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STATE OF TUCSON'S FOOD SYSTEM

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Pioneering Affordable Access to Food Biodiversity in
Tucson, Arizona, a UNESCO City of Gastronomy

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HIGHLIGHTS AND CORE CONCEPTS

Tucson, Arizona, has emerged as a global leader in pioneering novel means for providing an extraordinary variety of food plants to its citizens for both immediate consumption and for cultivation in home gardens and public spaces. Currently, we estimate that Tucsonans have local access to (and in any given year, potentially cultivate) over 2,020 named varieties of 130 cultivated annual food crops species, 140 species of wild, native desert edible plants, and over 200 named varieties of 70 domesticated fruit, nut, berry and succulent edible species.

In many metro areas, finding low-cost or free public access to healthy food and seeds, cuttings and live plants to aid in food security can be problematic for members of low-income households. The 2016 American Community Survey suggests that poverty levels inside Tucson's city limits remain high (24%) compared to its Metro Area in Pima County (18%) and to the state of Arizona as a whole (16%). It is no wonder then that providing more affordable access to a diversity of fresh, culturally appropriate foods has become a priority for many of Tucson's most innovative food justice organizations.

Diets low in species and varietal diversity often aggravate food insecurity and micronutrient deficiencies that differentially affect the poorest of the poor more than other community members. A loss of food diversity and dietary heterogeneity currently poses serious public health issues for many people around the world, including refugees, recent immigrants, and indigenous peoples in the Tucson area who have historically been marginalized.

As the first UNESCO-designated City of Gastronomy in the U.S., Tucson can use the designation to be a model for innovative means not only to conserve food crop diversity, but also to make propagation materials and prepared foods of these 340 wild and cultivated species widely and affordably available.

TECHNICAL ABSTRACT

One of the reasons that Tucson, Arizona, was designated as the first UNESCO City of Gastronomy in the United States is because of its wide range of programs, institutions, festivals, and food-relief efforts that foster public access to food biodiversity. While many scholars have proposed that diversifying diets of low-income households might potentially reduce micronutrient deficiencies, nutrition-related diseases, and food insecurity, there are few known surveys of food biodiversity access in metropolitan areas. We collaborated to document the range of means that have emerged in Metro Tucson to provide greater access to viable seeds, cuttings, live plants, prepared foods, and educational materials that promote and distribute diverse and often desert-adapted food plant species and varieties. We compared the overall diversity of species and varieties available at little or no cost through various venues, with special attention to so-called

Among the many means being tested in Tucson for their efficacy in heightening access to the biodiversity of food plants are:

1. The largest interlibrary loan network of seed libraries in the world, with back-up support from five scientifically-managed, community-oriented seed banks;
2. Seed and live plant sales at venues like farmers' markets and nurseries which allow low-income households to use Electronic Benefit Transfer (EBT) cards for their purchases as federal Supplemental Nutrition Assistance Program (SNAP) benefits;
3. Community gleaning collectives, public-private partnerships, and training initiatives for both native/indigenous and immigrant/refugee populations through which edible plants are sold at cost or given away;
4. Non-profit museums, botanical gardens, community farms, and school gardens that educate the public about the nutritional value and home uses of this agrobiodiversity
5. These community-based collaborations to conserve, propagate, regenerate, distribute, donate, plant, process, consume and celebrate our multi-cultural food biodiversity undoubtedly make Tucson a global leader in forging long-term solutions for food security. However, Tucson's non-profits, neighborhood alliances, and educational institutions still require more stable financial and logistical support to pilot, maintain, and evaluate these innovative means of making these foods affordable to all. We welcome interactions and cross-training opportunities with other Cities of Gastronomy and desert communities dedicated to similar goals.

heritage foods, native food plants, and heirloom fruits, vegetables and nuts. We estimate that Tucsonans have local access to (and in any given year, potentially cultivate) over 2,020 named varieties of 130 cultivated annual food crops species, 140 species of wild, native desert edible plants, and over 200 named varieties of domesticated fruit, nut, berry, and succulent edibles. These food crop varieties originated in many landscapes with many indigenous, immigrant, and refugee communities, many of whom are now engaged in regional events and micro-enterprises to offer their value-added food products for local consumption. While Metro Tucson may still have food access disparities in terms of social, cultural, economic, and logistical factors, it nevertheless has become a living laboratory to evaluate which means in the formal and informal economies best provide more equitable access to diverse foods to improve nutritional security.



Tucson, Arizona has become a model for urban desert communities seeking to conserve food biodiversity and make it accessible and affordable. Photo by Jonathan Mabry.

INTRODUCTION

The availability and affordability of a wide variety of foods in a community can be an indicator of food security among its citizens; in contrast, hunger and food insecurity are often exacerbated in communities where diets are chronically monotonous because many nutrient-dense foods are priced beyond their citizens' reach.

Tucson, Arizona, is one community that has been working for decades to offer more affordable access to a diversity of both foods and live plants from which foods can be harvested. This is an urgent task, since the 2016 American Community Survey suggests that poverty levels inside Tucson's city limits remain high (24%) compared to its surrounding Metro Area of Pima County (18%), and to the state of Arizona as a whole (16%).

Among the more glaring and egregious omissions evident in Michael Pollan's (2009) best-selling *Food Rules: An Eater's Manual* is its virtual lack of attention to the role that food diversity can play in ensuring healthy diets, especially among the poor. Such "optimal diet" advocates presume there is some ideal one-size-fits-all formula for healthy eating—a formula that these advocates suggest all eaters are familiar with, fond of, and have affordable access to. Unfortunately, they ignore the many socioeconomic reasons that such an optimal diet is accessible or even applicable to peoples of all ages, genders, races, and cultures (Guthman 2009, Nabhan 2012).

Lack of access to diverse, affordable, culturally-appropriate foods and the means to cultivate them may be particularly limited in certain metro areas. In many cities, residents from many ethnicities, nations, and races find it difficult to encounter or cultivate the very seeds, cuttings, and live plants of the particular food crop species and varieties that have long been part of their traditional cuisines. If these traditional foods can be located in their vicinity, it is often through the informal economy of flea markets, swap meets, and door-to-door vendors of the "informal economy" that is not typically surveyed by dietitians or nutritionists (Nock 2009; Dean et al 2011; Sharkey et al 2012). The dilemmas of lack of access to, and affordability of, favored traditional foods may be evident for both recent immigrants (including political refugees) from other countries, and for indigenous residents who have recently moved to large metro areas.

In fact, a growing body of literature from the social and nutrition sciences suggests that there are direct health and food security consequences of a reduction in agrobiodiversity in human diets (Khoury et al 2014). Using new metrics to characterize nutritional diversity, the relative abundance of macro- and micro-nutrients provided by various cropping systems can be correlated with food security and health of the villagers or city dwellers dependent upon them (Remans et al 2011). As a probable result of the increasing homogeneity or reduced nutritional diversity of contemporary diets, more than two billion persons are globally affected by deficiencies in dietary uptake of vitamin A, iodine, folate, iron, and zinc, and such nutritional deficits persist in more than half of all nations on the planet (Khoury 2015; WHO 2015).

As scientists and policy-makers seek leveraging points for rapidly improving global food security and the resilience of our food systems in the face of climate change (West et al 2014), health professionals have insisted that one viable leveraging point is the promotion of the multiple health benefits of diverse forms of urban agriculture (Bellows, Brown and Smit 2008). And yet, in the United States at least, well-established and -funded long term ecological research networks in the metro areas of Philadelphia and Phoenix do not necessarily include food biodiversity in their pattern analysis and urban planning efforts (Beyer 2010; Faeth, Bang, and Saari 2011).

For these reasons, we were prompted to undertake a collaborative effort to document the current level of agrobiodiversity for food crop species and varieties in the metropolitan area of Tucson, Arizona, which was designated as the first UNESCO City of Gastronomy in the U.S.A. in December 2015. One unique feature of this desert city's food system, which has gained attention is its many novel means of providing public access to the seeds and cuttings of diverse food crops that have persisted among many cultures over long periods of Tucson's history (Newman 2017; Nabhan and Glennon 2016). We now wish to assess whether these novel means actually do provide easy and affordable public access—particularly for low-income households—to a significantly diverse set of desert-adapted food crop species and varieties.

MATERIALS AND METHODS

For the purposes of this study, we have decided to include both wild and cultivated food plants—annual as well as perennial—that are currently grown and held in reserve as seeds and other propagation materials within the Metro Tucson area. With a population of over 985,000, Tucson is the second-most populated city (after Phoenix) both in the state of Arizona, and in the binational Sonoran Desert region. For domesticated vegetables, cereals, legumes, and some fruit species, we were able to identify and tally unique foods at the varietal level; when that was not possible, we used the species level to assess the diversity of available foods.

For the most part, we relied on the taxonomies found for crops in van Wyk’s (2005) *Food Plants of the World: An Illustrated Guide*, and for wild food plants in Moerman’s (2004) fifth edition of *Native American Ethnobotany*. We supplemented these standard references with the more regional inventory of wild desert food plants compiled by Hodgson (2001) for the Sonoran Desert as a whole, and of historically-cultivated food plants compiled by Nabhan and Glennon (2016).

To assess Metro Tucson’s diversity of wild and cultivated food plants that are publically accessible as propagation materials and as locally-produced foods to Tucson residents, we devised the following provisional means of stratified sampling. We inventoried the locally-grown food plants found in two non-profit seed banks, two nurseries, two community gardens, two public (educational) botanical gardens or museums, two gleaning and/or gardening programs for recently-arrived immigrants and refugees, two seed library networks, and one urban tree planting program. In addition, we included inventories from “anonymous vendors” in the informal food economy who may use roadside stands, pop-up nurseries, *pulgas* (flea markets) or *tianguis* (swap meets) to sell their food plants. We did not do interviews with vendors per se, more than asking for names of hard-to-identify foods. For multiple ethical, legal, and logistical reasons, we are refraining from more specifically identifying these venues and vendors in the informal food economy of the Metro Tucson area. For a summary of places or programs sampled, see Table 1.

RESULTS

We determined that at least eight non-profits, as well as other county, school district, and tribal entities, and one community-based but independently-owned for-profit utilize a remarkable variety of means to provide the citizens of Metro Tucson with access to food biodiversity. This food biodiversity often takes the form of seeds available for planting, but also includes the provision of rooted stems, cuttings, tubers, bulbs, parthenocarpic plantlets, and grafted rootstocks. Some also feature locally-harvested, prepared, or processed foods and beverages made from community-grown or foraged food species. The varieties of the cultivated species made available are typically what are known as “standard” (usually non-hybrid or non-GMO), but also include what are colloquially termed “traditional,” “old-timey,” “heirloom,” “heritage,” “native,” or “*raza criolla*” land races of both annuals and perennials. As one might expect, there is not as much

Table 1: Stratified Sample of Tucson Organizations Engaged with Food Diversity

Seed Banks	Native Seeds/SEARCH	Desert Legume Program (DELEP)
Free Seed Libraries	Pima County Public Library Seed Library Inter-Library Loan Network	Community Seed Bank of Southern Arizona’s Community Food Resource Center
Non-Profit or Locally-Owned Community Nurseries	Desert Survivors	Civano Nursery
Refugee Gleaning and Gardening Programs	Iskashitaa Refugee Network	International Rescue Committee/Community Gardens of Tucson
Botanical Gardens or Garden Museums	Tohono Chul Park Nursery	Mission Gardens of Friends of Tucson’s Birthplace
Non-Profit Sources of Plants for Transplanting	Food Conspiracy	Trees for Tucson
Farmers Markets	St Phillips Plaza	Mercado San Agustin
Community Farms	San Xavier Co-op Farm, Tohono O’odham Nation	Tucson Village Farm of the (University of) Arizona Cooperative Extension
School Gardens	Manzo Elementary School of TUSD	Robert-Naylor K-8 School

varietal differentiation of native wild edible species from the Sonoran Desert area around Metro Tucson, although some of these wild species are colloquially named for the landscape or locality from which they are derived (eg., Rock Corral Canyon or Devil’s River chiltepins).

Table 2 provides a summary of the number of cultivated food crop and wild edible species made publically accessible in Tucson through selected outlets. To be sure, this is an initial sampling, not a comprehensive inventory, and even this “stratified” sampling underestimates cultivated winter annuals and self-transplanted wild edible species. Our sampling was largely focused on cultivated food crop and wild edible species made publically from April through September 2017. However, some organizations divulged their total listings (regardless of seasonality) for the years 2016 and 2017.

Table 2: Diversity of Food Plants Offered by Each Organization Sampled

Seed Banks	Native Seeds/SEARCH	53 cult. food species, 7 wild edible species as seed. 5-8 species as transplants	Desert Legume Program (DELEP)	15 cult. food species, 29 wild edible species, all as seed
Free Seed Libraries	Pima County Public Library Seed Library Inter-Library Loan Network	141 cult. food species, 9 wild species as seed packets or bulbs	Community Seed Bank of Southern Arizona's Community Food Resource Center	20 cult. food species, as seed packets seasonally
Non-Profit or Locally-Owned Community Nurseries	Desert Survivors	7 cult. species, >70 wild edible species as live plants for transplanting	Civano Nursery	64 cult. food species, 4-8 wild edible species as live plants for transplanting
Refugee Gleaning & Gardening Programs	Ishkashitaa Refugee Network	83 cult. food crop species, plus 3 wild edible species as food gleaned	International Rescue Committee/Community Gardens of Tucson	31 cult. food species to give to refugee gardens as seeds or bulbs
Botanical Gardens or Garden Museums	Tohono Chul Park Nursery	17 cult. food species & 33 wild edible species as transplants or seeds	Mission Garden of Friends of Tucson's Birthplace	24 cult. food species, 7 wild edible species on display & as cuttings offered at events
Non-Profit Sources of Plants for Transplanting	Food Conspiracy	3 cult. food species available as transplants, to members	Trees for Tucson	34 cult. species, & 12 wild edible species give away to neighborhoods or prisons
Farmers Markets	St Phillips Plaza	21 cult. food species sold as produce	Mercado San Agustin	40 cult. food species sold as transplants, 36 as food & 3 wild edible species as food
Community Farms	San Xavier Co-op Farm, Tohono O'odham Nation	10 cult. species & 4 edible wild species as produce	Tucson Village Farm of the (University of) Arizona Cooperative Extension	58 cult. food species planted, 2 wild edibles planted for educational purposes
School Gardens	Manzo Elementary of TUSD	35 cult. food species & 1 wild edible as seeds & starts	Robert-Naylor K-8 School	See IRC counts, above
Community Gardens	Blue Moon Community Gardens of Tucson	24 cult. food species, 3 wild edible species grown as food, seeds saved	St. Demetrios Garden/ CGT and IRC	23 cult. food species, 1 wild edible species grown as food, seeds saved
Pulgas, Roadside Stands, Swap Meets, Tianguis	Anonymous southside site	14 cult. food species, 2 wild edible species	Anonymous mid-town site	10 cult. food species, & 1 wild edible species
		sold as transplants		sold as transplants

The following descriptions are for most but not all of the outlets we found in Metro Tucson that make food biodiversity accessible, the means by which they provide access, how long they have been doing it, and how it relates to their missions and constituencies.

FREE SEED LIBRARIES

The free seed library movement began with the formation of the Bay Area Seed Interchange Library (BASIL) in 2000, housed in the Berkeley Ecology Center in California. The concept was picked up by the Hudson Valley Seed Library in 2004, then quickly spread and diversified on the East Coast, and to other regions in the U.S., Canada, and Europe. In May of 2015, Tucson non-profits and institutions co-hosted the first ever **International Seed Library Forum**. Southern Arizona continues to be a leader in seed-saving education nationally and internationally, with 20 seed libraries established in the border counties.

In 2012, the **Pima County Public Library system's Seed Library Program** headquartered in Tucson became one of the first in the nation to circulate seeds of food, dye and medicinal plants, as well as ornamentals and wildflowers. It is now the largest free seed library "inter-library loan" program for garden seeds in the country, with seeds available at all 26 library branch locations, most of them within Metro Tucson. It includes roughly 3,400 unique accessions including 2,000 named and unnamed varieties of seeds. These including not only edibles, but also fiber, ornamental, medicinal, and decorative plants. Over the past five and a half years, library users have checked out an average of 28,000 packets (for free) annually. These currently include 141 cultivated food crop species and 9 wild edible species, making it

one of the largest free seed library collections to develop within the last decade. In May of 2015, it co-hosted with the University of Arizona's Southwest Center and other organizations the first ever International Seed Library Forum. It continues to be a leader in seed-saving education and the innovation of better means to make seeds accessible to low-income households.

Founded in Tucson in 1975, the **Community Food Bank of Southern Arizona** provides hunger relief, health, food production and nutrition education, and community development assistance across the five counties in southern Arizona. Its 120 employees and many volunteers help to advance more lasting food security in Tucson and other communities by not only feeding the hungry, but also through a variety of innovative programs. Three of its programs offer low-income households and others public access to food biodiversity: the Santa Cruz Farmers Market at Mission San Agustin; the Las Milpitas de Cottonwood Community Farm; and a free seed library in its Community Food Resource Center. The seed library inventory changes seasonally, and currently has seed packets of 20 food crop species on a seed rack in its headquarters in south Tucson that are available to any walk-in client or visitor.



Residents can visit any Pima County library branch to check out free desert-adapted seeds to grow food at home. Photo by Jonathan Mabry.

SEED BANKS

Formal long-term storage of seeds and other food-crop germplasm began well over a century ago in botanical gardens and plant breeding institutes. Such short- and medium-term seed collections of desert crops have been kept at the University of Arizona for at least 110 years, and have been established in at least four other institutions in Tucson over the last four decades. Their “field collections” from desert environments and traditional farmers have, through time, become the core “back-up support system” for what other seed distribution programs have propagated and provided access to in the last two decades.

The Desert Legume Program (DELEP) was established in 1988 as a joint project of the University of Arizona’s College of Agriculture and Life Sciences and the Boyce Thompson Arboretum. DELEP plays an important role in conserving legume biodiversity. Its focus is on food and forage legumes, because they are the most important group of plants in human nutrition after the cereal grains. DELEP has developed a valuable collection of wild legume species from the southwestern United States and around the world. By June 2014, this collection had grown to include 1,374 species totaling 3,686 individual accessions

originating from 64 countries. No less than 15 cultivated food crop species and 29 wild edible species are available for free as seed packets via its on-line *Index Seminum*. Few gardeners in Tucson, however, are probably aware of this seed bank, which is largely used by researchers for investigation and evaluation.

Native Seeds/SEARCH is a non-profit founded in 1983 that identifies, collects or receives, protects, and preserves the seeds of the diverse native and immigrant peoples of the U.S./Mexico borderlands. It focuses on regenerating, conserving, and distributing 1,900 different accessions of seeds in the Greater Southwest so that these arid-adapted crops may benefit all peoples and nourish them in a changing world. In particular, it has a free distribution program in the region to individuals, families, and communities (and their schools) of Native American descent, and has assisted the establishment of free seed libraries, including one in its store in Metro Tucson. It offers over 100 varieties of 53 cultivated food crop species and seven edible crop wild relatives as seeds in its store and online, and five to eight species per year as live plants sold at its store





NON-PROFIT OR INDEPENDENTLY-OWNED COMMUNITY NURSERIES

Metro Tucson is home to at least a dozen commercial nurseries, including ones managed by at least three non-profits. Because the international botanical and horticultural journal *Plant World* (later known as *Ecology*) was edited from the **Desert Laboratory** on Tumamoc Hill in downtown Tucson from 1911 to 1919, Tucson became a pioneer in the promotion and propagation of native plants for desert landscaping and culinary use.

Founded in 1981, **Desert Survivors**, Inc. is a unique non-profit organization that combines a highly diverse native plant nursery with an employment program for adults with developmental disabilities. It is a mid-sized job training center based at a desert landscape nursery located in south Tucson. It has 55 full-time employees as well as dozens of trainees and volunteers, and generates \$1.0 million in annual revenue. Its inventory includes over 70 wild native edible plant species and seven species of heirloom or heritage fruit tree species introduced to Tucson in the Spanish Mission Era. It grew most of the original fruit trees planted at Mission Garden (see below) and at Kino Heritage Fruit Tree orchards at Manzo Elementary School and Tumacacori National Historical Park.

The **Civano Nursery** is a family-owned and -operated business with a garden center that was opened on the east side of Tucson by the Shipleys in 1998. It also has a 70-acre farm that was started later in nearby Sahuarita as a nursery propagation area for nearly 700 different plant varieties and species. It regularly hosts Arbor Day and Earth Day events. A non-profit, it is strongly linked to the planned sustainable community of Civano and is a long-standing supporting business member of Civano Neighbors, the neighborhood association specific to the area that was founded in 2002. It currently offers more than 64 species of cultivated food crops and four to eight edible wild species as potted live plants for transplanting, in addition to seed packets from nationally-distributed brands.

NON-PROFIT PROGRAMS OFFERING TRANSPLANTS OF EDIBLES FOR CULTIVATION AT HOME OR IN PUBLIC SPACES

Thanks in part to the “**LEAF Network**,”—**Linking Edible Arizona Forests**,”—founded in 2011 by Ann Audrey and her colleagues, Tucson organizations have been active players in coordinated community-wide efforts to link Arizonans of all cultures and income levels with the benefits of edible trees. The LEAF Network is a community-based organization affiliated with the nonprofit Arizona Community Tree Council. LEAF encourages and promotes the planting, care, harvest, and celebration of 55 edible trees that grow in Tucson. These trees include native and nonnative species that yield fruits, seeds, pods, nuts, and other edible products for people, wildlife, and the environment. Its funding is provided by the Urban and Community Forestry Financial Assistance Program administered through Arizona Department of Forestry and Fire Management – Urban and Community Forestry Program and the U.S. Department of Agriculture (USDA) Forest Service.

Initiated in 1987, **Trees for Tucson** is an urban forestry program of Tucson Clean & Beautiful, Inc. that aims to use trees to enhance the natural environment, save energy, combat the urban heat island effect, and enhance the quality of life in the region through a variety of collaborations with neighborhood organizations, prisons, schools, and the city government.

The Trees for Tucson program plants desert-adapted fruit- and shade-bearing trees at individual residences, along streets, in parks, in prisons, and at schools to cool the urban environment and create healthier, safer, more equitable, and livable urban spaces. In 2016, the Trees for Tucson urban forestry program provided 7,605 native and/or edible trees for planting in Metro Tucson, with a strong focus in the southern, low-income neighborhoods of the Metro area. Among the trees provided are 34 cultivated fruit, nut, and spice species and 14 wild edible species.

The **Food Conspiracy Co-op** of Tucson was born in 1971, and remains the city’s only full-service consumer cooperative owned by its members. In the summer of 2013, the Food Conspiracy Co-op installed a rainwater harvesting system for a grow-out garden, paid for with a grant from the City of Tucson. The system will feed an urban micro farm, which provides 11 varieties of four warm-season vegetable starts to its members. They are sold as two vegetable starts for \$5, but Electronic Benefit Transfer (EBT) cards for federal Supplemental Nutrition Assistance Program (SNAP) benefits can be used for their purchase.



The Iskashitaa Refugee Network gleans a wide variety of foods from edible trees and cactus that would otherwise be wasted, and turns them into value-added food products that create incomes for recent-arriving refugee families. Photo by Jonathan Mabry.

GLEANNING AND GARDENING PROGRAMS FOR RECENT REFUGEES

Only three states in the U.S. regularly accept more refugees for resettlement than Arizona, which has received as many as 4,700 individuals per year for resettlement in recent years (in addition to its estimated 375,000 undocumented immigrant residents from Mexico and Central America). At least five organizations in Metro Tucson assist refugees with food security: Catholic Community Services (associated with Catholic Charities); the International Rescue Committee Tucson office; the Iskashitaa Refugee Network; the Refugee and Integration Service Provider Network of Tucson, Tucson International Alliance of Refugee Communities; and the Tucson Refugee Ministry.

The Iskashitaa Refugee Network has created opportunities to integrate United Nations refugees into the Southern Arizona community through food-related initiatives in the Tucson area since 2003. It assists refugees from at least 21 countries while educating the Tucson public at large and strengthening the local food system, reducing local food waste, and increasing food security. Its participants annually harvest and glean over 100,000 pounds of fruits, nuts, and other foods from the streets of Metro Tucson and the farms that surround it, processing them into saleable value-added food products. Its refugee participants harvest at least 16 cultivated food crop species, plus three wild edible species. These gleaned foods are made into value-added products used by refugee families, or sold to restaurants or farmers market customers. The organization also provides free seeds, plants, and other support for the gardeners and gardens located at Desert Courtyard Apartments, where many refugee families reside.

The International Rescue Committee opened its Tucson Resettlement Office in 1997. Since then, this office has helped more than 3,000 refugees from over 23 countries rebuild their lives in Southern Arizona. IRC Tucson is the only non-sectarian resettlement agency in Southern Arizona dedicated exclusively to refugees. It collaborates with the Community Gardens of Tucson to provide a comprehensive continuum of services that empower refugees to build a new life in our community, including seeds and garden spaces at seven school and community gardens in the Metro Tucson area. It coordinates its services with Community Gardens of Tucson to assist refugees from Burundi, the Congo, and other countries in gaining free seeds and bulbs for gardening. Among seven sites at schools and community gardens where it provides seeds to refugees, 31 cultivated food species are currently grown, at least two of which are not available anywhere else in Metro Tucson.

COMMUNITY FARMS

In addition to 14 commercial farms and ranches in the Metro Tucson area, which deliver fresh foods to urban consumers, there are at least three community farms in Metro Tucson. One is associated with the University of Arizona and its Cooperative Extension affiliate, one with a tribal collective, and the third with a food bank. All are less than 15 years old, and function as educational and professional training centers.

The Tucson Village Farm (TVF) is a working urban farm built by and for the youth of our community. A program of the Pima County Cooperative Extension and the University of Arizona, TVF is a seed-to-table program designed to reconnect young people to a healthy food system, teach them how to grow and prepare fresh food, and empower them to make healthy life choices. To accomplish this, Tucson Village Farm offers year-round, instructional, hands-on programs for youth of all ages. It targets urban youth from all ethnic and socio-economic backgrounds. In 2016, it served just under 10,000 youth on the farm and delivered 41,000 hours of education. Its K-5 program serves nearly 6,000 K-5th grade students through its Growing Forward program, in addition to its teen Healthy Living Ambassador program, summer camp offerings, and general programming. In 2017, it launched a new FARMacy program (a partnership that TVF initiated among the University of Arizona College of Medicine and several El Rio Health

Centers), which donates vegetable planters to families whose children are at high risk for developing childhood obesity and type-2 diabetes. Each family plants and takes home a planter with both starts of four leafy vegetable species and seeds of root crops, in addition to carrying home fresh produce from 58 cultivated species and two wild edibles, as well as recipes for making culturally relevant, healthy meals.

The San Xavier Co-op Farm is a project of the San Xavier Cooperative Association that was incorporated on Tohono O'odham tribal lands just south of the City of Tucson in 1972. The co-op members and stewards of the 850-acre farm have been involved in crop production, education, and training for well over a decade. In addition to cultivating native food crops and irrigated fields and orchards for the benefit of the local community, it also hosts a Wild Foods Community Harvest Program to teach O'odham youth and others how to harvest, process, and prepare Sonoran Desert foods in a culturally and environmental healthy way. Its store at the farm sells a variety of traditional wild and cultivated foods to the public at large, but these same foods are also made available to both school children and elderly residents in the San Xavier District of the Tohono O'odham Nation. At least ten cultivated native crop species and four wild, native edible plant species are harvested and processed into value-added food products, which can be purchased with SNAP benefit EBT cards by community members.



The San Xavier Co-op Farm has revived traditional farming and sells heritage food products at festivals, markets, and stores. Photo by Jonathan Mabry

BOTANICAL GARDENS AND AGRICULTURAL MUSEUMS

There are at least four botanical gardens, and agricultural or natural history museums in Metro Tucson, including the world famous Arizona-Sonora Desert Museum, Mission Garden, Tohono Chul Park, and Tucson Botanical Gardens. Collectively, these institutions have had an enormous impact on Tucson by offering native edible plants through nursery sales and events, and providing dozens of educational workshops each year on desert edibles. Tucson is often ranked among the top-five cities in the United States with regard to the extent of use of native plants in public landscaping and private home-scapes.

Tohono Chul Park is a non-profit botanical garden, nature preserve, and cultural museum located in Northwest Tucson that was founded in 1985. The mission of Tohono Chul is to enrich people's lives by connecting them with the wonders of nature, art, and culture in the Sonoran Desert region. Its 49 acres feature 150 native species of shrubs and trees; 300 species of cacti and succulents; and 50 species of wildflowers. In addition to an ethnobotanical education exhibit teaching the public about edible native plants, it has a nursery and fall plant sale that offer both wild native plants for transplanting, and seeds of cultivated heirloom food crops. Its fall plant sales features 33 species of edible wild plants, and 17 domesticated perennial food plant species

SCHOOL GARDENS

There are currently 57 school gardens in Tucson Unified School District (TUSD), while others are located at private and parochial schools in the Metro Tucson area. Within the last decade, TUSD began to partner with the University of Arizona College of Social and Behavioral Sciences to involve college student interns in assisting and supporting teachers' use of the gardens in environmental, nutritional, and health science educational activities. In addition, this program branched out to foster the use of fresh produce grown both in school gardens and nearby farms in class settings and cafeterias throughout the Unified School District. Since 2015, many of TUSD's 50,000 students, spread across 86 school sites, have tried heritage fruits, heirloom vegetables and wild greens produced on Tucson area farms or in school gardens, greenhouses, hydroponic demos, and agrivoltaic food system pilot projects.

Manzo Elementary School is a public neighborhood school in the Tucson Unified School District serving Barrio Hollywood. The school garden at Manzo was initiated in 2006 as a school counseling tool and as a means to foster the social and emotional development of the Manzo students. Manzo has a number of on-ground and container gardens, heritage orchard trees, water harvesting demos, chickens, an extensive water harvesting system, an aquaponic system, and Tucson's largest agrivoltaic research garden. It seasonally features 35 crop species, and one wild edible (chiltepin bushes).

The Roberts Naylor School Garden was launched in the early spring on 2017, in partnership with the International Rescue Committee (IRC, see above.) The Garden was designed to serve two purposes. Half of the plots provide access to the school students, while the other half is reserved for refugee families (many with children in the school) in the neighborhood. During the summer, refugee families maintain and tend the entire garden.

to its members and visitors. It is highly visited by, and sometimes donates plant materials to, neighboring schools which have their own gardens.

Mission Garden is a project of the non-profit Friends of Tucson's Birthplace, which is working to implement the Tucson Origins Heritage Park in downtown Tucson. By 2011, it began replanting the Spanish Colonial walled garden that was part of Tucson's historic San Agustin Mission. The Garden features heirloom Sonoran Desert-adapted fruit orchards and vegetable gardens interpreting 4,000 years of agriculture in Tucson. Currently, 24 cultivated food species and seven wild, edible species are on display, and their fruit sold at the Santa Cruz Farmers market and offered as cuttings at special events. The Friends also donate heirloom fruit tree varieties to school gardens at several schools in low-income areas of the city. It too is highly visited by neighboring schools.



The school garden program at Manzo Elementary School teaches students how to cultivate desert-adapted foods that are served in the school cafeteria. Photo by Jonathan Mabry.

ROADSIDE STANDS, TIANGUIS, PULGAS, AND SWAP MEETS

Metro Tucson, like many major urban areas whose residents suffer from poverty and food insecurity, is home to a highly-functioning "informal economy" in which food is exchanged or purchased through a variety of means not tracked by the USDA or Department of Commerce (Nock 2009; Dean et al 2011; Sharkey et al 2012). Two of our team of co-authors have spent considerable time trying to understand the significance of this informal economy to food-insecure households, without drawing problematic attention to either the particular (usually unpermitted) venues or vendors through which these interactions occur. While we decline to divulge the exact locations or producers involved in these neighbor-to-neighbor exchanges, they are protected legally by the Arizona Department of Agriculture Substantive Policy Statement advisory on ARS 3-561 to 3-563 ruling on farm products sales to neighbors within the same county. These consensual exchanges of plants and prepared foods occur at roadside stands, tianguis, pulgas, swap meets, and a variety of "pop-up" tabling at community events. A minimum of 14 cultivated food species and two wild edible species are shared in this manner, often at prices far less than those garnered at formal farmers markets. However, EBT for SNAP benefits are not usually accepted at these venues.

CONCLUSIONS

In a study comparing Tucson with cities in Italy and Vietnam, Di Giovine, Mabry and Majewski (2016) concluded that renewed awareness and appreciation of heritage foods linked to community identity may motivate movements to conserve them, along with traditional knowledge about how they are foraged, grown, processed, and cooked. They find that such engagement with heritage foods in an urban setting can also lead to the revitalization and appreciation of a city's place-based identity and often multi-cultural heritage. Tucson's creative strategies for conserving and disseminating food biodiversity was a major factor in its designation as the first UNESCO City of Gastronomy in the U.S. This has not only reinforced such cultural revitalization, but has also fostered a more diverse diet, the creation of new "green jobs" and business opportunities for heritage food producers and food artisans, and international attention and local pride with regard to the community's many innovative means of conserving food biodiversity and making it publically accessible and affordable.

Since this desert city received the UNESCO City of Gastronomy designation, its official tourism agency Visit Tucson calculates that the value of media food-related publicity about the Tucson region has increased from \$5 million to \$30 million annually. This increase in media attention has helped promote Tucson's vibrant food scene of food festivals, farmers markets, co-ops, restaurants, and educational food events. Without the little or no investment from state or federal agencies, or from national philanthropic foundations to date, grassroots efforts in Tucson have created more opportunities for accessing diverse diets and finding jobs with livable wages in the food and agricultural sectors.

However, the survival of heritage food traditions faces difficult challenges if their most knowledgeable and skilled participants cannot make a decent living in the very activities which support and enliven such traditions; "heritage" then risks becoming a façade that does not necessarily help the unemployed or underemployed gain better opportunities to support their families and their place-based practices. While no single organization or strategy can vanquish poverty or disparities in poverty-stricken cities such as Tucson, the many still underfunded organizations working to employ food biodiversity to help "close the hunger gap" in this multi-cultural community deserve our attention, respect, and support.

In conclusion, this preliminary survey of access to food biodiversity found the following:

1. Through the efforts of 14 local organizations, Tucsonans currently have local access to (and in any given year, potentially cultivate) over 2,020 named varieties of 130 cultivated annual food crops species, 140 species of wild, native desert edible plants, and over 200 named varieties of domesticated fruit, nut, berry, and succulent edibles.
2. At least 80 percent of the annual food crop varieties and 40 percent of the woody perennial food species in this larger inventory are now available for free or at discounted cost to food-insecure refugees from at least 20 countries, as well as to Native American and Hispanic families that have lived in this desert landscape for millennia.
3. Over 45 local producers—most of them working through micro-enterprises that have started only within the last three years—have begun to produce and direct-market more than 145 artisanally-prepared food products using foods foraged or grown in the Tucson area, creating dozens of new "green livelihoods," including seasonal jobs for both long-time Native American and Hispanic inhabitants and recently arrived refugee residents.
4. Tucson is home to at least five storehouses of edible plant genetic resources or "seed banks," and hosts the largest free seed library "inter-library loan" program for garden seeds anywhere in the U.S.
5. Tucson area farmers and ranchers continue to preserve more seeds of rare food plants and breeds of rare livestock that have been listed on the Slow Food International Ark of Taste than those in any other metro region of the U.S. of comparable size.
6. Because of local organizations such as the Desert Harvesters, the Iskashitaa Refugee Network, the LEAF Network, the Arizona-Sonora Desert Museum, San Xavier Farm Co-op, Desert Survivors Nursery, Mission Garden, and Tohono Chul Park, there is a wealth of non-formal educational resources and experiences available to residents who care to learn about harvesting techniques, wild-foraging ethics, and culinary preparations of edible plants found in Tucson landscapes.
7. With a continuous tradition of desert agriculture in the Tucson Basin reaching back at least 4,000 years, native cultivated varieties of maize, beans, squash, chiles, and other food crops have persisted in home use, roadside stands, farmer's markets and restaurants. However, the vast majority of seed and fruit varieties grown in Tucson arrived via immigrant cultures new in residence in the Sonoran Desert. The first Old World cultigens introduced 300 years ago have become locally adapted and valued as heritage foods, and more recently arriving plants will also soon be ecologically-adapted to the environmental conditions of Tucson's urban heat islands. These adapted varieties may potentially enhance local food security and community resilience in the face of global climate change.

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