course at UA CEAC greenhouses. Top left: Students planting in teaching greenhouse. Top right: Dr. Kubota inspecting experimental strawberry crops. Below top right: Strawberries raised for flavor and eating in Kubota lab at CEAC. Middle left: CEAC greenhouses. Middle right: Myles Lewis demonstrating hydroponic lettuce systems. Bottom: Dr. Kacira uses 3DCFD models to view climate uniformity.

Above: Student tomato plantings in the teaching greenhouse at CEAC.



Above left: Plants grow under bright light in controlled experiments inside the Lunar Greenhouse at CEAC. Partners in this program include, UA/CALS/CEAC, NASA and Sadler Machine of Arizona.
Above right: Hydroponic lettuce growing on a vertical A-frame.

Here, Gene points out that because the delivery of light, water, and nutrients can be tailored to the needs of each particular plant species, this system of farming can dependably produce efficient harvests for better food—by which he means better taste, better nutrition, more sustainably grown (less fertilizer and less water).

You might wonder, as I did, about the cost of all that energy to monitor, heat, and cool. It turns out that innovative people are moving this high-tech agriculture toward appropriate designs with sustainable energy use and increasingly efficient production. As a general rule, Gene notes, you can get ten times the yield per year in a greenhouse over the same area of traditional soil farming, and you have far fewer losses, consistent top-quality crops, and an extended (or continuous) growing season. The amount of energy consumed for successful crops reveals a system less energy-consumptive per unit of edible produce than one might imagine.

What, where, and who?

It is estimated that super-high-tech greenhouses currently cover between 600 and 700 acres in the United States (of a total 2300 acres of greenhouses producing vegetables). In Arizona alone, there are more than 300 acres (of a total 800 acres). In the Sonoran Desert Region, most of those acres are owned by NatureSweet, which grows tomatoes in Willcox. Another major player is Wholesum Family Farms, which has farmland and greenhouses near Hermosillo, Sonora, and just north of the border in Amado, Arizona. Here, in greenhouses with hydroponic systems, they cultivate organic tomatoes and sweet peppers. One third of their electrical consumption is produced by their solar energy system.

Gene points out that "locally grown, urban agriculture is the newest complement following greenhouse/indoor crop production and outdoor field production agriculture." And, he says, the locally grown movement has favored the greenhouse industry, and vice versa. Small farmers have begun to supplement open fields with greenhouse crops for off-season and extended seasons.

He spoke of one company that harvested an average of 600,000 pounds of tomatoes a day in a 300-acre glass greenhouse. Each day! Generally speaking, he said, you can get significantly higher yields because you have fewer losses—you get almost 100% first quality, and you can grow when they can't grow in the open field.

Of course, not all crops lend themselves to growing in enclosed environments. According to a study by the University of Arizona, agriculture in this state is a $17 billion industry, growing 250 crops. Grains and other such crops are more practically grown in traditional soil fields, stored, and shipped. Right now, the crops grown in CEA are fresh produce: mainly tomatoes, cucumbers, peppers, and lettuce. Small-headed lettuces are popular because growers can turn over a crop every 30 days. Now microgreens, baby lettuce, baby kale, and such are also gaining popularity, and these are ideal for hydroponic cultivation and harvest. People are going after nutrition, roughage, quality, and freshness.

Artificial light

A new branch of CEA focuses on growing indoors using only artificial light. According to an article in the *New York Times* last summer, Aerofarms in Newark, New Jersey, uses internal lighting systems combined with closed loop irrigation systems that consume 95% less water than farms with conventionally cultivated crops. The owner of Aerofarms explained, "Using light-emitting diodes [LED lamps] instead of sunlight means that a growing cycle takes about two weeks, allowing for up to 30 harvests a year."

Historically, lighting has been expensive, but that is changing, and there is a great deal of research being done to make it more cost-effective, including at the CEAC. Last summer, they constructed a fully enclosed, insulated building in which there will be multi-layered lighting. With some microgreens, Gene says, you don't even have to turn the light on until the last day or two. The greens use energy from the seed to sprout and retain all their natural genetic nutritional value. They get the color—the red, purple, black, true green—with just a little bit of light in the last few days. Fast turn-over and delivery to a local consumer increases the energy efficiency. No soil needed. No water wasted. When provided with the right environment, they are nutritious, tasty, clean, and fast.

Another factor when comparing CEA to traditional farming systems is the supply chain from super-sized typically monocultural farms, which depend on huge markets, often at great distance, while local greenhouses are apt to source nearby markets, including small groceries and farmer's markets.

Fortunately, more and more efficient systems are being created. Gene spoke of Houweling Family Farms, which recycles heat energy from its own refrigeration equipment, from solar thermal, and from other sources to heat its green-

houses. At one site in California, owner Casey Houweling collected rainwater and stored it in a pond for use. Over the pond he installed solar panels, which shielded the pond water from evaporation and generated electricity. And, he recently built a CEA system in Utah next to a facility, where he could get recycled waste heat.

At the CEAC, Dr. Murat Kacira has a new research project in which photovoltaic cells are being sewn in to a plastic film that will cover a greenhouse. That project got underway this fall. Gene and the CEAC team also oversee the "Lunar Greenhouse" for NASA. In this totally enclosed cylinder, they grow plants, harvest them, and measure all the electricity put into the process. Gene smiled. "No one is doing it yet, but they will be. You've seen electrical efficiency ratings on appliances by underwriter laboratories or the EPA? Well, we will do that with all our crops, and particularly for this NASA project for the moon. How many grams—that is, what weight of edible food—is produced per kilowatt-hour of electricity needed to grow the food? That's the bottom line."

More and more people are adopting CEA. Many growers are electing to add simple hoop greenhouses to their existing outdoor farms to extend the growing season for a small acreage. Since 2005, the USDA has been supporting these small commercial farms with grants for CEA extensions. Then, with the local agriculture movement, have come the new, "non-farmers"—people who want to know how the crops are grown, who begin to do it for themselves and start selling at farmers' markets. Gene observes, "Once you get the routine down, it's a lot easier to grow in a controlled environment than in the open field, where you're not sure what the next storm is going to bring." Which brings up climate change: "Outdoors, we don't know what's going to happen 10 years from now. Indoors, we do."

The advantages are evident. The ability to control optimal water, nutrient sources, and ambient conditions in an enclosed space allows these foods to be grown in areas not naturally conducive to certain types of food crops—like much of our Sonoran Desert Region. While traditional soil farms with increasingly sophisticated precision-water-delivery systems will continue to serve a need for many types of staple foods, and while native fruits, vegetables, and legumes can provide another food source in our region, with the growing population, and in the face of climate change, we will need to use every agricultural approach, where appropriate, to responsibly feed the people of our region and other regions around the world. S

Suggested Readings and Resources:

New York Times, "How Does This Garden Grow? To the Ceiling," by Tammy La Gorce, July 22, 2016.

Controlled Environment Agriculture Center, Agriculture and Bio-systems Department, University of Arizona: http://ceac.arizona.edu/

Top left: Attendees at CEAC's Annual Greenhouse Short Course perusing a hydroponic A-frame of lettuce. Top right: Mix of seedlings; beet root, arugula, green coral, and green lettuce. Left: Sweet peppers. Cut out: Lettuce seedling.

L.M. Brewer

The Cindy Garden and Farm Coop table at St. Philips farmers' market. Here, produce-farm broker Cindy Williams sells organic produce from farms in southern Arizona, as well as a small selection of organic fruits from further afield.

Know Your FARMER?

Linda M. Brewer, *ASDM* Sonorensis *editor*

We could hardly talk about food in the Sonoran Desert without talking about locavores and the "locally grown" movement that has swelled to encouraging proportions in this region. People like Barbara Kingsolver, Wendell Berry, Michael Pollan, Richard Felger, and Gary Nabhan have long been riding a wave of innovative alternatives to a food system/ecosystem in need of help—from diversity of products, to production, to harvest, to delivery.

Since then, farmers' markets have become ubiquitous here and across the United States, offering heritage varieties of tomatoes and other fruits and vegetables raised locally, as well as organic, pasture-raised meats from nearby ranches. In addition to farmers' markets, locally farmed and organic fruits and vegetables have become available through "community supported agriculture" (CSA), a farming business model that began in Japan and spread to the States in the late 1980s. In this model, consumers typically pay in advance and pick up a pre-determined share of in-season produce delivered by local farmers once a week. New shareholders may find produce they have never eaten or prepared—amaranth, portulaca (purslane), cushaw squash, and other native and heritage species like those saved by Native Seeds/SEARCH—as well as familiar market veggies like corn, tomatoes, chiles, melons, potatoes, lettuce, beets, carrots, radishes, onions, cauliflower, cucumbers, etc.

Some farmers' markets and some CSAs also sell meat from ranches in the local foodshed focused on sustainable, free-range grazing, or pasture-raised livestock like Chiricahua Pasture-Raised Meats near Willcox, where Josh Kohen and his brother Steve raise cattle, pigs, chicken, turkeys, and sheep. Some farmers' markets and CSAs also sell local eggs, cheeses, and breads. Don Guerera, who bakes his "Barrio Bread" in Tucson, uses a high percentage of local Durham wheat, a heritage wheat better adapted to drylands, and uses a traditional slow-rise, natural yeast process. There are drawbacks to these local models, of course, because the food palette is more limited by season. But choosing "local," as much as possible, is about balancing practicality, preference, and sustainability. Luckily, tasty recipes are abundant. And if you are a foodie, CSAs and farmers' markets are a great adventure—the results are delicious. It's hard to go wrong with fresh food, well seasoned and well prepared.

Google farmers' markets or community supported agriculture (CSA) in your city or town to find the nearest outlet that suits your needs. Or pick up a copy of *Edible Baja Arizona* or *Edible Phoenix* magazine. The staff, authors, and photographers do an outstanding job introducing fledgling locavores to our farmers and to the restaurants and markets where we can enjoy the taste of our own lands. S

R. Brusca

Above: Grilled mahi mahi *(Coryphaena hippurus)* with roe.

A FRUITFUL *Sea*

Richard C. Brusca, Ph.D.,
Executive Director Emeritus, ASDM
& **Linda M. Brewer,** *ASDM* Sonorensis, *editor*

If you eat shrimp, the best option is to avoid the large penaeid shrimps altogether, and just buy the smaller bay/pink shrimps, which make just as tasty shrimp cocktails, shrimp tacos, shrimp salad, etc. These shrimps are more-or-less always sustainably harvested, with traps, in California, Oregon, and Washington. However, they can be hard to find (they are shipped frozen). The next best option is U.S. farmed shrimp.

R. Brusca

David Littman

Greg Jensen

Alex Kerstitch

featherollector

Above left to right: Blue crab *(Callinectes arcuatus);* Giant (black) sea bass *(Stereolepis gigas);* Brown shrimp *(Farfantepenaeus californiensis);* Commercially harvested octopus *(Octopus bimaculatus);* Giant, or Humboldt, squid *(Dosidicus gigas).*

Our Sonoran Desert sea has been harvested for thousands of years for its delectable shellfish and finfish. The Gulf of California (also known as the Sea of Cortez) has long been the leading fisheries region in Mexico. Today, in restaurants and in homes, enticing aromas rise from traditional and modern seafood plates—Sonoran seafood stew with fish, shrimp, squid, octopus, and clams, nopales salad with shrimp, Baja-style fish tacos, crab-and-mango salad. Mouth-watering recipes abound. But will these delectables be available to future generations?

Nearly 900 species of finfish inhabit the Gulf. However, over the years, populations of large predators like sea bass, grouper, shark, and marlin have been greatly depleted by new and sophisticated fishing technology, along with increased demand. Both industrial and artisanal shrimp fishing continue to take tons of shrimp annually. In the case of industrial shrimp trawlers, there is an inordinate amount of "bycatch" (species caught other than the targeted shrimp), and these animals die before being discarded over the side of the ship. Today, shrimp, Gulf corvina *(Cynoscion othonopterus),* sardine *(Sardinops sagax),* and giant, or Humboldt, squid *(Dosidicus gigas)* are the backbone of the Sea of Cortez seafood industry. Forty years ago, almost no one in the Gulf harvested giant squid, because tuna, shark, grouper, sea bass, and other large finfish abounded, and the squid were few in number. But as these other large predators disappeared, squid populations have grown.

Although overharvesting has greatly reduced most commercial fish populations, the Mexican government has recently instituted a number of strict regulations aimed at avoiding catastrophic collapse of key species. And over the past 20 years, Mexico has become a world leader in environmental protection. The Upper Gulf of California and Colorado River Delta Biosphere Reserve provides protection for that region, though enforcement has been challenging. In July 2016, Mexico instituted a permanent ban on all gillnets in this region in an attempt to save the vaquita, a small endemic porpoise with population numbers estimated at less than 60 individuals. And there are now a dozen carefully regulated MPA's (Marine Protected Areas) in the Gulf, such as Cabo Pulmo National Park, Bahía de Loreto National Park, and Isla San Pedro Mártir Biosphere Reserve.

Unfortunately, the industrial shrimping industry, with their large ships and highly destructive bottom trawls, has already devastated vast areas of sea-bottom habitat and continues to do so. According to the Sustainable Fisheries Partnership, "prior to the fleet reduction 8 years ago, it was estimated that high levels of bycatch had resulted in the wasteful discard of *tens of thousands of tonnes* of approximately 600 marine species...including turtles and porpoises now threatened with extinction." New shrimp fishery regulations mandate use of bycatch-reduction devices that allow most marine mammals (and large finfish) to escape the net before drowning. However, the industrial fleet has been slow to move to the new net design, and in 2015 less than half of the fleet was using the new nets. Shrimp trawls continue to take high levels of bycatch and demolish the seabed habitat by dragging heavy chains across the sediment, destroying everything in their wake.

For now, all Gulf of California shrimp are listed in the "Avoid" category in the Monterey Bay Aquarium's Sustainable Seafood Guide. And, in general, we recommend you avoid eating any fish taken by longlines, which also have high bycatch. Look up sources of sustainable fish [see resources at the end of this article], and when you dine out ask, "Do you sell certified sustainable seafood?"

The Desert Museum's Sustainable Seafood Program cautions, "herbivorous fish (those species low in the food chain), such as catfish and tilapia, are the best options for harvesting and for consumers. If you must buy shrimp, buy U.S. wild-caught or farmed shrimp where strict guidelines are in place. Avoid purchasing all top carnivores (apex predators), such as grouper, sea bass, corvina, snapper, orange roughy, rockfish, and sharks. These fish are long-lived and commonly harvested before they have spawned." The Marine Stewardship Council certifies sustainable fisheries, and you can look for their stamp in your marketplace. The Baja California spiny lobster and blue crab fisheries, for example, are MSC certified. Aquaculture has the potential to relieve pressures on declining wild populations and create sustainable seafood production—if it is done correctly. Unfortunately, this is rarely the case.

Despite the halting progress, there is good reason to expect the seafood conservation movement in Mexico and the United States to continue to grow. With effort, education, and investment, we can turn around the past spiral of losses. But it will take all of us contributing as we can—voting with our mouths and pocketbooks, choosing to buy and eat only sustainable seafood.

Few restaurants in the Sonoran Desert Region focus on sustainable seafood (there are far more in California), but there is a growing movement. In Tucson, Fini's Landing is certified by Monterey Bay Aquarium Seafood Watch. When shopping for your home seafood meals, Walmart and Whole Foods top a very short list of supermarkets making a serious effort to provide sustainable seafood. Neither retailer (in the U.S.) sells red-listed seafood caught through ecologically damaging methods. With consumer pressure, times are changing. ◘

Suggested Readings and Resources

Monterey Bay Aquarium Seafood Watch, *seafoodwatch.org*

Seafood Choices Alliance, *seafoodchoices.com*

"Seafood and the Sea of Cortez" by Richard C. Brusca *(Sonorensis* 2009), *desertmuseum.org/center/sonorensis_seafood.pdf*

Richard C. Brusca, ed. *The Gulf of California: Biodiversity and Conservation*. Tucson: The University of Arizona Press and Arizona-Sonora Desert Museum, 2010.

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